REPORT No. : SZ17120100S01

SAR TEST REPORT

APPLICANT	:	Shenzhen Jingwah Information Technology Co., Ltd.
PRODUCT NAME	:	Laptop
MODEL NAME	:	N141A, N14500
BRAND NAME	:	PACKARD BELL
FCC ID	:	RBD-N141A
STANDARD(S)	:	47CFR 2.1093 IEEE 1528-2013
TEST DATE	:	2017-12-28 to 2017-12-28
ISSUE DATE	:	2018-01-04

Tested by: Peng Fuwei (Test engineer)

Approved by: Peng Huarui (Supervisor)

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DIRECTORY

Change History		
Issue	**Date**	**Reason for change**
1.0	2018-01-04	First edition

1. Technical Information

Note: Provide by manufacturer.

1.1. Applicant and Manufacturer Information

Applicant:	Shenzhen Jingwah Information Technology Co., Ltd.
Applicant Address:	4F, Bldg 4, Jinghua Square, No.1 Huafa North Road, Futian District, Shenzhen, China
Manufacturer:	Shenzhen Jingwah Information Technology Co., Ltd.
Manufacturer Address:	4F, Bldg 4, Jinghua Square, No.1 Huafa North Road, Futian District, Shenzhen, China

1.2. Equipment Under Test (EUT) Description

Model Name:	N141A, N14500		
Brand Name:	PACKARD BELL		
Hardware Version:	EM_A8316C_178B_V1.0		
Software Version:	windows 10 home		
Frequency Bands:	WLAN 2.4GHz: 2412 MHz ~ 2462 MHz WLAN 5GHz Band 1: 5180 MHz ~ 5240 MHz; WLAN 5GHz Band 2: 5260 MHz ~ 5320 MHz; WLAN 5GHz Band 3: 5470 MHz ~ 5725 MHz; WLAN 5GHz Band 4: 5725 MHz ~ 5850 MHz; Bluetooth: 2402 MHz ~ 2480 MHz		
Modulation Mode:	802.11b/g/n HT20/HT40 802.11a/n HT20/HT40 Bluetooth:4.2BR+EDR+LE		
Hotspot function:	Only2.4GHz Wi-Fi Support Hotspot		
Max Scaled SAR-1g(W/Kg)	Body-worn	0.436 W/kg	Limit(W/kg): 1.6W/kg
	Hotspot(only 2.4GHz)	0.139 W/kg	

Note: For a more detailed description, please refer to specification or user's manual supplied by the applicant and/or manufacturer.

1.3. Summary of Maximum SAR Value

Frequency Band	Maximum SAR(1-g: W/kg) Body-worn (Distance 0mm)	Maximum SAR(1-g: W/kg) Hot-spot (Distance 0mm)
WLAN 2.4GHz	0.139	0.139
WLAN 5GHz	0.436	N/A

Note:

1、Bluetooth is not required for SAR testing.

1.4. Photographs of the EUT

Please refer to the External Photos for the Photos of the EUT

1.5. Applied Reference Documents

Leading reference documents for testing:

No.	Identity	Document Title
1	**47 CFR§2.1093**	Radiofrequency Radiation Exposure Evaluation: Portable Devices
2	**IEEE 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
3	**KDB 447498 D01v06**	General RF Exposure Guidance
4	**KDB 616217 D04v01r02**	SAR for laptop and Tablets
5	**KDB 248227 D01v02r02**	SAR Measurement Guidance for IEEE 802.11 Transmitters
6	**KDB 865664 D01v01r04**	SAR Measurement 100 MHz to 6 GHz
6	**KDB 865664 D02v01r02**	SAR Reporting

2. Device Category and SAR Limits

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.

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. The 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.

Limits for Occupational/Controlled Exposure (W/kg)

Whole-Body	Partial-Body	Hands, Wrists, Feet and Ankles
0.4	8.0	20.0

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

Whole-Body	Partial-Body	Hands, Wrists, Feet and Ankles
0.08	1.6	4.0

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

3. Specific Absorption Rate (SAR)

3.1. Introduction

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 Middle than the limits for general population/uncontrolled.

3.2. SAR Definition

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:

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

SAR is expressed in units of Watts per kilogram (W/kg)
SAR measurement can be either related to the temperature elevation in tissue by,

$$\mathbf{SAR} = C\left(\frac{\delta T}{\delta t}\right)$$

Where C is the specific head capacity, δT is the temperature rise and δt the exposure duration, or related to the electrical field in the tissue by

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

Where σ is the conductivity of the tissue, ρ is the mass density of the tissue and $|E|$ is the rmselectrical field strength.

However for evaluating SAR of low power transmitter, electrical field measurement is typically applied.

4. SAR Measurement Setup

4.1. The Measurement System

Como SAR is a system that is able to determine the SAR distribution inside a phantom of human being according to different standards. The Como SAR system consists of the Following items:

- Main computer to control all the system
- 6 axis robot
- Data acquisition system
- Miniature E-field probe
- Phone holder
- Head simulating tissue

The Following figure shows the system.

The EUT under test operating at the maximum power level is placed in the phone holder, under the phantom, which is filled with head simulating liquid. The E-Field probe measures the electric field inside the phantom. The OpenSAR software computes the results to give a SAR value in a 1g or 10g mass.

4.2. Probe

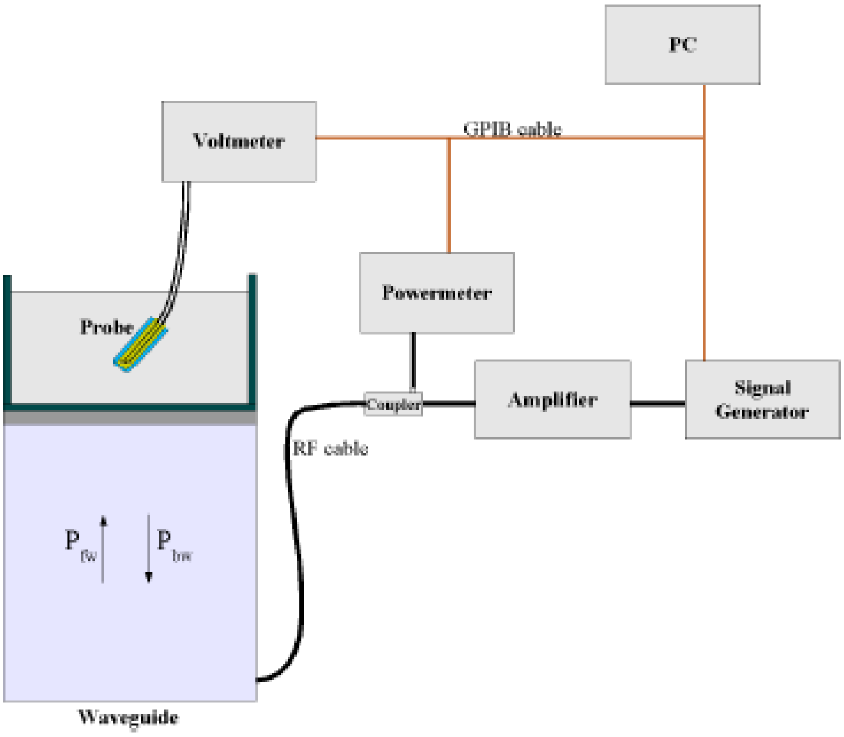
For the measurements the Specific Dosimetric E-Field Probe SN 37/08 EP80 with Following specifications is used

- Dynamic range: 0.01-100 W/kg

- Tip Diameter: 6.5 mm
- Distance between probe tip and sensor center: 2.5mm
- Distance between sensor center and the inner phantom surface: 4 mm (repeatability better than +/- 1mm)
- Probe linearity: <0.25 dB
- Axial Isotropy: <0.25 dB
- Spherical Isotropy: <0.25 dB
- Calibration range: 835to 2500MHz for head & body simulating liquid.

Angle between probe axis (evaluation axis) and surface normal line: less than 30°

Probe calibration is realized, in compliance with CENELEC EN 62209 and IEEE 1528 std, with CALISAR, Antennessa proprietary calibration system. The calibration is performed with the EN 622091 annex technique using reference guide at the five frequencies.



$$SAR = \frac{4\left(P_{fw} - P_{bw}\right)}{ab\delta}\cos^2\left(\pi\frac{y}{a}\right)e^{\left(2z/\delta\right)}$$

Where :

Pfw = Forward Power

Pbw = Backward Power

a and b = Waveguide dimensions

ı = Skin depth

Keithley configuration:

Rate = Medium; Filter =ON; RDGS=10; FILTER TYPE =MOVING AVERAGE; RANGE AUTO

After each calibration, a SAR measurement is performed on a validation dipole and compared with aNPL calibrated probe, to verify it.

The calibration factors, CF(N), for the 3 sensors corresponding to dipole 1, dipole 2 and dipole 3 are:

CF(N)=SAR(N)/Vlin(N) (N=1,2,3)

The linearised output voltage Vlin(N) is obtained from the displayed output voltage V(N) using

Vlin(N)=V(N)*(1+V(N)/DCP(N)) (N=1,2,3)

Where DCP is the diode compression point in mV.

4.3. Probe Calibration Process

Dosimetric Assessment Procedure

Each E-Probe/Probe Amplifier combination has unique calibration parameters. SATIMO Probe calibration procedure is conducted to determine the proper amplifier settings to enter in the probe parameters. The amplifier settings are determined for a given frequency by subjecting the probe to a known E-field density (1 mW/cm^2) using an with CALISAR, Antenna proprietary calibration system.

Free Space Assessment Procedure

The free space E-field from amplified probe outputs is determined in a test chamber. This calibration can be performed in a TEM cell if the frequency is below 1 GHz and in a waveguide or other methodologies above 1 GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity and at the proper orientation with the field. The probe is rotated 360 degrees until the three channels show the maximum reading. The power density readings equates to 1 mW/cm^2.

Temperature Assessment Procedure

E-field temperature correlation calibration is performed in a flat phantom filled with the appropriate simulating head tissue. The E-field in the medium correlates with the temperature rise in the dielectric medium. For temperature correlation calibration a RF transparent thermistor-based temperature probe is used in conjunction with the E-field probe.

Where:

δt = exposure time (30 seconds),

C = heat capacity of tissue (brainor muscle),

δT = temperature increase due to RF exposure.

SAR is proportional to ΔT/Δt, the initial rate of tissue heating, before thermal diffusion takes place. The electric field in the simulated tissue can be used to estimate SAR by equating the thermally derived SAR to that with the E- field component.

Where:

σ = simulated tissue conductivity,

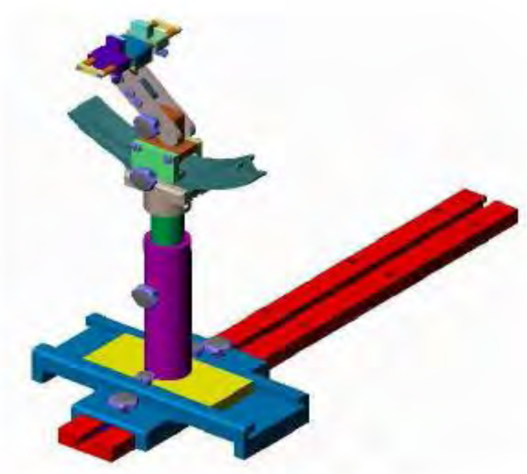
ρ = Tissue density (1.25 g/cm³ for brain tissue)

4.4. Phantom

For the measurements the Specific Anthropomorphic Mannequin (SAM) defined by the IEEE SCC-34/SC2 group is used. The phantom is a polyurethane shell integrated in a wooden table. The thickness of the phantom amounts to 2mm +/- 0.2mm. It enables the dosimetric evaluation of left and right phone usage and includes an additional flat phantom part for the simplified performance check. The phantom set-up includes a cover, which prevents the evaporation of the liquid.

4.5. Device Holder

The positioning system allows obtaining cheek and tilting position with a very good accuracy. In compliance with CENELEC, the tilt angle uncertainty is Middle than 1°.



Device holder

System Material	Permittivity	Loss Tangent
Delrin	3.7	0.005

5. Tissue Simulating Liquids

For SAR measurement of the field distribution inside the phantom, the phantom must be filled with Homogeneous tissue simulating liquid to a depth of at least 15cm. For head SAR testing, the liquid height from the ear reference point(ERP) of the phantom to the liquid top surface is larger than 15cm. For body SAR testing, the liquid height from the center of the flat phantom to the liquid top surface is larger than 15cm. The nominal dielectric values of the tissue simulating liquids in the phantom and the tolerance of 5% are listed in below table.

Liquid Level

The following table gives the recipes for tissue simulating liquids

Frequency Band (MHz)	2450	5200-5800	
Tissue Type	Body	Head	Body
Deionised Water	73.20	65.53	78.60
Salt(NaCl)	0.10	0.00	0.00
Sugar	0.00	0.00	0.00
Tween 20	0.00	0.00	0.00
HEC	0.00	0.00	0.00
Bactericide	0.00	0.00	0.00
Triton X-100	0.00	17.24	10.70
DGBE	26.70	0.00	0.00
Diethylenglycol monohexylether	0.00	17.24	10.70
Dielectric Constant	52.70	35.3	48.7
Conductivity (S/m)	1.95	5.07	5.53

Note: Please refer to the validation results for dielectric parameters of each frequency band.

The dielectric properties of the tissue simulating liquids were verified prior to the SAR evaluation using an Agilent 85033E Dielectric Probe Kit and an Agilent Network Analyzer.

Table 1: Dielectric Performance of Tissue Simulating Liquid

Temperature: 22.0~23.8°C, humidity: 54~60%.							
Date	**Freq. (MHz)**	**Liquid Parameters**	**Liquid Temp. (℃)**	**Meas.**	**Target**	**Delta(%)**	**Limit ±(%)**
2017.12.28	Body 2450	Relative Permittivity(ϵr):	21.8	52.88	52.70	0.34	5
		Conductivity(σ):	21.8	1.97	1.95	1.03	5
2017.12.28	Body 5200	Relative Permittivity(ϵr):	22.1	48.27	49.0	-1.49	5
		Conductivity(σ):	22.1	5.54	5.30	4.53	5
2017.12.28	Body 5600	Relative Permittivity(ϵr):	22.1	48.39	48.5	-0.23	5
		Conductivity(σ):	22.1	5.74	5.77	-0.52	5
2017.12.28	Body 5800	Relative Permittivity(ϵr):	22.1	48.09	48.2	-0.23	5
		Conductivity(σ):	22.1	5.93	6.00	-1.17	5

6. Uncertainty Assessment

The Following table includes the uncertainty table of the IEEE 1528. The values are determined by Antennessa.

6.1. Uncertainty Evaluation For EUT SAR Test

a	b	c	d	e= f(d,k)	f	g	h= c*f/e	i= c*g/e	k
Uncertainty Component	Sec.	Tol (+- %)	Prob. Dist.	Div.	Ci (1g)	Ci (10g)	1g Ui (+-%)	10g Ui (+-%)	Vi
Measurement System									
Probe calibration	E.2.1	5.83	N	1	1	1	5.83	5.83	∞
Axial Isotropy	E.2.2	3.5	R	$\sqrt{3}$	1	1	2.02	2.02	∞
Hemispherical Isotropy	E.2.2	5.9	R	$\sqrt{3}$	1	1	3.41	3.41	∞
Boundary effect	E.2.3	1.0	R	$\sqrt{3}$	1	1	0.58	0.58	∞
Linearity	E.2.4	4.7	R	$\sqrt{3}$	1	1	2.71	2.71	∞
System detection limits	E.2.5	1.0	R	$\sqrt{3}$	1	1	0.58	0.58	∞
Readout Electronics	E.2.6	0.5	N	1	1	1	0.5	0.5	∞
Reponse Time	E.2.7	3.0	R	$\sqrt{3}$	1	1	3.0	3.0	∞
Integration Time	E.2.8	1.4	R	$\sqrt{3}$	1	1	0.81	0.81	∞
RF ambient Conditions	E.6.1	3.0	R	$\sqrt{3}$	1	1	1.73	1.73	∞
Probe positioner Mechanical Tolerance	E.6.2	1.4	R	$\sqrt{3}$	1	1	0.81	0.81	∞
Probe positioning with respect to Phantom Shell	E.6.3	1.4	R	$\sqrt{3}$	1	1	0.81	0.81	∞
Extrapolation, interpolation and integration Algoritms for Max. SAR Evaluation	E.5.2	2.3	R	$\sqrt{3}$	1	1	1.33	1.33	∞
Test sample Related									
Test sample positioning	E.4.2.1	2.6	N	1	1	1	2.6	2.6	N-1
Device Holder Uncertainty	E.4.1.1	3.0	N	1	1	1	3.0	3.0	N-1
Output power Power drift - SAR drift measurement	6.6.2	5.0	R	$\sqrt{3}$	1	1	2.89	2.89	∞

Phantom and Tissue Parameters									
Phantom Uncertainty (Shape and thickness tolerances)	E.3.1	4.0	R	$\sqrt{3}$	1	1	2.31	2.31	∞
Liquid conductivity - deviation from target value	E.3.2	2.0	R	$\sqrt{3}$	0.64	0.43	1.69	1.13	∞
Liquid conductivity - measurement uncertainty	E.3.3	2.5	N	1	0.64	0.43	3.20	2.15	M
Liquid permittivity - deviation from target value	E.3.2	2.5	R	$\sqrt{3}$	0.6	0.49	1.28	1.04	∞
Liquid permittivity - measurement uncertainty	E.3.3	5.0	N	1	0.6	0.49	6.00	4.90	M
Liquid conductivity–temperature uncertainty	E.3.4		R	$\sqrt{3}$	0.78	0.41			∞
Liquidpermittivity–temperature uncertainty	E.3.4		R	$\sqrt{3}$	0.23	0.26			∞
Combined Standard Uncertainty			RSS				11.55	12.07	
Expanded Uncertainty (95% Confidence interval)			K=2				±23.20	±24.17	

6.2. Uncertainty For System Performance Check

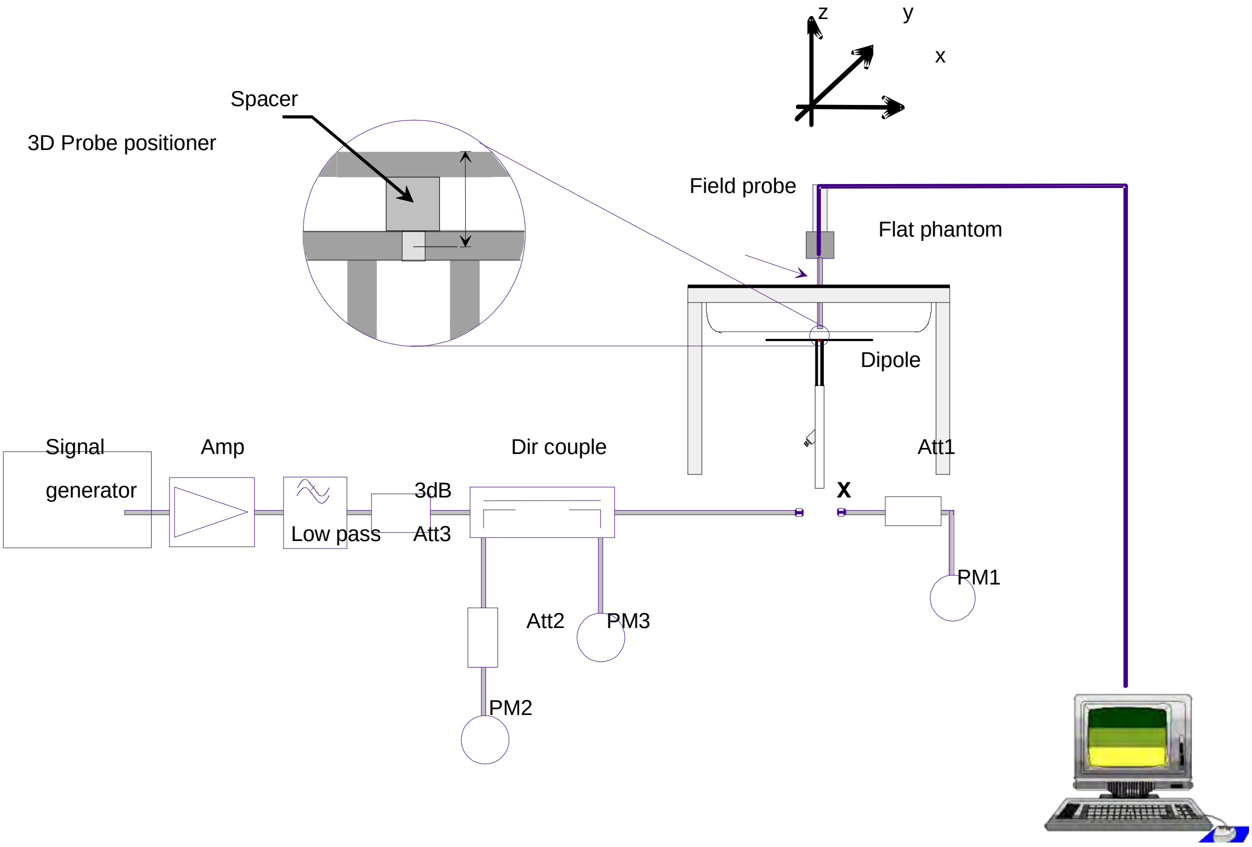
a	b	c	d	e= f(d,k)	f	g	h= c*f/e	i= c*g/e	k
Uncertainty Component	Sec.	Tol (+-%)	Prob. Dist.	Div.	Ci (1g)	Ci (10g)	1g Ui (+-%)	10g Ui (+-%)	Vi
Measurement System									
Probe calibration	E.2.1	4.76	N	1	1	1	4.76	4.7	∞
Axial Isotropy	E.2.2	2.5	R	$\sqrt{3}$	0.7	0.7	1.01	1.0	∞
Hemispherical Isotropy	E.2.2	4.0	R	$\sqrt{3}$	0.7	0.7	1.62	1.6	∞
Boundary effect	E.2.3	1.0	R	$\sqrt{3}$	1	1	0.58	0.5	∞
Linearity	E.2.4	5.0	R	$\sqrt{3}$	1	1	2.89	2.8	∞

System detection limits	E.2.5	1.0	R	$\sqrt{3}$	1	1	0.58	0.5	∞
Readout Electronics	E.2.6	0.02	N	1	1	1	0.02	0.0	∞
Reponse Time	E.2.7	3.0	R	$\sqrt{3}$	1	1	1.73	1.7	∞
Integration Time	E.2.8	2.0	R	$\sqrt{3}$	1	1	1.15	1.1	∞
RF ambient Conditions	E.6.1	3.0	R	$\sqrt{3}$	1	1	1.73	1.7	∞
Probe positioner Mechanical Tolerance	E.6.2	2.0	R	$\sqrt{3}$	1	1	1.15	1.15	∞
Probe positioning with respect to Phantom Shell	E.6.3	0.05	R	$\sqrt{3}$	1	1	0.03	0.03	∞
Extrapolation, interpolation and integration Algoritms for Max. SAR Evaluation	E.5.2	5.0	R	$\sqrt{3}$	1	1	2.89	2.89	∞
Dipole									
Dipole axis to liquid Distance	8,E.4.2	1.00	N	$\sqrt{3}$	1	1	0.58	0.58	∞
Input power and SAR drift measurement	8,6.6.2	4.04	R	$\sqrt{3}$	1	1	2.33	2.33	∞
Phantom and Tissue Parameters									
Phantom Uncertainty (Shape and thickness tolerances)	E.3.1	0.05	R	$\sqrt{3}$	1	1	0.03	0.03	∞
Liquid conductivity - deviation from target value	E.3.2	4.57	R	$\sqrt{3}$	0.64	0.43	1.69	1.13	∞
Liquid conductivity - measurement uncertainty	E.3.3	5.00	N	$\sqrt{3}$	0.64	0.43	1.85	1.24	M
Liquid permittivity - deviation from target value	E.3.2	3.69	R	$\sqrt{3}$	0.6	0.49	1.28	1.04	∞
Liquid permittivity - measurement uncertainty	E.3.3	10.00	N	$\sqrt{3}$	0.6	0.49	3.46	2.83	M
Combined Standard Uncertainty			RSS				8.83	8.37	
Expanded Uncertainty (95% Confidence interval)			K=2				17.66	16.73	

7. SAR Measurement Evaluation

7.1. System Setup

In the simplified setup for system evaluation, the DUT is replaced by a calibrated dipole and the power source is replaced by a continuous wave which comes from a signal generator. The calibrated dipole must be placed beneath the flat phantom section of the SAM twin phantom with the correct distance holder. The distance holder should touch the phantom surface with a light pressure at the reference marking and be oriented parallel to the long side of the phantom. The system check verifies that the system operates within its specifications. It is performed daily or before every SAR measurement. The system check uses normal SAR measurements in the flat section of the phantom with a matched dipole at a specified distance. The system verification setup is shown as below



The validation dipole is placed beneath the flat phantom with the specific spacer in place. The distance spacer is touch the phantom surface with a light pressure at the reference marking and be oriented parallel to the long side of the phantom. The power meter PM1 measures the forward power at the location of the system check dipole connector. The signal generator is adjusted for the desired forward power (250mW is used for 700MHz to 3GHz, 100mW is used for 3.5GHz to 6 GHz) at the dipole connector and the power meter PM2 is read at that level. After connecting the cable to the dipole, the signal generator is readjusted for the same reading at power meter.

7.2. Validation Results

After system check testing, the SAR result will be normalized to 1W forward input power and compared with the reference SAR value derived from validation dipole certificate report. The deviation of system check should be within 10 %.

Frequency	2450MHz	5200MHz	5600MHz	5800MHz
Target value 1W (1g)	50.93 W/Kg	163.36 W/Kg	172.11 W/Kg	177.10 W/Kg
Test value 1g (100 mW input power)	5.081 W/Kg	16.284 W/Kg	17.196 W/Kg	17.695 W/Kg
Normalized to 1W value(1g)	50.81 W/Kg	162.84W/Kg	171.96 W/Kg	176.95 W/Kg
Deviation (%)	-0.24	-0.32	-0.09	-0.08
Target value 1W (10g)	23.3 W/Kg	57.09 W/Kg	58.61 W/Kg	59.95 W/Kg
Test value 10g (100 mW input power)	2.377 W/Kg	5.694 W/Kg	5.847 W/Kg	5.982 W/Kg
Normalized to 1W value(10g)	23.77 W/Kg	56.94 W/Kg	58.47 W/Kg	59.82 W/Kg
Deviation (%)	2.02	-0.26	-0.24	0.22

Note: System checks the specific test data please see Annex C

8. Operational Conditions During Test

8.1. Body-worn Configurations

Body-worn Configurations

The body-worn configurations shall be tested with the supplied accessories (belt-clips, holsters, etc.) attached to the device in normal use configuration.

For body-worn and other configurations a flat phantom shall be used which is comprised of material with electrical properties similar to the corresponding tissues.

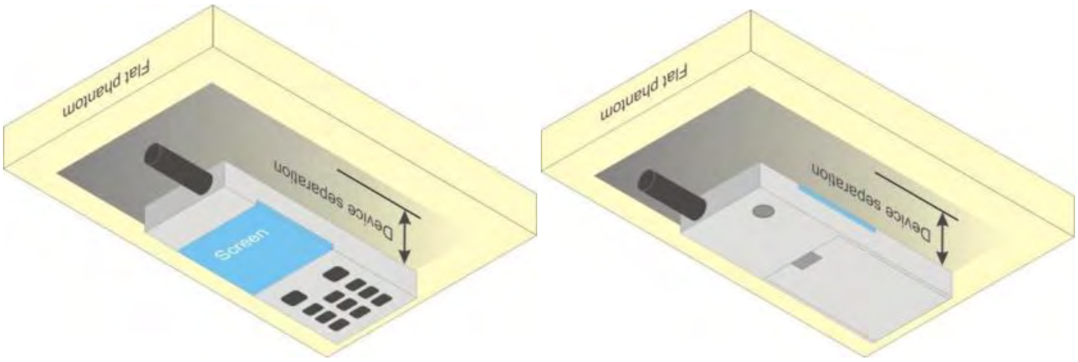


Illustration for Body-Worn Position

8.2. Measurement procedure

The Following steps are used for each test position

1. Establish a call with the maximum output power with a base station simulator. The connection between the mobile and the base station simulator is established via air interface.
2. Measurement of the local E-field value at a fixed location. This value serves as a reference value for calculating a possible power drift.
3. Measurement of the SAR distribution with a grid of 8 to 16mm * 8 to16 mm and a constant distance to the inner surface of the phantom. Since the sensors cannot directly measure at the inner phantom surface, the values between the sensors and the inner phantom surface are extrapolated. With these values the area of the maximum SAR is calculated by an interpolation scheme.
4. Around this point, a cube of 30 * 30 * 30 mm or 32 * 32 * 32 mm is assessed by measuring 5 or 8 * 5 or 8*4 or 5 mm. With these data, the peak spatial-average SAR value can be calculated.

8.3. Description of interpolation/extrapolation scheme

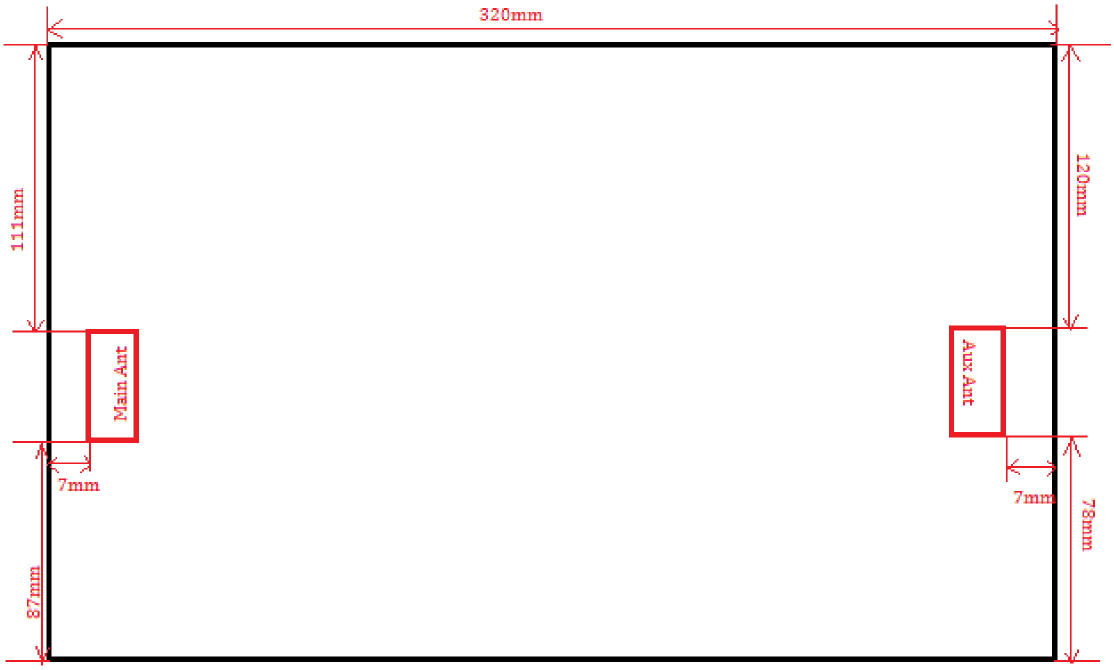
The local SAR inside the phantom is measured using small dipole sensing elements inside a probe body. The probe tip must not be in contact with the phantom surface in order to minimize measurements errors, but the highest local SAR will occur at the surface of the phantom.

An extrapolation is using to determinate this highest local SAR values. The extrapolation is based on a fourth-order least-square polynomial fit of measured data. The local SAR value is then extrapolated from the liquid surface with a 1mm step.

The measurements have to be performed over a limited time (due to the duration of the battery) so the step of measurement is high. It could vary between 5 and 8 mm. To obtain an accurate assessment of the maximum SAR averaged over 10 grams and 1 gram requires a very fine resolution in the three dimensional scanned data array.

9. Antenna location and test evaluation

Antenna position



Note : Aux antenna supports RX only, so it is not required for SAR testing.

SAR exclusion

Test distance:0mm				
Exposure Position	Wireless Interface	Bluetooth	WLAN 2.4GHz	WLAN 5GHz
	Calculated Frequency	2402MHz	2462MHz	5300MHz
	Maximum power (dBm)	3.5	15	12.5
	Maximum rated power(mW)	2.2	31.6	17.8
Bottom Face	Separation distance(mm)	5.0	5.0	5.0
	exclusion threshold	1.3	10.0	4.8
	Testing required?	No	**Yes**	**Yes**
Left Side	Separation distance(mm)	5.0	5.0	5.0
	exclusion threshold	1.3	10.0	4.8
	Testing required?	No	**Yes**	**Yes**
Right Side	Separation distance(mm)	64.0	64.0	64.0
	exclusion threshold	235.0	236.0	202.0
	Testing required?	No	No	No
Bottom Side	Separation distance(mm)	150.0	150.0	150.0
	exclusion threshold	1095.0	1096.0	1062.0
	Testing required?	No	No	No
Left Side	Separation distance(mm)	140.0	140.0	140.0
	exclusion threshold	995.0	996.0	962.0
	Testing required?	No	No	No

Note:

1、For tablets with a display and overall diagonal dimension 39.0cm >20cm, the SAR procedure in KDB 447498 should be used. The tablet procedures required by KDB 447498 generally do not require separate hotspot mode testing.

2、According to KDB 447498 D01, the bottom face (back of the device) is required to be tested touching the flat phantom and the Front Face is not required according to KDB 616217 section 4.3.

3、According to KDB 616217 Section 4.3 and KDB 447498 SAR Test Exclusion Threshold ,the Left Side and Right Side are not required, For 100 MHz to 6 GHz and test separation distances > 50 mm, the 1-g and 10-g SAR test exclusion thresholds are determined by the following:

[Power allowed at numeric threshold for 50 mm in step a)] + [(test separation distance – 50 mm)·10] mW, for > 1500 MHz and ≤ 6 GHz

10. Measurement of Conducted output power

1. 2.4GHz Wi-Fi Average output power

	Mode	Channel	Frequency (MHz)	Average power (dBm)	Tune-Up Limit
WLAN 2.4GHz	802.11b 1Mbps	CH 1	2412	14.41	15.00
		CH 6	2437	14.41	15.00
		CH 11	2462	14.99	15.50
	802.11g 6Mbps	CH 1	2412	11.96	12.50
		CH 6	2437	14.20	14.50
		CH 11	2462	14.08	14.50
	802.11n-HT20 MCS0	CH 1	2412	11.33	11.50
		CH 6	2437	14.08	14.50
		CH 11	2462	11.40	11.50
	802.11n-HT40 MCS0	CH 3	2422	10.71	11.00
		CH 6	2437	14.20	14.50
		CH 9	2452	10.41	11.50

2. 5GHz Wi-Fi Average output power

	Mode	Channel	Frequency (MHz)	Average power (dBm)	Tune-Up Limit
WLAN 5.2GHz	802.11a 6Mbps	CH 36	5180	9.24	9.50
		CH 40	5200	10.55	11.00
		CH 48	5240	9.98	10.50
	802.11n-HT20 MCS0	CH 36	5180	8.65	9.00
		CH 44	5220	10.22	10.50
		CH 48	5240	9.65	10.00
	802.11n-HT40 MCS0	CH 38	5190	5.82	6.00
		CH 46	5230	10.55	11.00

	Mode	Channel	Frequency (MHz)	Average power (dBm)	Tune-Up Limit
WLAN 5.3GHz	802.11a 6Mbps	CH 52	5260	11.68	12.00
		CH 60	5300	12.00	12.50
		CH 64	5320	9.31	10.00
	802.11n-HT20 MCS0	CH 52	5260	10.99	11.50
		CH 60	5300	11.41	11.50
		CH 64	5320	8.78	9.00
	802.11n-HT40 MCS0	CH 54	5270	10.99	11.50
		CH 62	5310	8.09	8.50

	Mode	Channel	Frequency (MHz)	Average power (dBm)	Tune-Up Limit
WLAN 5.5GHz	802.11a 6Mbps	CH 100	5500	9.79	10.00
		CH 120	5600	11.33	12.00
		CH 140	5700	7.53	8.00
	802.11n-HT20 MCS0	CH 100	5500	9.27	9.50
		CH 120	5600	10.96	11.50
		CH 140	5700	7.09	7.50
	802.11n-HT40 MCS0	CH 102	5510	8.47	9.00
		CH 126	5630	10.29	11.00
		CH 134	5670	9.72	10.00

	Mode	Channel	Frequency (MHz)	Average power (dBm)	Tune-Up Limit
5.8GHz WLAN ANT 1	802.11a MCS0	CH 149	5745	9.98	10.50
		CH 157	5785	9.63	10.00
		CH 165	5825	9.58	10.00
	802.11n-HT20 MCS0	CH 149	5745	9.62	10.00
		CH 157	5785	9.16	10.00
		CH 165	5825	9.47	10.00
	802.11n-HT40 MCS0	CH 151	5755	9.64	10.00
		CH 159	5795	9.05	9.50

3. BT average output power

Band	Channel	Frequency (MHz)	Output Power(dBm)		
			GFSK	π/4-DQPSK	8-DPSK
BT 2.1+EDR	0	2402	**3.24**	-0.38	-1.30
	39	2441	3.12	-0.54	-1.30
	78	2480	2.03	-0.78	-2.33

Band	Channel	Frequency (MHz)	Output Power(dBm)
			GFSK
BT4.0	0	2402	**1.77**
	19	2441	1.45
	39	2480	0.68

11. Test Results List

Summary of Measurement Results (WLAN 2.4GHz & 5GHz Band)

Temperature: 21.0~23.8°C, humidity: 54~60%.

Power Drift limit:-5%~+5% SAR Limit: 1.6W/Kg averaged over 1gram, Spatial Peak

Band	Mode	Test Position	Gap (mm)	Ch.	Tune-up Scaling Factor	Duty Cycle %	Duty Cycle Scaling Factor	Measured 1g SAR (W/kg)	Reported 1g SAR (W/kg)
WLAN2.4GHz	802.11b	Back Side	0mm	11	1.002	99	1.010	0.137	**0.139**
WLAN2.4GHz	802.11b	Left Side	0mm	11	1.002	99	1.010	0.030	0.030
WLAN5GHz	802.11a	Back Side	0mm	60	1.122	99	1.010	0.306	0.347
WLAN5GHz	802.11a	Left Side	0mm	60	1.122	99	1.010	0.343	0.389
WLAN5GHz	802.11a	Back Side	0mm	120	1.167	99	1.010	0.286	0.337
WLAN5GHz	802.11a	Left Side	0mm	120	1.167	99	1.010	0.370	**0.436**
WLAN5GHz	802.11a	Back Side	0mm	149	1.127	99	1.010	0.339	0.386
WLAN5GHz	802.11a	Left Side	0mm	149	1.127	99	1.010	0.221	0.252

Notes:

1. Per KDB 248227 D01v02r02, SAR test reduction is determined according to 802.11 transmission mode configurations and certain exposure conditions with multiple test positions. In the 2.4 GHz band, separate SAR procedures are applied to DSSS and OFDM configurations to simplify DSSS test requirements. For OFDM, in both 2.4 and 5 GHz bands, an initial test configuration must be determined for each standalone and aggregated frequency band, according to the transmission mode configuration with the highest maximum output power specified for production units to perform SAR measurements. If the same highest maximum output power applies to different combinations of channel bandwidths, modulations and data rates, additional procedures are applied to determine which test configurations require SAR measurement. When applicable, an initial test position may be applied to reduce the number of SAR measurements required for next to the ear, UMPC mini-tablet or hotspot mode configurations with multiple test positions.
2. For 2.4 GHz 802.11b DSSS, either the initial test position procedure for multiple exposure test positions or the DSSS procedure for fixed exposure position is applied; these are mutually exclusive. For 2.4 GHz and 5 GHz OFDM configurations, the initial test configuration is applied to measure SAR using either the initial test position procedure for multiple exposure test position configurations or the initial test configuration procedures for fixed exposure test

conditions. Based on the reported SAR of the measured configurations and maximum output power of the transmission mode configurations that are not included in the initial test configuration, the subsequent test configuration and initial test position procedures are applied to determine if SAR measurements are required for the remaining OFDM transmission configurations. In general, the number of test channels that require SAR measurement is minimized based on maximum output power measured for the test sample(s).

3. For OFDM transmission configurations in the 2.4 GHz and 5 GHz bands, When the same maximum power is specified for multiple transmission modes in a frequency band, the largest channel bandwidth, lowest order modulation, lowest data rate and lowest order 802.11a/g/n/ac mode is used for SAR measurement, on the highest measured output power channel for each frequency band.
4. DSSS and OFDM configurations are considered separately according to the required SAR procedures. SAR is measured in the initial test position using the 802.11 transmission mode configuration required by the DSSS procedure or initial test configuration and subsequent test configuration(s) according to the OFDM procedures.18 The initial test position procedure is described in the following:
   a. When the reported SAR of the initial test position is ≤ 0.4 W/kg, further SAR measurement is not required for the other test positions in that exposure configuration and 802.11 transmission mode combinations within the frequency band or aggregated band.
   b. When the reported SAR of the test position is > 0.4 W/kg, SAR is repeated for the 802.11 transmission mode configuration tested in the initial test position to measure the subsequent next closet/smallest test separation distance and maximum coupling test position on the highest maximum output power channel, until the report SAR is ≤ 0.8 W/kg or all required test position are tested.
   c. For all positions/configurations, when the reported SAR is > 0.8 W/kg, SAR is measured for these test positions/configurations on the subsequent next highest measured output power channel(s) until the reported SAR is ≤ 1.2 W/kg or all required channels are tested.
5. Per KDB 248227 D01v02r02, U-NII-1 SAR testing is not required when the U-NII-2A band highest reported SAR for a testconfiguration is ≤ 1.2 W/kg, SAR is not required for U-NII-1 band.

Scaling Factor calculation

Band	Tune-up power tolerance(dBm)	SAR test channel Power (dBm)	Scaling Factor
WLAN2.4GHz (802.11b)	Max output power =14.5+-0.5	14.99	1.002
WLAN5.3GHz (802.11a)	Max output power =12+-0.5	12.00	1.122
WLAN5.6GHz (802.11a)	Max output power =11.5+-0.5	11.33	1.167
WLAN5.8GHz (802.11nHT-40)	Max output power =10+-0.5	9.98	1.127

12. Repeated SAR Measurement

In accordance with published RF Exposure KDB procedure 865664 D01 SAR measurement 100 MHz to 6 GHz. These additional measurements are repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device should be returned to ambient conditions (normal room temperature) with the battery fully charged before it is re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results.

1) Repeated measurement is not required when the original highest measured SAR is < 0.80 W/kg; steps 2) through 4) do not apply.
2) When the original highest measured SAR is ≥ 0.80 W/kg, repeat that measurement once.
3) Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is ≥ 1.45 W/kg (~ 10% from the 1-g SAR limit).
4) Perform a third repeated measurement only if the original, first or second repeated measurement is ≥1.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.

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Http://www.morlab.cn E-mail: service@morlab.cn

13. Multiple Transmitters Evaluation

Stand-alone SAR

Test distance: 10mm			
Band	**Highest power(mW) per tune up**	**1-g SAR test threshold**	**Test required?**
Wi-Fi (2.4G)	31.62	[(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] • [√f(GHz)] ≤ 3.0 for 1-g SAR	Yes
Wi-Fi (5.2G&5.3GHz)	17.78		Yes
Wi-Fi (5.6G)	15.85		Yes
Wi-Fi (5.8G)	11.22		Yes
Bluetooth	2.24		No

The SAR test for BT is not required.

The BT stand-alone SAR is not required, the standalone SAR must be estimated according to following to determine simultaneous transmission SAR test exclusion:
(*max. power of channel, including tune-up tolerance, mW*)/(*min. test separation distance, mm*)]·[√f(GHz)/*x*] W/kg for *test separation distances* ≤ 50 mm;
where x = 7.5 for 1-g SAR, and x = 18.75 for 10-g SAR.
(Max power=2.24 mW; *min. test separation distance*= 10mm for Body; f=2.4GHz)
BT estimated Body SAR =0.042 W/Kg (1g)

END OF REPORT

Annex A General Information

1. Identification of the Responsible Testing Laboratory

Company Name:	Shenzhen Morlab Communications Technology Co., Ltd.
Department:	Morlab Laboratory
Address:	FL.3, Building A, FeiYang Science Park, No.8 LongChang Road, Block 67, BaoAn District, ShenZhen, GuangDong Province, P. R. China
ResponsibleTest Lab Manager:	Mr. Su Feng
Telephone:	+86 755 36698555
Facsimile:	+86 755 36698525

2. Identification of the Responsible Testing Location

Name:	Shenzhen Morlab Communications Technology Co., Ltd. Morlab Laboratory
Address:	FL.3, Building A, FeiYang Science Park, No.8 LongChang Road, Block 67, BaoAn District, ShenZhen, GuangDong Province, P. R. China

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3. List of Test Equipments

No.	Instrument	Type	Cal. Date	Cal. Due
1	PC	Dell (Pentium IV 2.4GHz, SN:X10-23533)	(n.a)	(n.a)
2	Network Emulator	Aglient (8960, SN:10752)	2017-5-24	1year
3	Network Emulator	Rohde&Schwarz (CMW500,SN:124534)	2017-5-25	1year
4	Network Analyzer	Agilent(E5071B ,SN:MY42404762)	2017-5-25	1year
5	Voltmeter	Keithley (2000, SN:1000572)	2017-7-8	1year
6	Synthetizer	Rohde&Schwarz (SML_03, SN:101868)	2017-8-24	1year
7	Signal Generator	Rohde&Schwarz (SMP_02)	2017-7-8	1year
8	Power Amplifier	PRANA (Ap32 SV125AZ)	2017-7-8	1year
9	Power Meter	Agilent (E4416A, SN:MY45102093)	2017-7-8	1year
10	Power Sensor	Agilent (N8482A, SN:MY41091706)	2017-7-8	1year
11	Power Meter	Rohde&Schwarz (NRVD, SN:101066)	2017-7-8	1year
12	Power Sensor	MA2411B	2017-7-8	1year
13	Directional coupler	Giga-tronics(SN:1829112)	2017-7-24	1year
14	Probe	Satimo (SN:SN 37/08 EP80)	2017-7-5	1year
15	Probe	Satimo (SN:SN 37/13 EPG193)	2017-7-5	1year
16	Dielectric Probe Kit	Agilent (85033E)	2017-7-5	1year
17	Phantom	Satimo (SN:SN_36_08_SAM62)	N/A	N/A
18	Liquid	Satimo(Last Calibration: 2017-11-15 to 2017-12-01)	N/A	N/A
19	Dipole 750MHz	Satimo (SN30/13 DIP0G750)	2017-7-5	1year
20	Dipole 835MHz	Satimo (SN 20/08 DIPC99)	2017-7-5	1year
21	Dipole 1800MHz	Satimo (SN 36/08 DIPF101)	2017-7-5	1year
22	Dipole 2000MHz	Satimo (SN 20/08 DIPI102)	2017-7-5	1year
23	Dipole 2450MHz	Satimo (SN 30/13 DIP2G450-263)	2017-7-5	1year
24	Dipole 2600MHz	Satimo (SN 30/13 DIP2G600-265)	2017-7-5	1year
25	Dipole 5-6GHz	Satimo (SN 41/12 WGA21)	2017-7-5	1year
26	Thermo meter	KTJ(mode-01)	2017-5-10	1year

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Annex C Plots of System Performance Check

System Performance Check Data(2450MHz Body)

Type: Phone measurement (Complete)

Area scan resolution: dx=8mm,dy=8mm

Zoom scan resolution: dx=8mm, dy=8mm, dz=5mm

Date of measurement: 2017.12.28

Measurement duration: 13 minutes 31 seconds

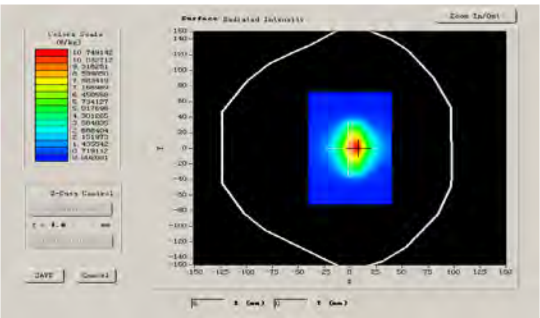
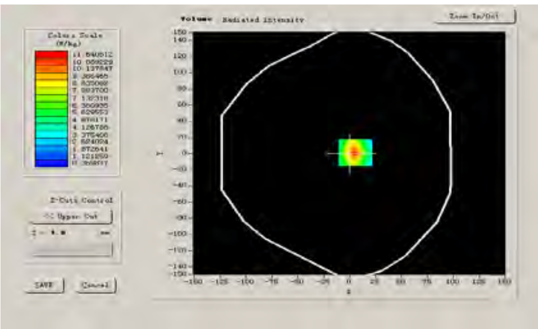
A. Experimental conditions.

Phantom File	surf_sam_plan.txt
Phantom	Flat
Device Position	
Band	2450MHz
Channels	
Signal	CW

B. SAR Measurement Results

Band SAR

Frequency (MHz)	2450.000000
Relative permittivity (real part)	52.884446
Conductivity (S/m)	1.966143
Power Drift (%)	1.080000
Ambient Temperature:	22.0°C
Liquid Temperature:	21.8°C
ConvF:	4.93
Crest factor:	1:1

SURFACE SAR	VOLUME SAR
	

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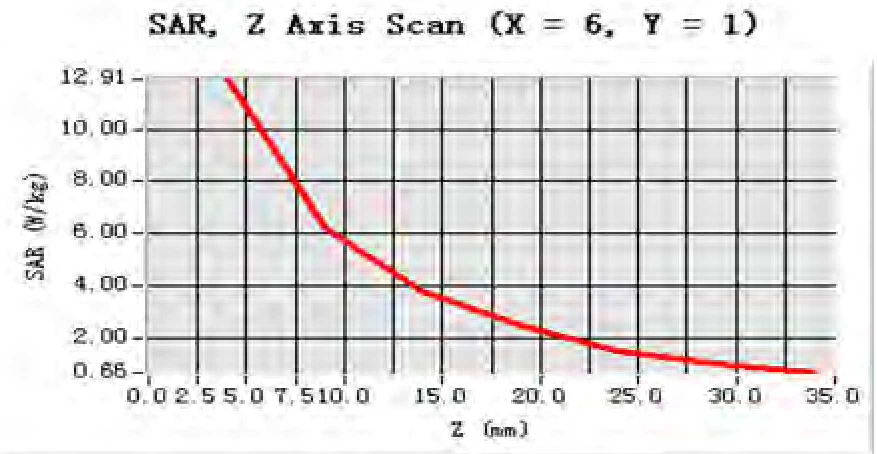
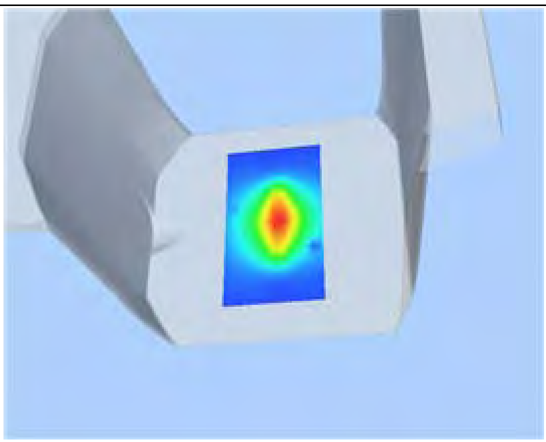
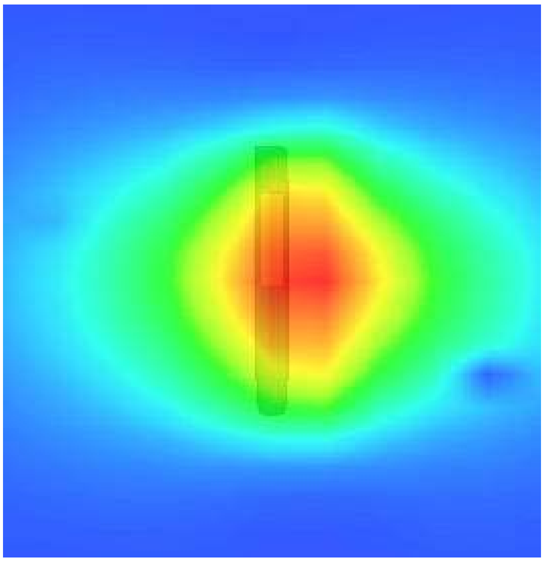
Maximum location: X=6.00, Y=1.00

SAR 10g (W/Kg)	2.377250
SAR 1g (W/Kg)	5.081074

Z Axis Scan

Z (mm)	**0.00**	**4.00**	**9.00**	**14.00**	**19.00**	**24.00**	**29.00**
SAR (W/Kg)	**0.0000**	**12.9615**	**6.2096**	**3.8187**	**2.4504**	**1.5036**	**1.0219**



3D sceen shot	**Hot spot position**
	

System Performance Check Data(5200MHz Body)

Type: Phone measurement (Complete)

Area scan resolution: dx=8mm,dy=8mm

Zoom scan resolution: dx=4mm, dy=4mm, dz=2mm

Date of measurement: 2017.12.28

Measurement duration: 13 minutes 27 seconds

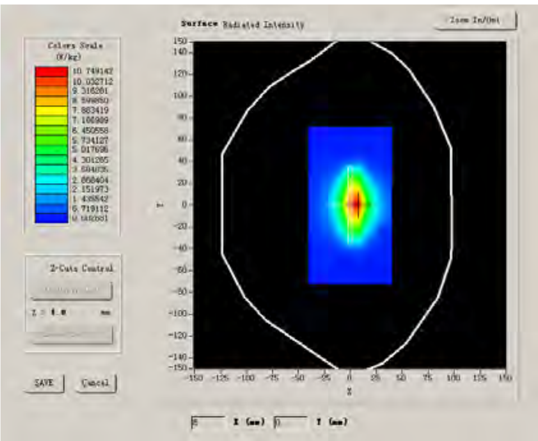
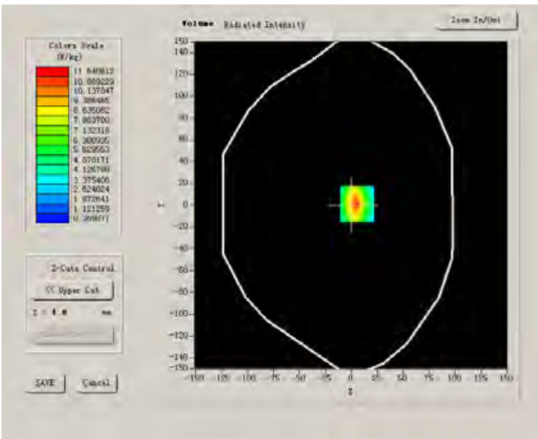
A. Experimental conditions.

Phantom File	surf_sam_plan.txt
Phantom	Validation plane
Device Position	
Band	5200MHz
Channels	
Signal	CW

B. SAR Measurement Results

Band SAR

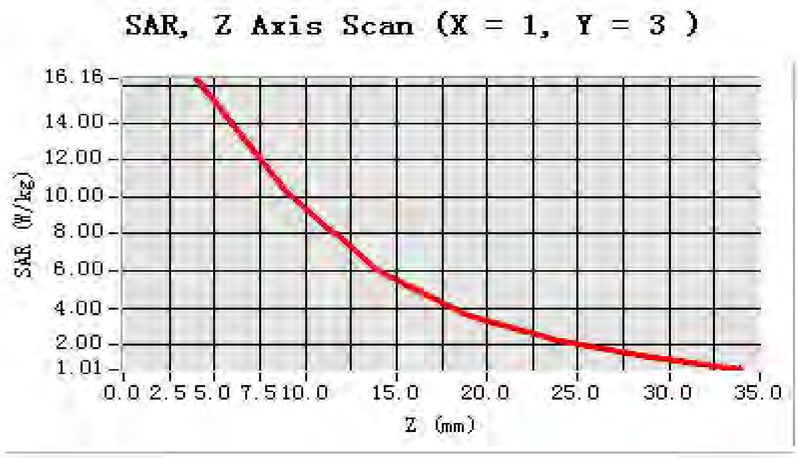
Frequency (MHz)	5200.000000
Relative permittivity (real part)	48.273014
Conductivity (S/m)	5.543260
Power Drift (%)	2.310000
Ambient Temperature:	22.9°C
Liquid Temperature:	22.1°C
ConvF:	22.11
Crest factor:	1:1

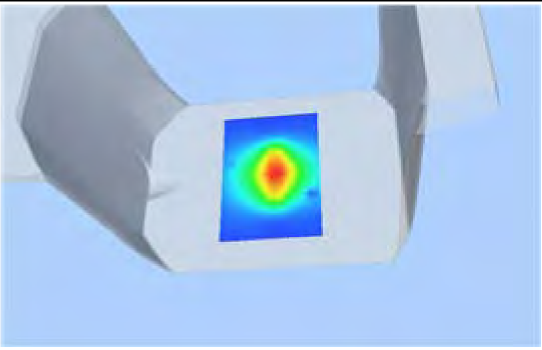
SURFACE SAR	**VOLUME SAR**
	

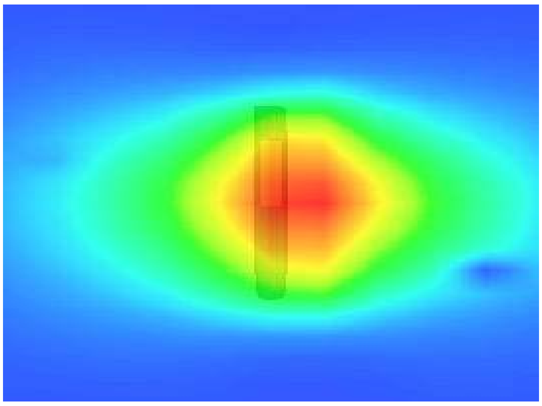
Maximum location: X=1.00, Y=3.00

SAR 10g (W/Kg)	5.694355
SAR 1g (W/Kg)	16.28442

Z Axis Scan







System Performance Check Data(5600MHz Body)

Type: Phone measurement (Complete)

Area scan resolution: dx=8mm,dy=8mm

Zoom scan resolution: dx=4mm, dy=4mm, dz=2mm

Date of measurement: 2017.12.28

Measurement duration: 13 minutes 27 seconds

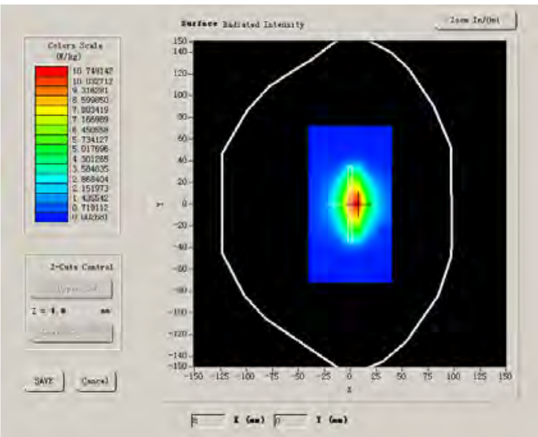
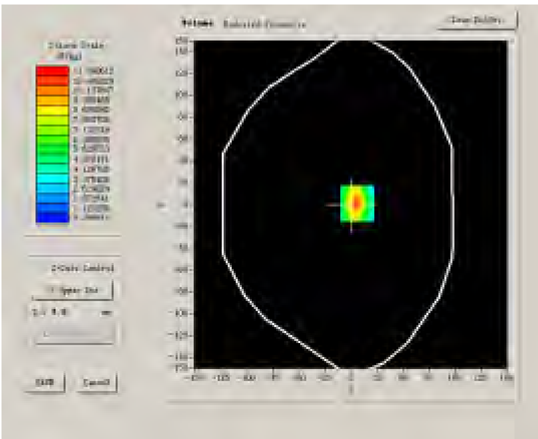
A. Experimental conditions.

Phantom File	surf_sam_plan.txt
Phantom	Validation plane
Device Position	
Band	5600MHz
Channels	
Signal	CW

B. SAR Measurement Results

Band SAR

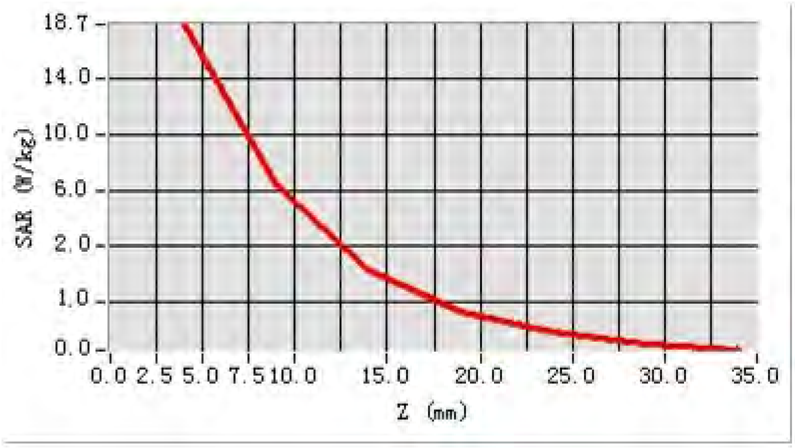
Frequency (MHz)	5600.000000
Relative permittivity (real part)	48.194381
Conductivity (S/m)	5.7432600
Power Drift (%)	1.080000
Ambient Temperature:	22.9°C
Liquid Temperature:	22.1°C
ConvF:	23.69
Crest factor:	1:1

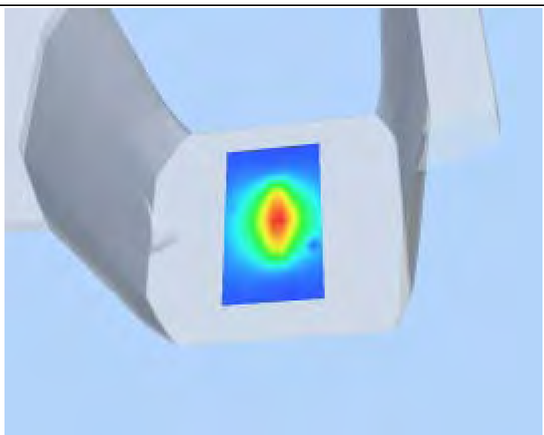
SURFACE SAR	VOLUME SAR
	

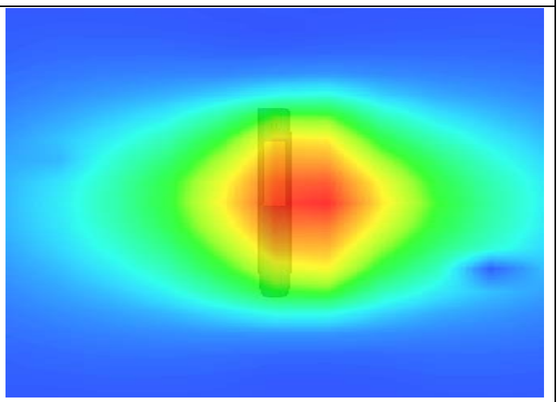
Maximum location: X=-1.00, Y=-5.00

SAR 10g (W/Kg)	5.8466961
SAR 1g (W/Kg)	17.19624

Z Axis Scan







System Performance Check Data(5800MHz Body)

Type: Phone measurement (Complete)

Area scan resolution: dx=8mm,dy=8mm

Zoom scan resolution: dx=4mm, dy=4mm, dz=2mm

Date of measurement: 2017.12.28

Measurement duration: 13 minutes 27 seconds

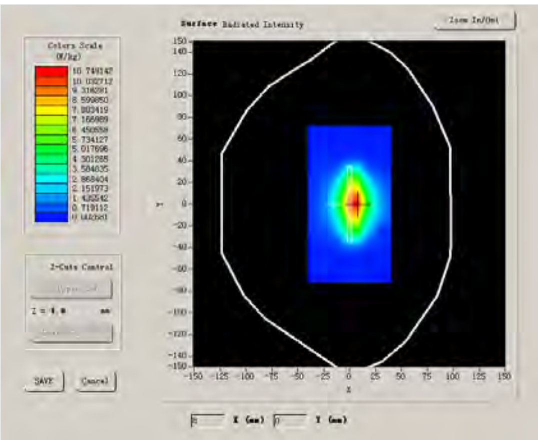
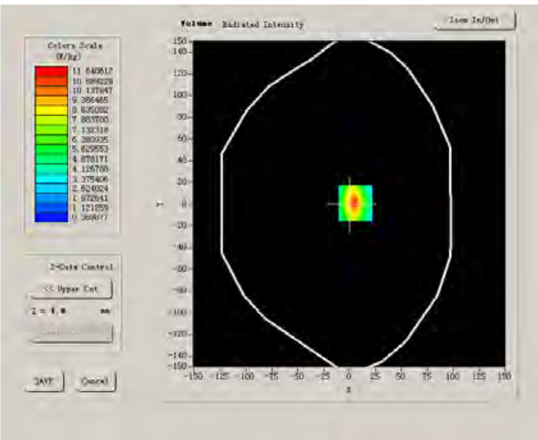
A. Experimental conditions.

Phantom File	surf_sam_plan.txt
Phantom	Validation plane
Device Position	
Band	5800MHz
Channels	
Signal	CW

B. SAR Measurement Results

Band SAR

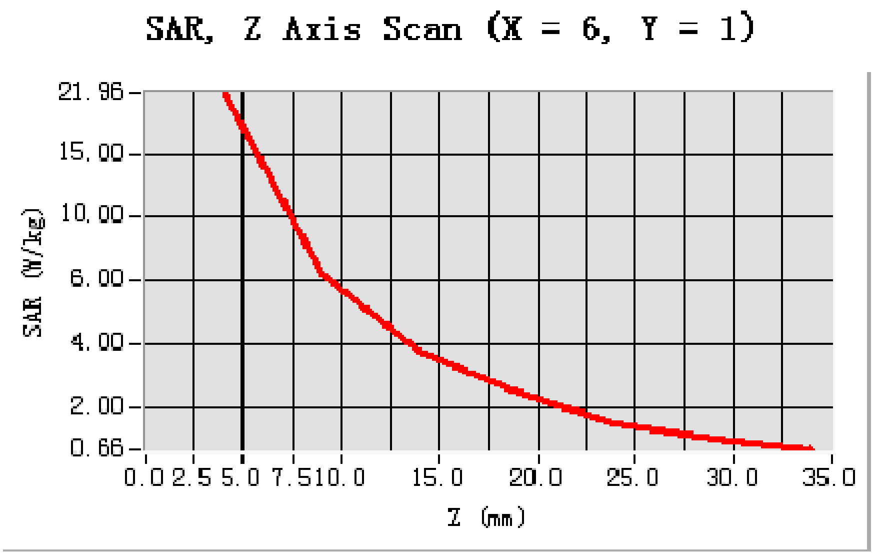
Frequency (MHz)	5800.000000
Relative permittivity (real part)	48.093428
Conductivity (S/m)	5.930716
Power Drift (%)	1.260000
Ambient Temperature:	22.9°C
Liquid Temperature:	22.1°C
ConvF:	23.02
Crest factor:	1:1

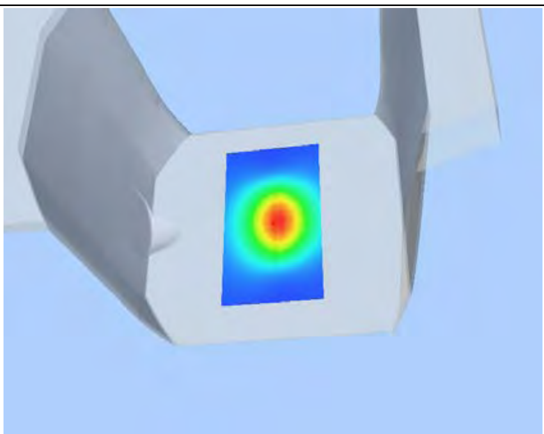
SURFACE SAR	**VOLUME SAR**
	

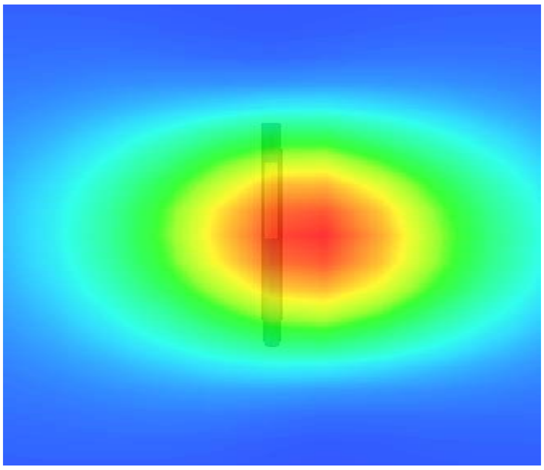
Maximum location: X=-6.00, Y=-1.00

SAR 10g (W/Kg)	5.9824634
SAR 1g (W/Kg)	17.695290

Z Axis Scan







Annex D Plots of Maximum SAR Test Results

MEASUREMENT 1

Type: Phone measurement (Complete)

Area scan resolution: dx=10mm,dy=10mm

Zoom scan resolution: dx=4mm, dy=4mm, dz=2mm

Date of measurement: 2017.12.28

Measurement duration: 18 minutes 46 seconds

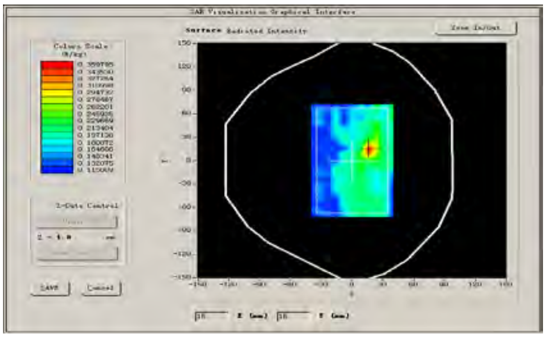
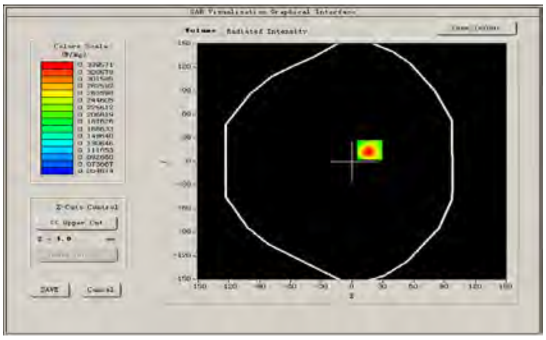
A. Experimental conditions.

Phantom File	surf_sam_plan.txt
Phantom	Validation plane
Device Position	Body
Band	IEEE 802.11a U-NII
Channels	Middle
Signal	OFDM

B. SAR Measurement Results

Middle Band SAR (Channel 60):

Frequency (MHz)	5300.000000
Relative permittivity (real part)	48.105215
Conductivity (S/m)	5.556260
Power drift (%)	-3.450000
Ambient Temperature:	22.9°C
Liquid Temperature:	22.1°C
ConvF:	22.11
Crest factor:	1:1

SURFACE SAR	VOLUME SAR
	

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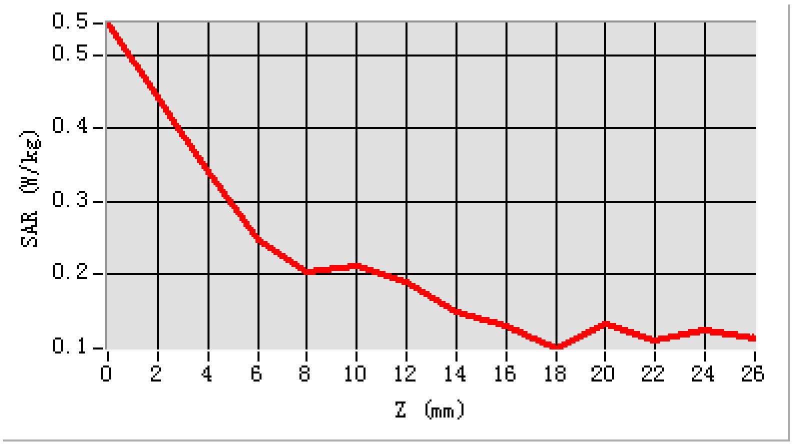
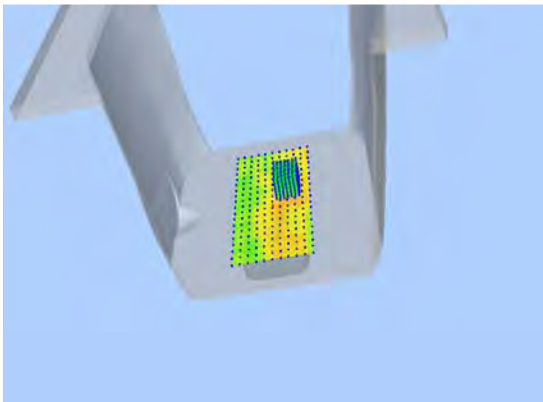
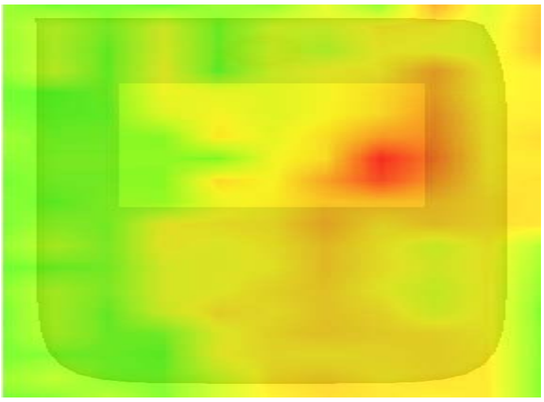
Maximum location: X=17.00, Y=15.00

SAR Peak: 0.67 W/kg

SAR 10g (W/Kg)	0.213654
SAR 1g (W/Kg)	0.343374

Z (mm)	0.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00
SAR (W/Kg)	0.5431	0.3396	0.2472	0.2027	0.2125	0.1905	0.1495	0.1287	0.0999	0.1318	0.1100	0.1232



3D screen shot	Hot spot position
	

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MEASUREMENT 2

Type: Phone measurement (Complete)

Area scan resolution: dx=10mm,dy=10mm

Zoom scan resolution: dx=4mm, dy=4mm, dz=2mm

Date of measurement: 2017.12.28

Measurement duration: 18 minutes 46 seconds

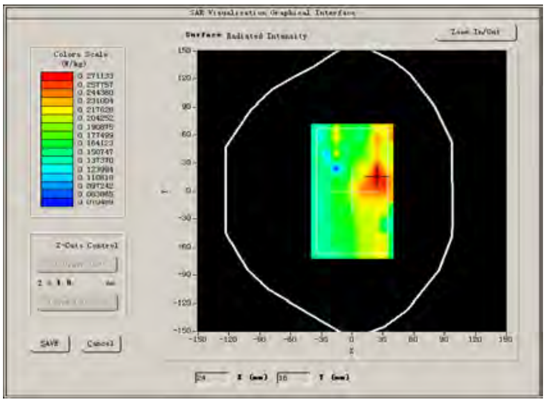
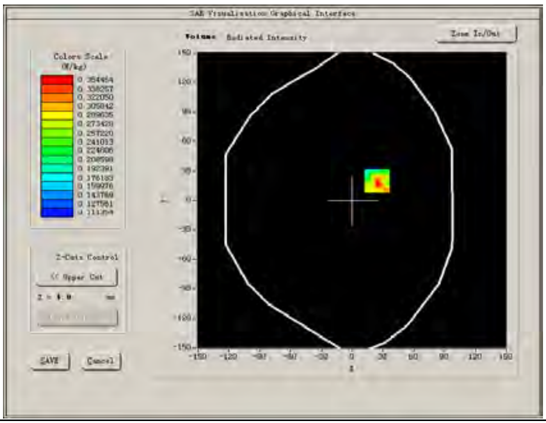
A. Experimental conditions.

Phantom File	surf_sam_plan.txt
Phantom	Validation plane
Device Position	Body
Band	IEEE 802.11a U-NII
Channels	High
Signal	OFDM

B. SAR Measurement Results

Higher Band SAR (Channel 149):

Frequency (MHz)	5745.000000
Relative permittivity (real part)	48.292564
Conductivity (S/m)	5.846600
Power drift (%)	-3.450000
Ambient Temperature:	22.9°C
Liquid Temperature:	22.1°C
ConvF:	23.02
Crest factor:	1:1

SURFACE SAR	VOLUME SAR
	

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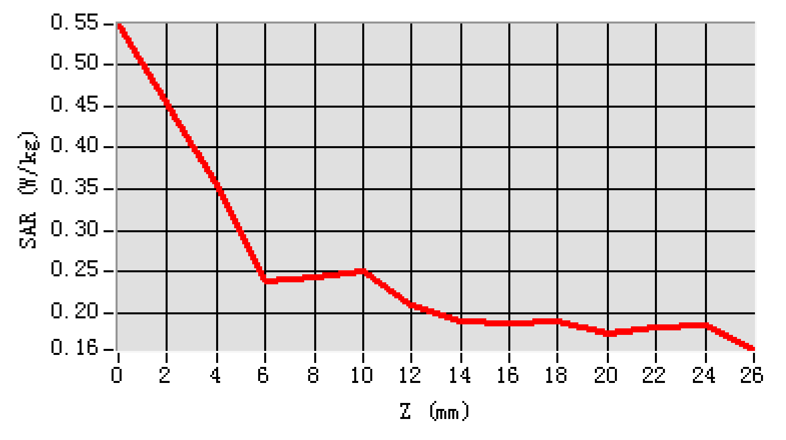
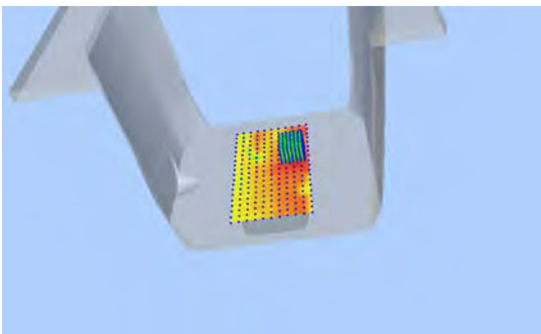
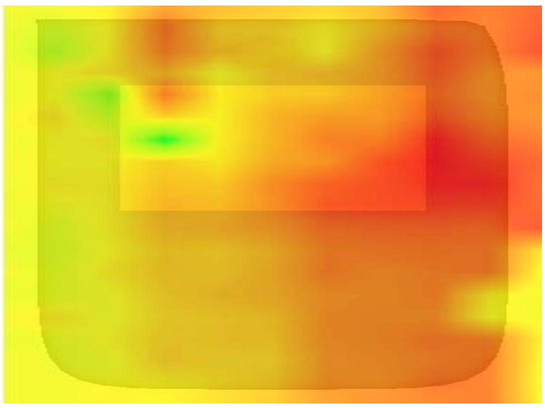
Maximum location: X=24.00, Y=20.00

SAR Peak: 0.76 W/kg

SAR 10g (W/Kg)	0.251904
SAR 1g (W/Kg)	0.339358

Z (mm)	**0.00**	**4.00**	**6.00**	**8.00**	**10.00**	**12.00**	**14.00**	**16.00**	**18.00**	**20.00**	**22.00**	**24.00**
SAR (W/Kg)	**0.5489**	**0.3545**	**0.2374**	**0.2421**	**0.2507**	**0.2086**	**0.1905**	**0.1863**	**0.1900**	**0.1744**	**0.1838**	**0.1861**



3D screen shot	**Hot spot position**
	

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MEASUREMENT 3

Type: Phone measurement (Complete)

Area scan resolution: dx=10mm,dy=10mm

Zoom scan resolution: dx=4mm, dy=4mm, dz=2mm

Date of measurement: 2017.12.28

Measurement duration: 18 minutes 45 seconds

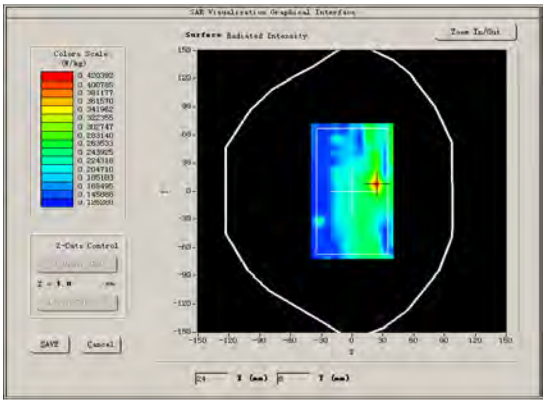
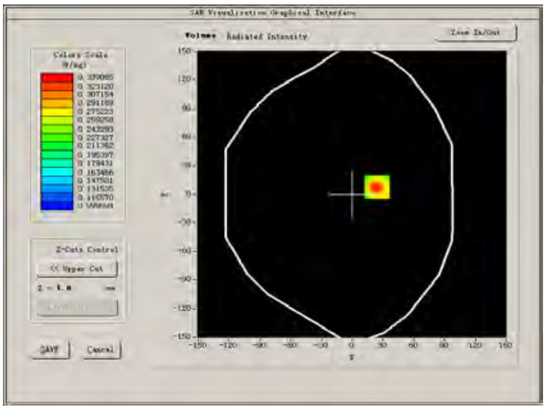
A. Experimental conditions.

Phantom File	surf_sam_plan.txt
Phantom	Validation plane
Device Position	Body
Band	IEEE 802.11a U-NII
Channels	High
Signal	OFDM

B. SAR Measurement Results

Higher Band SAR (Channel 120):

Frequency (MHz)	5600.000000
Relative permittivity (real part)	48.394381
Conductivity (S/m)	5.7432600
Power drift (%)	-3.450000
Ambient Temperature:	22.9°C
Liquid Temperature:	22.1°C
ConvF:	23.69
Crest factor:	1:1

SURFACE SAR	VOLUME SAR
	

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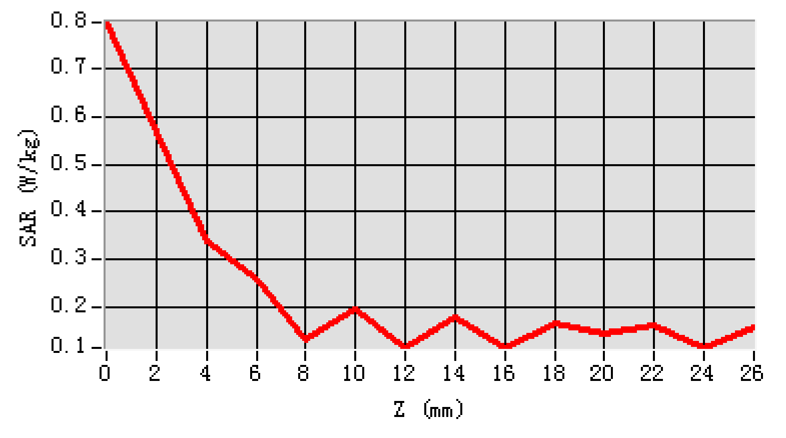
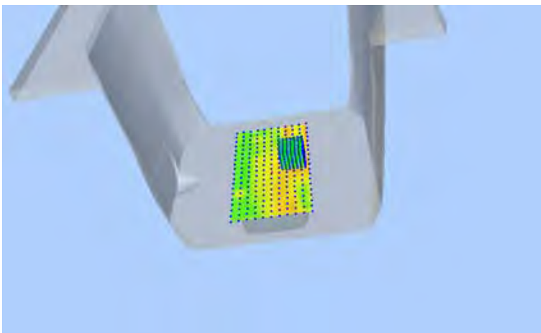
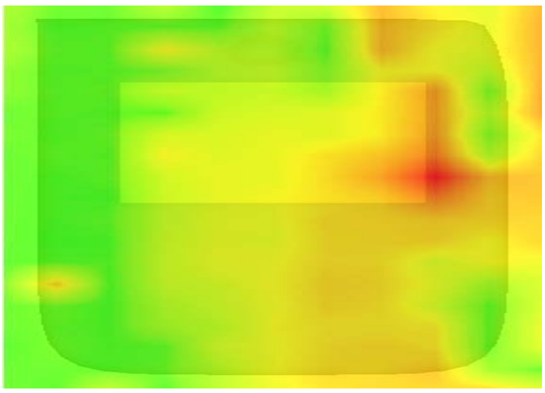
Maximum location: X=24.00, Y=8.00

SAR Peak: 0.79 W/kg

SAR 10g (W/Kg)	0.237125
SAR 1g (W/Kg)	0.369692

Z (mm)	0.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00
SAR (W/Kg)	0.7976	0.3391	0.2566	0.1327	0.1965	0.1148	0.1762	0.1149	0.1667	0.1422	0.1619	0.1144



3D screen shot	Hot spot position
	

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MEASUREMENT 4

Type: Phone measurement (Complete)

Area scan resolution: dx=10mm,dy=10mm

Zoom scan resolution: dx=4mm, dy=4mm, dz=2mm

Date of measurement: 2017.12.28

Measurement duration: 13 minutes 13 seconds

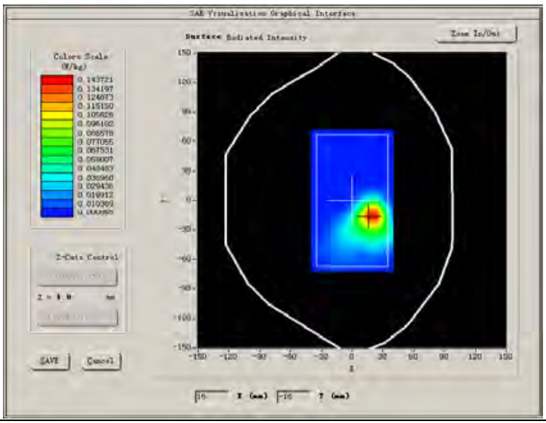
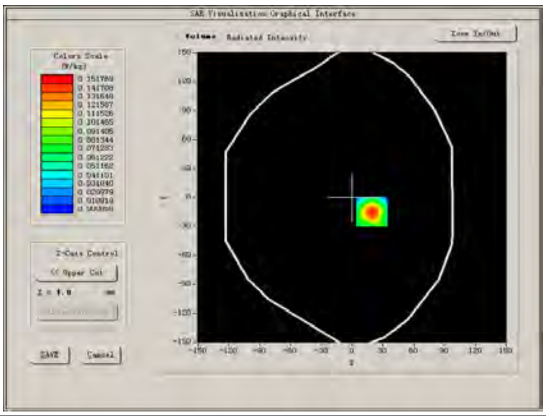
A. Experimental conditions.

Phantom File	surf_sam_plan.txt
Phantom	Validation plane
Device Position	Body
Band	IEEE 802.11b ISM
Channels	High
Signal	DSSS

B. SAR Measurement Results

Higher Band SAR (Channel 11):

Frequency (MHz)	2462.000000
Relative permittivity (real part)	52.769446
Conductivity (S/m)	2.016143
Power drift (%)	-3.450000
Ambient Temperature:	22.0°C
Liquid Temperature:	21.8°C
ConvF:	4.93
Crest factor:	1:1

SURFACE SAR	VOLUME SAR
	

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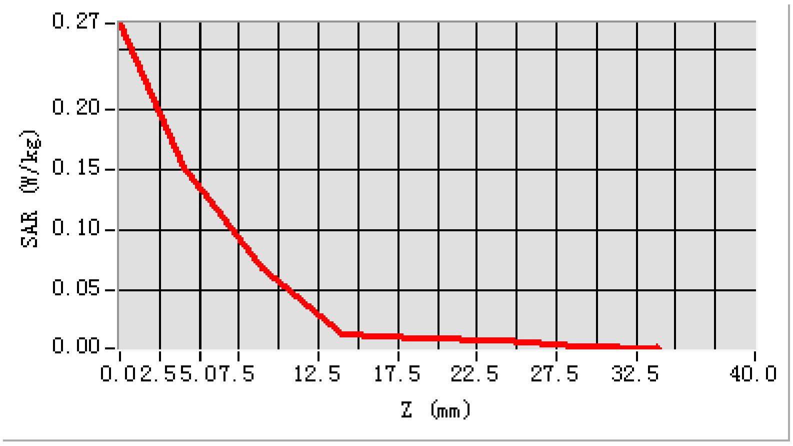
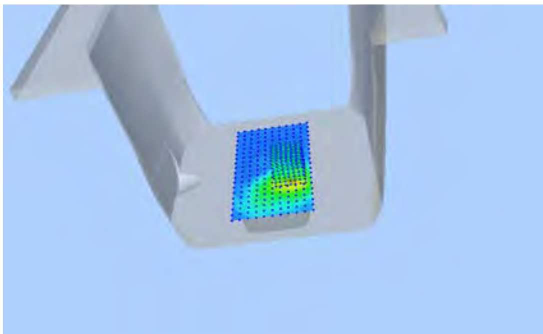
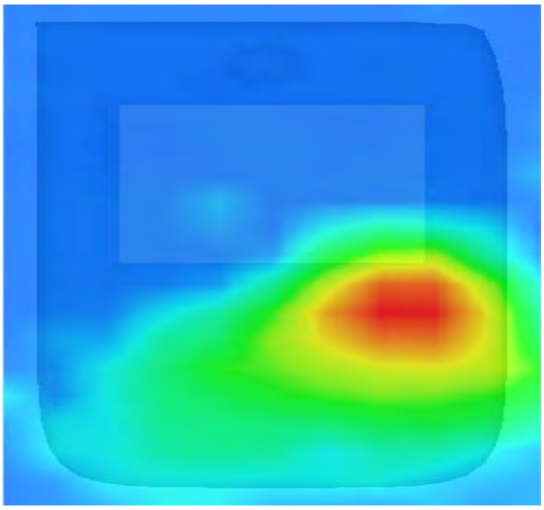
Maximum location: X=19.00, Y=-15.00

SAR Peak: 0.27 W/kg

SAR 10g (W/Kg)	0.060755
SAR 1g (W/Kg)	0.137349

Z (mm)	**0.00**	**4.00**	**9.00**	**14.00**	**19.00**	**24.00**	**29.00**
SAR (W/Kg)	**0.2712**	**0.1518**	**0.0689**	**0.0141**	**0.0093**	**0.0083**	**0.0030**



3D screen shot	**Hot spot position**
	

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Annex E SATIMO Calibration Certificate

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COMOSAR E-Field Probe Calibration Report

Ref : ACR.189.2.16.SATU.A

SHENZHEN MORLAB COMMUNICATIONS TECHNOLOGY CO., LTD

FL3, BUILDING A, FEIYANG SCIENCE PARK, NO.8 LONGCHANG ROAD,

BLOCK 67, BAOAN DISTRICT, SHENZHEN, GUANGDONG PROVINCE, P.R. CHINA

MVG COMOSAR DOSIMETRIC E-FIELD PROBE

SERIAL NO.: SN 27/13 EPG193

Calibrated at MVG US

2105 Barrett Park Dr. - Kennesaw, GA 30144

Calibration Date: 07/05/2017

Summary:

This document presents the method and results from an accredited COMOSAR Dosimetric E-Field Probe calibration performed in MVG USA using the CALISAR / CALIBAIR test bench, for use with a COMOSAR system only. All calibration results are traceable to national metrology institutions.

	Name	*Function*	*Date*	*Signature*
Prepared by :	Jérôme LUC	Product Manager	7/7/2017	
Checked by :	Jérôme LUC	Product Manager	7/7/2017	
Approved by :	Kim RUTKOWSKI	Quality Manager	7/7/2017	Kim Rutkowski

	Customer Name
Distribution :	Shenzhen Morlab Communications Technology Co., Ltd

Issue	*Date*	*Modifications*
A	7/7/2017	Initial release

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TABLE OF CONTENTS

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1 DEVICE UNDER TEST

Device Under Test	
Device Type	COMOSAR DOSIMETRIC E FIELD PROBE
Manufacturer	MVG
Model	SSE2
Serial Number	SN 27/13 EPG193
Product Condition (new / used)	Used
Frequency Range of Probe	0.7 GHz-6GHz
Resistance of Three Dipoles at Connector	Dipole 1: R1=0.205 MΩ Dipole 2: R2=0.175 MΩ Dipole 3: R3=0.213 MΩ

A yearly calibration interval is recommended.

2 PRODUCT DESCRIPTION

2.1 GENERAL INFORMATION

MVG's COMOSAR E field Probes are built in accordance to the IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209 standards.

Figure 1 – *MVG COMOSAR Dosimetric E field Dipole*

Probe Length	330 mm
Length of Individual Dipoles	2 mm
Maximum external diameter	8 mm
Probe Tip External Diameter	2.5 mm
Distance between dipoles / probe extremity	1 mm

3 MEASUREMENT METHOD

The IEEE 1528, OET 65 Bulletin C, CENELEC EN50361 and CEI/IEC 62209 standards provide recommended practices for the probe calibrations, including the performance characteristics of interest and methods by which to assess their affect. All calibrations / measurements performed meet the fore mentioned standards.

3.1 LINEARITY

The evaluation of the linearity was done in free space using the waveguide, performing a power sweep to cover the SAR range 0.01W/kg to 100W/kg.

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3.2 SENSITIVITY

The sensitivity factors of the three dipoles were determined using a two step calibration method (air and tissue simulating liquid) using waveguides as outlined in the standards.

3.3 LOWER DETECTION LIMIT

The lower detection limit was assessed using the same measurement set up as used for the linearity measurement. The required lower detection limit is 10 mW/kg.

3.4 ISOTROPY

The axial isotropy was evaluated by exposing the probe to a reference wave from a standard dipole with the dipole mounted under the flat phantom in the test configuration suggested for system validations and checks. The probe was rotated along its main axis from 0 - 360 degrees in 15 degree steps. The hemispherical isotropy is determined by inserting the probe in a thin plastic box filled with tissue-equivalent liquid, with the plastic box illuminated with the fields from a half wave dipole. The dipole is rotated about its axis (0°–180°) in 15° increments. At each step the probe is rotated about its axis (0°–360°).

3.5 BOUNDARY EFFECT

The boundary effect is defined as the deviation between the SAR measured data and the expected exponential decay in the liquid when the probe is oriented normal to the interface. To evaluate this effect, the liquid filled flat phantom is exposed to fields from either a reference dipole or waveguide. With the probe normal to the phantom surface, the peak spatial average SAR is measured and compared to the analytical value at the surface.

4 MEASUREMENT UNCERTAINTY

The guidelines outlined in the IEEE 1528, OET 65 Bulletin C, CENELEC EN50361 and CEI/IEC 62209 standards were followed to generate the measurement uncertainty associated with an E-field probe calibration using the waveguide technique. All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

Uncertainty analysis of the probe calibration in waveguide					
ERROR SOURCES	**Uncertainty value (%)**	**Probability Distribution**	**Divisor**	**ci**	**Standard Uncertainty (%)**
Incident or forward power	3.00%	Rectangular	$\sqrt{3}$	1	1.732%
Reflected power	3.00%	Rectangular	$\sqrt{3}$	1	1.732%
Liquid conductivity	5.00%	Rectangular	$\sqrt{3}$	1	2.887%
Liquid permittivity	4.00%	Rectangular	$\sqrt{3}$	1	2.309%
Field homogeneity	3.00%	Rectangular	$\sqrt{3}$	1	1.732%
Field probe positioning	5.00%	Rectangular	$\sqrt{3}$	1	2.887%

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Field probe linearity	3.00%	Rectangular	$\sqrt{3}$	1	1.732%
Combined standard uncertainty					5.831%
Expanded uncertainty 95 % confidence level k = 2					12.0%

5 CALIBRATION MEASUREMENT RESULTS

Calibration Parameters	
Liquid Temperature	21 °C
Lab Temperature	21 °C
Lab Humidity	45 %

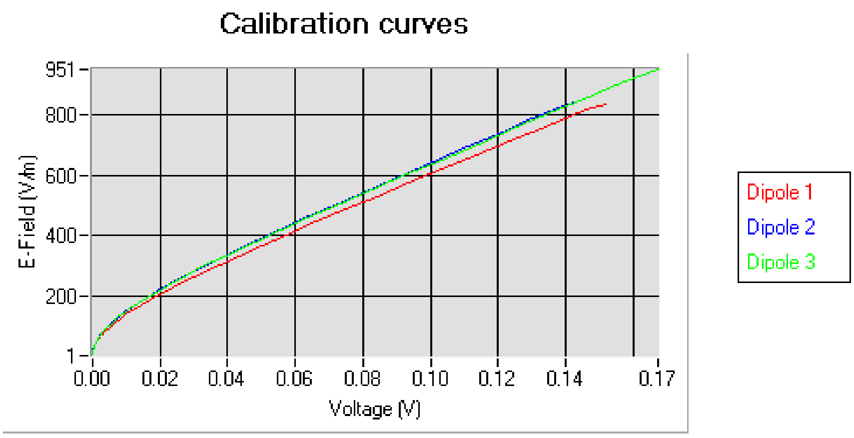
5.1 SENSITIVITY IN AIR

Normx dipole 1 ($\mu V/(V/m)^2$)	Normy dipole 2 ($\mu V/(V/m)^2$)	Normz dipole 3 ($\mu V/(V/m)^2$)
0.53	0.49	0.60

DCP dipole 1 (mV)	DCP dipole 2 (mV)	DCP dipole 3 (mV)
90	99	97

Calibration curves ei=f(V) (i=1,2,3) allow to obtain H-field value using the formula:

$$E = \sqrt{E_1{}^2 + E_2{}^2 + E_3{}^2}$$



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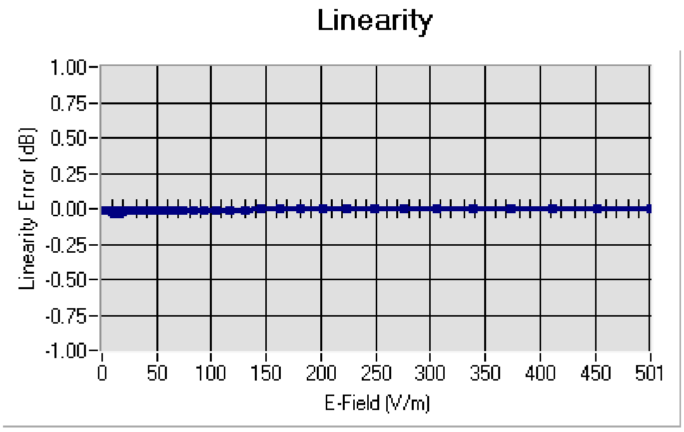
5.2 LINEARITY



Linearity:+/-0.86% (+/-0.04dB)

5.3 SENSITIVITY IN LIQUID

Liquid	Frequency (MHz +/- 100MHz)	Permittivity	Epsilon (S/m)	ConvF
HL5200	5200	35.64	4.67	21.61
BL5200	5200	48.64	5.51	22.11
HL5400	5400	36.44	4.87	22.47
BL5400	5400	46.52	5.77	23.20
HL5600	5600	36.66	5.17	22.92
BL5600	5600	46.79	5.77	23.69
HL5800	5800	35.31	5.31	22.42
BL5800	5800	47.04	6.10	23.02

LOWER DETECTION LIMIT: 9mW/kg

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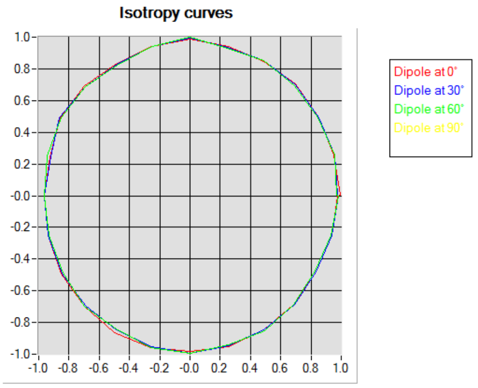
5.4 ISOTROPY

HL5600 MHz

- Axial isotropy: 0.06 dB
- Hemispherical isotropy: 0.08 dB



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6 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	**Manufacturer / Model**	**Identification No.**	**Current Calibration Date**	**Next Calibration Date**
Flat Phantom	MVG	SN-20/09-SAM71	Validated. No cal required.	Validated. No cal required.
COMOSAR Test Bench	Version 3	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rhode & Schwarz ZVA	SN100132	02/2016	02/2019
Reference Probe	MVG	EP 94 SN 37/08	10/2016	10/2017
Multimeter	Keithley 2000	1188656	12/2016	12/2019
Signal Generator	Agilent E4438C	MY49070581	12/2016	12/2019
Amplifier	Aethercomm	SN 046	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	HP E4418A	US38261498	12/2016	12/2019
Power Sensor	HP ECP-E26A	US37181460	12/2016	12/2019
Directional Coupler	Narda 4216-20	01386	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Waveguide	Mega Industries	069Y7-158-13-712	Validated. No cal required.	Validated. No cal required.
Waveguide Transition	Mega Industries	069Y7-158-13-701	Validated. No cal required.	Validated. No cal required.
Waveguide Termination	Mega Industries	069Y7-158-13-701	Validated. No cal required.	Validated. No cal required.
Temperature / Humidity Sensor	Control Company	150798832	10/2015	10/2017

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SAR Reference Dipole Calibration Report

Ref : ACR.189.9.16.SATU.A

SHENZHEN MORLAB COMMUNICATIONS TECHNOLOGY CO., LTD

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BLOCK 67, BAOAN DISTRICT, SHENZHEN, GUANGDONG PROVINCE, P.R. CHINA

MVG COMOSAR REFERENCE DIPOLE

FREQUENCY: 2450 MHZ

SERIAL NO.: SN 30/13 DIP2G450-263

Calibrated at MVG US

2105 Barrett Park Dr. - Kennesaw, GA 30144

ACCREDITED

Calibration CERT #2245-02

Calibration Date: 07/05/2017

Summary:

This document presents the method and results from an accredited SAR reference dipole calibration performed in MVG USA using the COMOSAR test bench. All calibration results are traceable to national metrology institutions.

	Name	*Function*	*Date*	*Signature*
Prepared by :	Jérôme LUC	Product Manager	7/7/2017	[signature]
Checked by :	Jérôme LUC	Product Manager	7/7/2017	[signature]
Approved by :	Kim RUTKOWSKI	Quality Manager	7/7/2017	[signature]

	Customer Name
Distribution :	Shenzhen Morlab Communications Technology Co., Ltd

Issue	*Date*	*Modifications*
A	7/7/2017	Initial release

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1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEEE 1528, FCC KDBs and CEI/IEC 62209 standards for reference dipoles used for SAR measurement system validations and the measurements that were performed to verify that the product complies with the fore mentioned standards.

2 DEVICE UNDER TEST

Device Under Test	
Device Type	COMOSAR 2450 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SID2450
Serial Number	SN 30/13 DIP2G450-263
Product Condition (new / used)	Used

A yearly calibration interval is recommended.

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

MVG's COMOSAR Validation Dipoles are built in accordance to the IEEE 1528, FCC KDBs and CEI/IEC 62209 standards. The product is designed for use with the COMOSAR test bench only.

Figure 1 – *MVG COMOSAR Validation Dipole*

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4 MEASUREMENT METHOD

The IEEE 1528, FCC KDBs and CEI/IEC 62209 standards provide requirements for reference dipoles used for system validation measurements. The following measurements were performed to verify that the product complies with the fore mentioned standards.

4.1 RETURN LOSS REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a return loss of -20 dB or better. The return loss measurement shall be performed against a liquid filled flat phantom, with the phantom constucted as outlined in the fore mentioned standards.

4.2 MECHANICAL REQUIREMENTS

The IEEE Std. 1528 and CEI/IEC 62209 standards specify the mechanical components and dimensions of the validation dipoles, with the dimensions frequency and phantom shell thickness dependent. The COMOSAR test bench employs a 2 mm phantom shell thickness therefore the dipoles sold for use with the COMOSAR test bench comply with the requirements set forth for a 2 mm phantom shell thickness.

5 MEASUREMENT UNCERTAINTY

All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

5.1 RETURN LOSS

The following uncertainties apply to the return loss measurement:

Frequency band	Expanded Uncertainty on Return Loss
400-6000MHz	0.1 dB

5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

Length (mm)	Expanded Uncertainty on Length
3 - 300	0.05 mm

5.3 VALIDATION MEASUREMENT

The guidelines outlined in the IEEE 1528, FCC KDBs, CENELEC EN50361 and CEI/IEC 62209 standards were followed to generate the measurement uncertainty for validation measurements.

Scan Volume	Expanded Uncertainty
1 g	20.3 %

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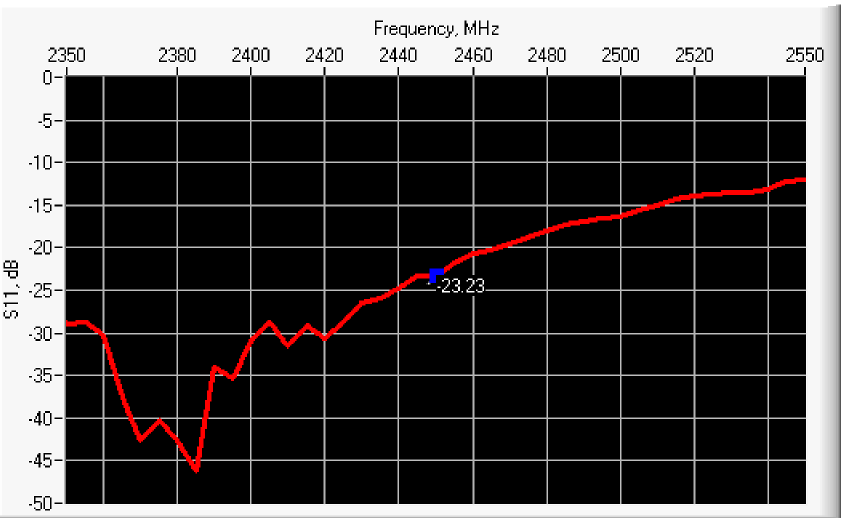
10 g	20.1 %

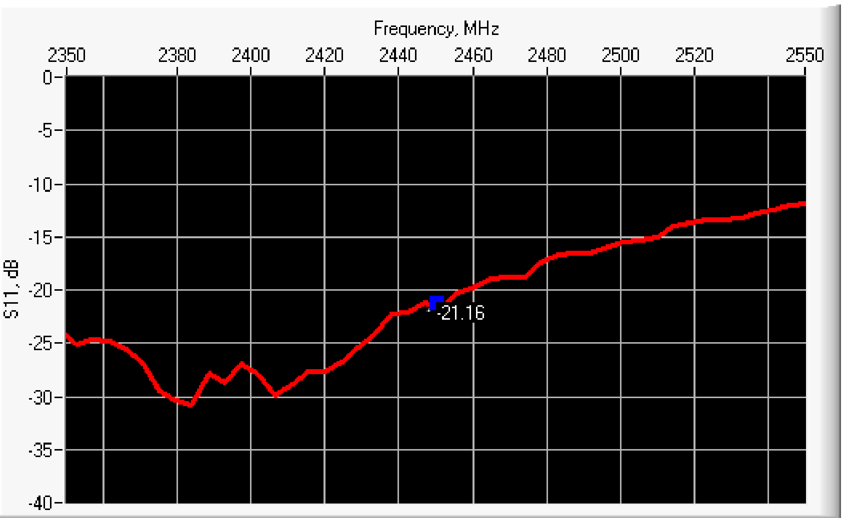
6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
2450	-23.23	-20	47.7 Ω - 6.4 jΩ

6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
2450	-21.16	-20	53.7 Ω - 8.3 jΩ

6.3 MECHANICAL DIMENSIONS

Frequency MHz	**L** mm		**h** mm		**d** mm	
	required	**measured**	**required**	**measured**	**required**	**measured**
300	420.0 ±1 %.		250.0 ±1 %.		6.35 ±1 %.	

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450	290.0 ±1 %.		166.7 ±1 %.		6.35 ±1 %.	
750	176.0 ±1 %.		100.0 ±1 %.		6.35 ±1 %.	
835	161.0 ±1 %.		89.8 ±1 %.		3.6 ±1 %.	
900	149.0 ±1 %.		83.3 ±1 %.		3.6 ±1 %.	
1450	89.1 ±1 %.		51.7 ±1 %.		3.6 ±1 %.	
1500	80.5 ±1 %.		50.0 ±1 %.		3.6 ±1 %.	
1640	79.0 ±1 %.		45.7 ±1 %.		3.6 ±1 %.	
1750	75.2 ±1 %.		42.9 ±1 %.		3.6 ±1 %.	
1800	72.0 ±1 %.		41.7 ±1 %.		3.6 ±1 %.	
1900	68.0 ±1 %.		39.5 ±1 %.		3.6 ±1 %.	
1950	66.3 ±1 %.		38.5 ±1 %.		3.6 ±1 %.	
2000	64.5 ±1 %.		37.5 ±1 %.		3.6 ±1 %.	
2100	61.0 ±1 %.		35.7 ±1 %.		3.6 ±1 %.	
2300	55.5 ±1 %.		32.6 ±1 %.		3.6 ±1 %.	
2450	51.5 ±1 %.	PASS	30.4 ±1 %.	PASS	3.6 ±1 %.	PASS
2600	48.5 ±1 %.		28.8 ±1 %.		3.6 ±1 %.	
3000	41.5 ±1 %.		25.0 ±1 %.		3.6 ±1 %.	
3500	37.0±1 %.		26.4 ±1 %.		3.6 ±1 %.	
3700	34.7±1 %.		26.4 ±1 %.		3.6 ±1 %.	

7 VALIDATION MEASUREMENT

The IEEE Std. 1528, FCC KDBs and CEI/IEC 62209 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. Per the standards, the dipole shall be positioned below the bottom of the phantom, with the dipole length centered and parallel to the longest dimension of the flat phantom, with the top surface of the dipole at the described distance from the bottom surface of the phantom.

7.1 HEAD LIQUID MEASUREMENT

Frequency MHz	**Relative permittivity (ε_r')**		**Conductivity (σ) S/m**	
	required	**measured**	**required**	**measured**
300	45.3 ±5 %		0.87 ±5 %	
450	43.5 ±5 %		0.87 ±5 %	
750	41.9 ±5 %		0.89 ±5 %	
835	41.5 ±5 %		0.90 ±5 %	
900	41.5 ±5 %		0.97 ±5 %	
1450	40.5 ±5 %		1.20 ±5 %	
1500	40.4 ±5 %		1.23 ±5 %	
1640	40.2 ±5 %		1.31 ±5 %	
1750	40.1 ±5 %		1.37 ±5 %	

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1800	40.0 ±5 %		1.40 ±5 %	
1900	40.0 ±5 %		1.40 ±5 %	
1950	40.0 ±5 %		1.40 ±5 %	
2000	40.0 ±5 %		1.40 ±5 %	
2100	39.8 ±5 %		1.49 ±5 %	
2300	39.5 ±5 %		1.67 ±5 %	
2450	39.2 ±5 %	PASS	1.80 ±5 %	PASS
2600	39.0 ±5 %		1.96 ±5 %	
3000	38.5 ±5 %		2.40 ±5 %	
3500	37.9 ±5 %		2.91 ±5 %	

7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

The IEEE Std. 1528 and CEI/IEC 62209 standards state that the system validation measurements should produce the SAR values shown below (for phantom thickness of 2 mm), within the uncertainty for the system validation. All SAR values are normalized to 1 W forward power. In bracket, the measured SAR is given with the used input power.

Software	OPENSAR V4
Phantom	SN 20/09 SAM71
Probe	SN 18/11 EPG122
Liquid	Head Liquid Values: eps' : 37.5 sigma : 1.80
Distance between dipole center and liquid	10.0 mm
Area scan resolution	dx=8mm/dy=8mm
Zoon Scan Resolution	dx=5mm/dy=5mm/dz=5mm
Frequency	2450 MHz
Input power	20 dBm
Liquid Temperature	21 °C
Lab Temperature	21 °C
Lab Humidity	45 %

Frequency MHz	**1 g SAR (W/kg/W)**		**10 g SAR (W/kg/W)**	
	required	**measured**	**required**	**measured**
300	2.85		1.94	
450	4.58		3.06	
750	8.49		5.55	
835	9.56		6.22	
900	10.9		6.99	
1450	29		16	
1500	30.5		16.8	
1640	34.2		18.4	
1750	36.4		19.3	
1800	38.4		20.1	

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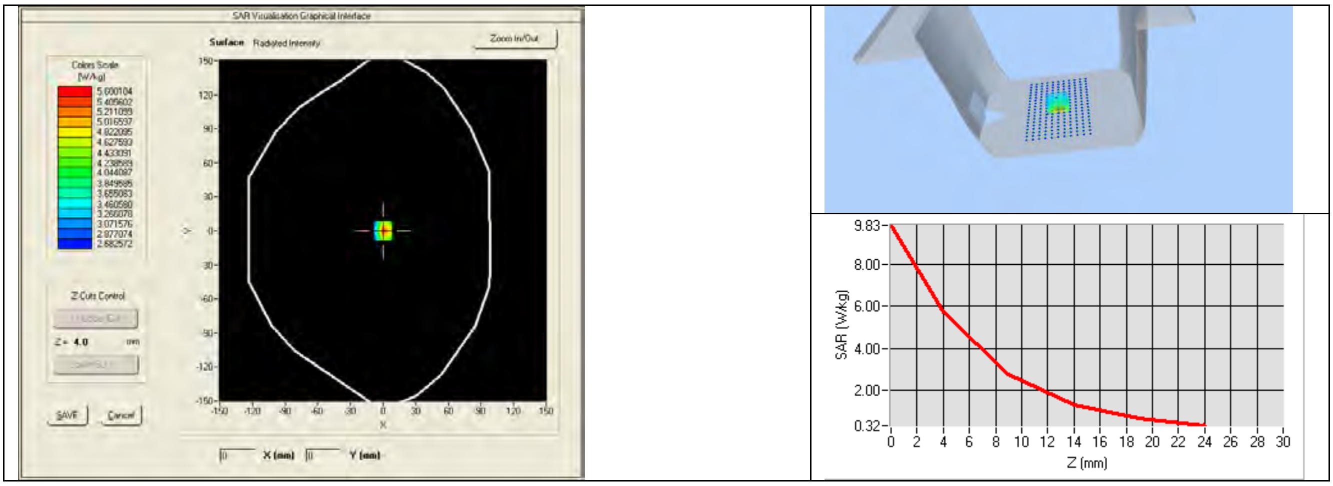
1900	39.7		20.5	
1950	40.5		20.9	
2000	41.1		21.1	
2100	43.6		21.9	
2300	48.7		23.3	
2450	52.4	53.34 (5.33)	24	24.22 (2.42)
2600	55.3		24.6	
3000	63.8		25.7	
3500	67.1		25	



7.3 BODY LIQUID MEASUREMENT

Frequency MHz	Relative permittivity (ε_r')		Conductivity (σ) S/m	
	required	measured	required	measured
150	61.9 ±5 %		0.80 ±5 %	
300	58.2 ±5 %		0.92 ±5 %	
450	56.7 ±5 %		0.94 ±5 %	
750	55.5 ±5 %		0.96 ±5 %	
835	55.2 ±5 %		0.97 ±5 %	
900	55.0 ±5 %		1.05 ±5 %	
915	55.0 ±5 %		1.06 ±5 %	
1450	54.0 ±5 %		1.30 ±5 %	
1610	53.8 ±5 %		1.40 ±5 %	
1800	53.3 ±5 %		1.52 ±5 %	
1900	53.3 ±5 %		1.52 ±5 %	
2000	53.3 ±5 %		1.52 ±5 %	
2100	53.2 ±5 %		1.62 ±5 %	
2450	52.7 ±5 %	PASS	1.95 ±5 %	PASS

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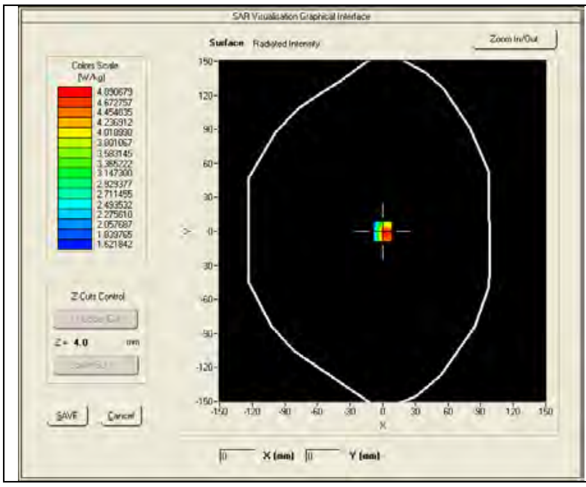
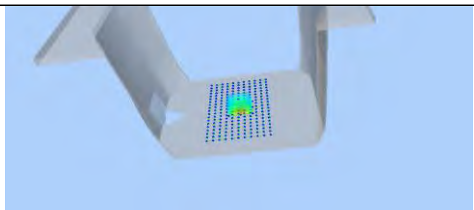
2600	52.5 ±5 %		2.16 ±5 %	
3000	52.0 ±5 %		2.73 ±5 %	
3500	51.3 ±5 %		3.31 ±5 %	
5200	49.0 ±10 %		5.30 ±10 %	
5300	48.9 ±10 %		5.42 ±10 %	
5400	48.7 ±10 %		5.53 ±10 %	
5500	48.6 ±10 %		5.65 ±10 %	
5600	48.5 ±10 %		5.77 ±10 %	
5800	48.2 ±10 %		6.00 ±10 %	

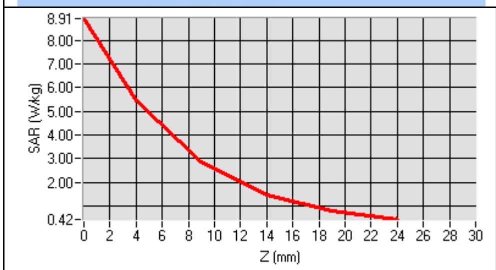
7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

Software	OPENSAR V4
Phantom	SN 20/09 SAM71
Probe	SN 18/11 EPG122
Liquid	Body Liquid Values: eps' : 53.2 sigma : 1.89
Distance between dipole center and liquid	10.0 mm
Area scan resolution	dx=8mm/dy=8mm
Zoon Scan Resolution	dx=5mm/dy=5mm/dz=5mm
Frequency	2450 MHz
Input power	20 dBm
Liquid Temperature	21 °C
Lab Temperature	21 °C
Lab Humidity	45 %

Frequency MHz	**1 g SAR (W/kg/W)**	**10 g SAR (W/kg/W)**
	measured	**measured**
2450	50.93 (5.09)	23.26 (2.33)







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8 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	**Manufacturer / Model**	**Identification No.**	**Current Calibration Date**	**Next Calibration Date**
SAM Phantom	MVG	SN-20/09-SAM71	Validated. No cal required.	Validated. No cal required.
COMOSAR Test Bench	Version 3	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rhode & Schwarz ZVA	SN100132	02/2016	02/2019
Calipers	Carrera	CALIPER-01	12/2016	12/2019
Reference Probe	MVG	EPG122 SN 18/11	10/2016	10/2017
Multimeter	Keithley 2000	1188656	12/2016	12/2019
Signal Generator	Agilent E4438C	MY49070581	12/2016	12/2019
Amplifier	Aethercomm	SN 046	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	HP E4418A	US38261498	12/2016	12/2019
Power Sensor	HP ECP-E26A	US37181460	12/2016	12/2019
Directional Coupler	Narda 4216-20	01386	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Temperature and Humidity Sensor	Control Company	150798832	10/2015	10/2017

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SAR Reference Waveguide Calibration Report

Ref : ACR.189.11.16.SATU.A

SHENZHEN MORLAB COMMUNICATIONS TECHNOLOGY CO., LTD
FL3, BUILDING A, FEIYANG SCIENCE PARK, NO.8 LONGCHANG ROAD,BLOCK 67, BAOAN DISTRICT, SHENZHEN, GUANGDONG PROVINCE, P.R. CHINAMVG COMOSAR REFERENCE WAVEGUIDE
FREQUENCY: 5000-6000 MHZ
SERIAL NO.: SN 41/12 WGA21

Calibrated at MVG US
2105 Barrett Park Dr. - Kennesaw, GA 30144

Calibration Date: 07/05/2017

Summary:

This document presents the method and results from an accredited SAR reference waveguide calibration performed in MVG USA using the COMOSAR test bench. All calibration results are traceable to national metrology institutions.

	Name	*Function*	*Date*	*Signature*
Prepared by :	Jérôme LUC	Product Manager	7/7/2017	
Checked by :	Jérôme LUC	Product Manager	7/7/2017	
Approved by :	Kim RUTKOWSKI	Quality Manager	7/7/2017	

	Customer Name
Distribution :	Shenzhen Morlab Communications Technology Co., Ltd

Issue	*Date*	*Modifications*
A	7/7/2017	Initial release

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1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEEE 1528 and CEI/IEC 62209 standards for reference waveguides used for SAR measurement system validations and the measurements that were performed to verify that the product complies with the fore mentioned standards.

2 DEVICE UNDER TEST

Device Under Test	
Device Type	COMOSAR 5000-6000 MHz REFERENCE WAVEGUIDE
Manufacturer	MVG
Model	SWG5500
Serial Number	SN 41/12 WGA21
Product Condition (new / used)	Used

A yearly calibration interval is recommended.

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

MVG's COMOSAR Validation Waveguides are built in accordance to the IEEE 1528 and CEI/IEC 62209 standards.

4 MEASUREMENT METHOD

The IEEE 1528 and CEI/IEC 62209 standards provide requirements for reference waveguides used for system validation measurements. The following measurements were performed to verify that the product complies with the fore mentioned standards.

4.1 RETURN LOSS REQUIREMENTS

The waveguide used for SAR system validation measurements and checks must have a return loss of -8 dB or better. The return loss measurement shall be performed with matching layer placed in the open end of the waveguide, with the waveguide and matching layer in direct contact with the phantom shell as outlined in the fore mentioned standards.

4.2 MECHANICAL REQUIREMENTS

The IEEE 1528 and CEI/IEC 62209 standards specify the mechanical dimensions of the validation waveguide, the specified dimensions are as shown in Section 6.2. Figure 1 shows how the dimensions relate to the physical construction of the waveguide.

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5 MEASUREMENT UNCERTAINTY

All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

5.1 RETURN LOSS

The following uncertainties apply to the return loss measurement:

Frequency band	Expanded Uncertainty on Return Loss
400-6000MHz	0.1 dB

5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

Length (mm)	Expanded Uncertainty on Length
3 - 300	0.05 mm

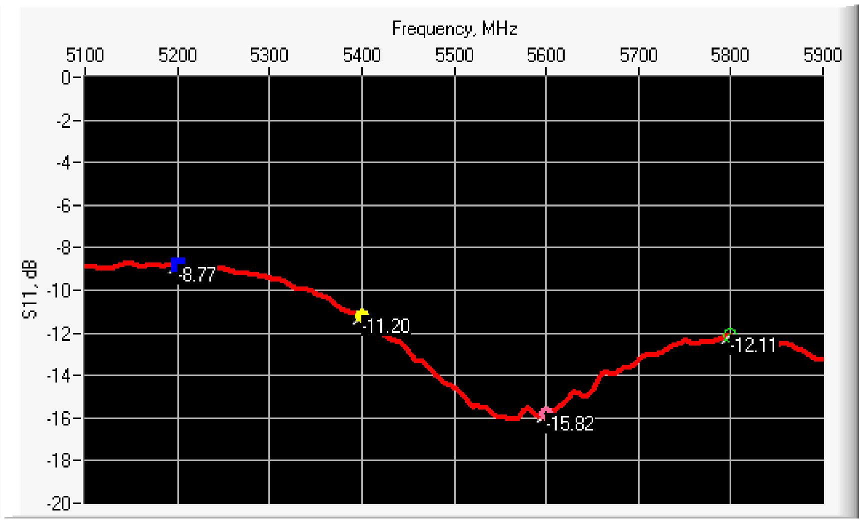
5.3 VALIDATION MEASUREMENT

The guidelines outlined in the IEEE 1528 and CEI/IEC 62209 standards were followed to generate the measurement uncertainty for validation measurements.

Scan Volume	Expanded Uncertainty
1 g	20.3 %
10 g	20.1 %

6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS IN HEAD LIQUID



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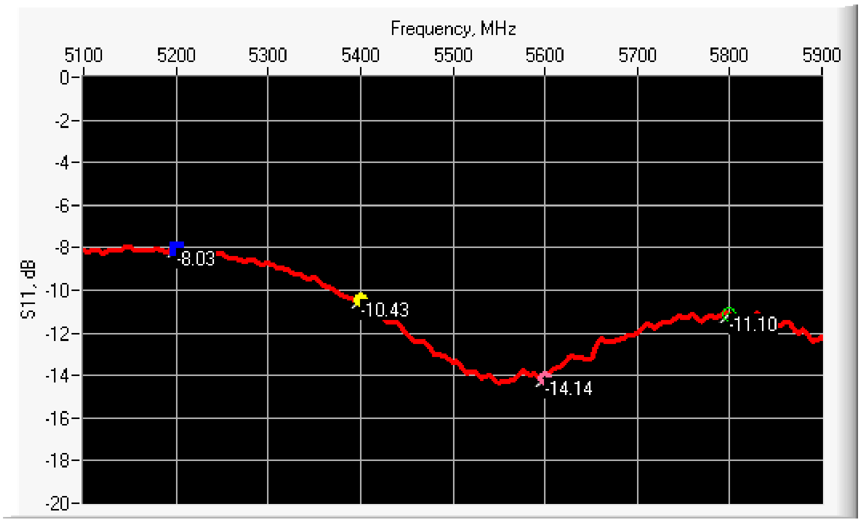
Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
5200	-8.77	-8	25.52 Ω + 13.34 jΩ
5400	-11.20	-8	85.09 Ω + 12.81 jΩ
5600	-15.82	-8	36.65 Ω - 4.32 jΩ
5800	-12.11	-8	53.20 Ω + 26.19 jΩ

6.2 RETURN LOSS IN BODY LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
5200	-8.03	-8	24.31 Ω + 15.75 jΩ
5400	-10.43	-8	92.67 Ω + 5.39 jΩ
5600	-14.14	-8	33.81 Ω - 2.99 jΩ
5800	-11.10	-8	57.11 Ω + 30.17 jΩ

6.3 MECHANICAL DIMENSIONS

Frequency (MHz)	L (mm)		W (mm)		L_f (mm)		W_f (mm)		T (mm)	
	Required	Measured	Required	Measured	Required	Measured	Required	Measured	Required	Measured
5200	40.39 ± 0.13	PASS	20.19 ± 0.13	PASS	81.03 ± 0.13	PASS	61.98 ± 0.13	PASS	5.3*	PASS
5800	40.39 ± 0.13	PASS	20.19 ± 0.13	PASS	81.03 ± 0.13	PASS	61.98 ± 0.13	PASS	4.3*	PASS

* The tolerance for the matching layer is included in the return loss measurement.

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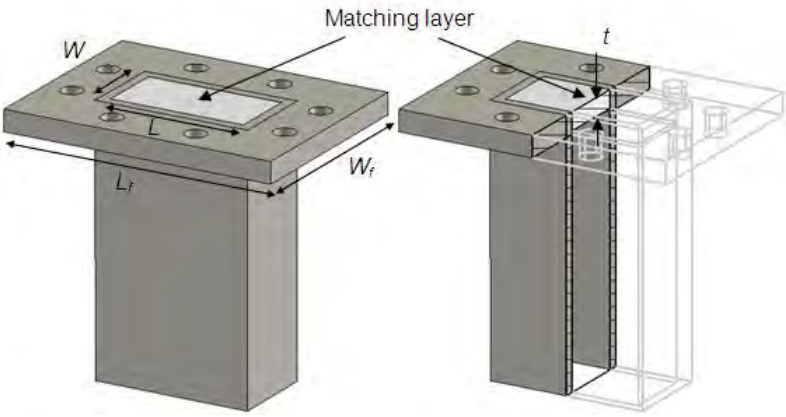

Figure 1: Validation Waveguide Dimensions

7 VALIDATION MEASUREMENT

The IEEE Std. 1528 and CEI/IEC 62209 standards state that the system validation measurements must be performed using a reference waveguide meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed with the matching layer placed in the open end of the waveguide, with the waveguide and matching layer in direct contact with the phantom shell.

7.1 HEAD LIQUID MEASUREMENT

Frequency MHz	**Relative permittivity (ε_r')**		**Conductivity (σ) S/m**	
	required	**measured**	**required**	**measured**
5000	36.2 ±10 %		4.45 ±10 %	
5100	36.1 ±10 %		4.56 ±10 %	
5200	36.0 ±10 %	PASS	4.66 ±10 %	PASS
5300	35.9 ±10 %		4.76 ±10 %	
5400	35.8 ±10 %	PASS	4.86 ±10 %	PASS
5500	35.6 ±10 %		4.97 ±10 %	
5600	35.5 ±10 %	PASS	5.07 ±10 %	PASS
5700	35.4 ±10 %		5.17 ±10 %	
5800	35.3 ±10 %	PASS	5.27 ±10 %	PASS
5900	35.2 ±10 %		5.38 ±10 %	
6000	35.1 ±10 %		5.48 ±10 %	

7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

At those frequencies, the target SAR value can not be generic. Hereunder is the target SAR value defined by MVG, within the uncertainty for the system validation. All SAR values are normalized to 1 W net power. In bracket, the measured SAR is given with the used input power.

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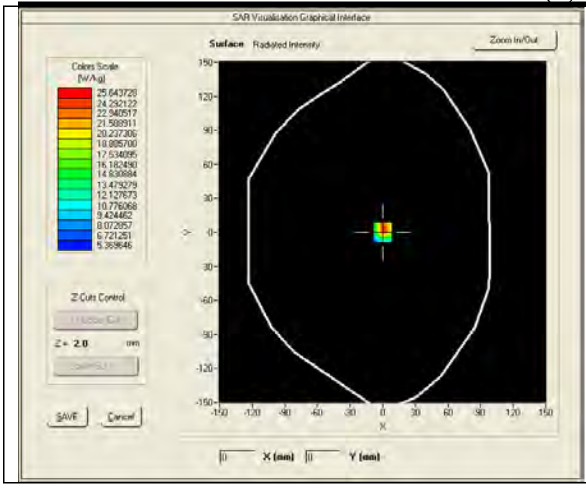
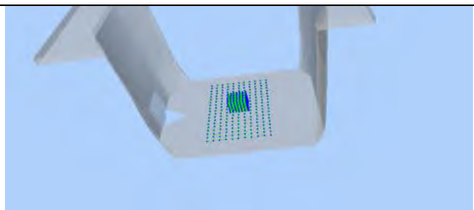
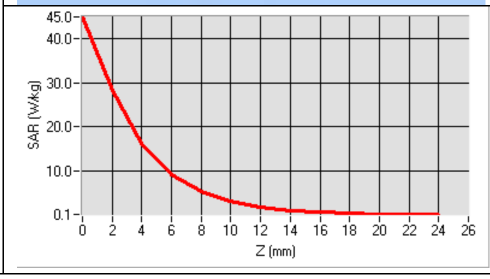
Software	OPENSAR V4
Phantom	SN 20/09 SAM71
Probe	SN 18/11 EPG122
Liquid	Head Liquid Values 5200 MHz: eps' :35.64 sigma : 4.67 Head Liquid Values 5400 MHz: eps' :36.44 sigma : 4.87 Head Liquid Values 5600 MHz: eps' :36.66 sigma : 5.17 Head Liquid Values 5800 MHz: eps' :35.31 sigma : 5.31
Distance between dipole waveguide and liquid	0 mm
Area scan resolution	dx=8mm/dy=8mm
Zoon Scan Resolution	dx=4mm/dy=4m/dz=2mm
Frequency	5200 MHz 5400 MHz 5600 MHz 5800 MHz
Input power	20 dBm
Liquid Temperature	21 °C
Lab Temperature	21 °C
Lab Humidity	45 %

Frequency (MHz)	1 g SAR (W/kg)		10 g SAR (W/kg)	
	required	measured	required	measured
5200	159.00	164.05 (16.41)	56.90	57.03 (5.70)
5400	166.40	171.66 (17.17)	58.43	59.33 (5.93)
5600	173.80	177.81 (17.78)	59.97	60.90 (6.09)
5800	181.20	185.02 (18.50)	61.50	62.43 (6.24)

SAR MEASUREMENT PLOTS @ 5200 MHz







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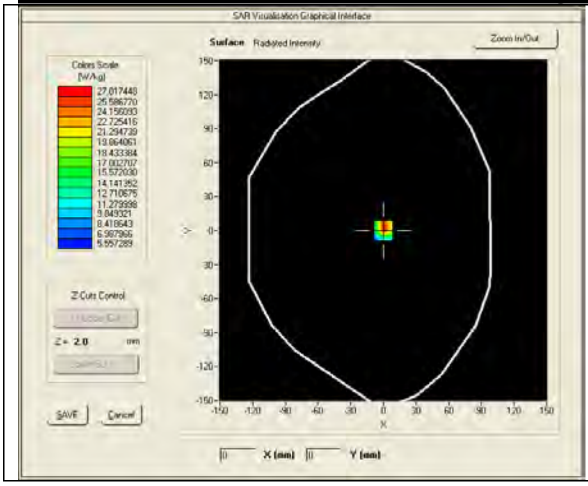
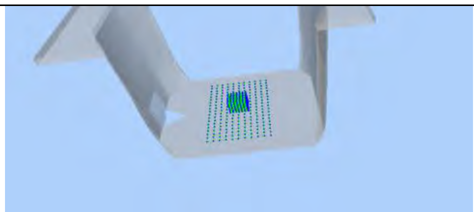
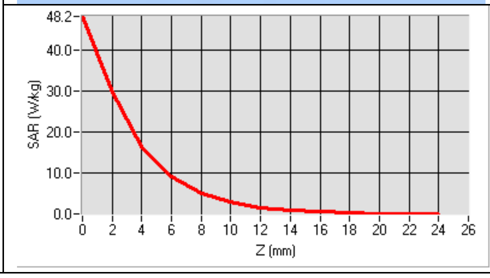
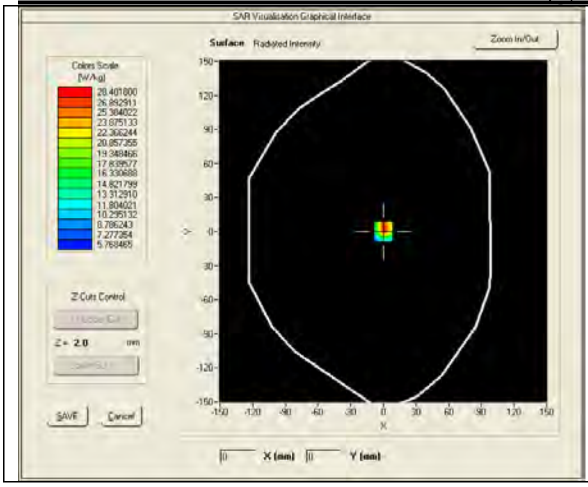
SAR MEASUREMENT PLOTS @ 5400 MHz

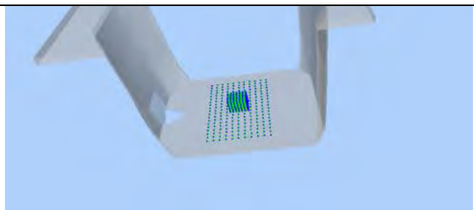


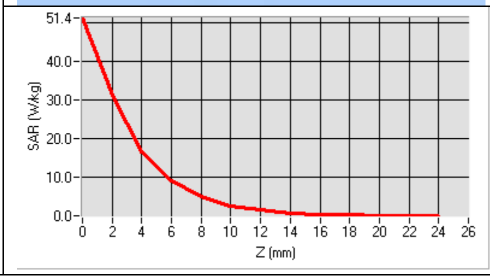




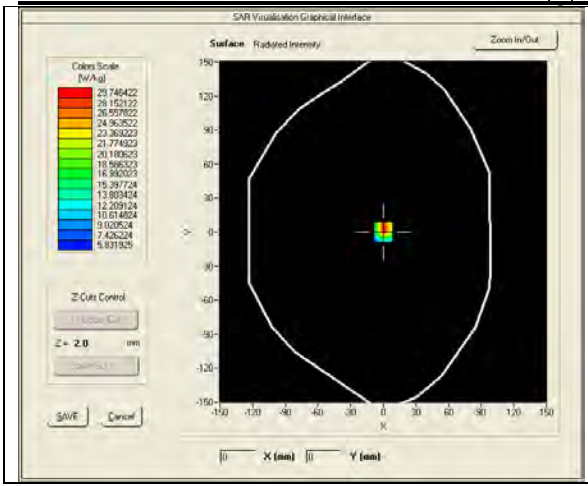
SAR MEASUREMENT PLOTS @ 5600 MHz

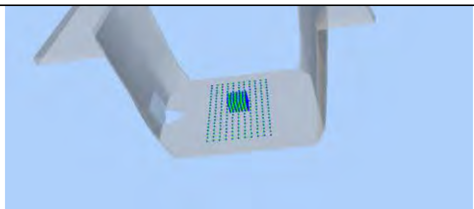


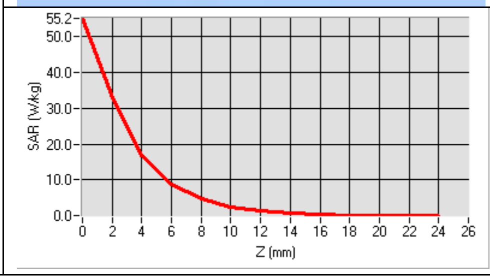




SAR MEASUREMENT PLOTS @ 5800 MHz







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7.3 BODY LIQUID MEASUREMENT

Frequency MHz	Relative permittivity (ε_r')		Conductivity (σ) S/m	
	required	measured	required	measured
5200	49.0 ±10 %	PASS	5.30 ±10 %	PASS
5300	48.9 ±10 %		5.42 ±10 %	
5400	48.7 ±10 %	PASS	5.53 ±10 %	PASS
5500	48.6 ±10 %		5.65 ±10 %	
5600	48.5 ±10 %	PASS	5.77 ±10 %	PASS
5800	48.2 ±10 %	PASS	6.00 ±10 %	PASS

7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

Software	OPENSAR V4
Phantom	SN 20/09 SAM71
Probe	SN 18/11 EPG122
Liquid	Body Liquid Values 5200 MHz: eps' :48.64 sigma : 5.51 Body Liquid Values 5400 MHz: eps' :46.52 sigma : 5.77 Body Liquid Values 5600 MHz: eps' :46.79 sigma : 5.77 Body Liquid Values 5800 MHz: eps' :47.04 sigma : 6.10
Distance between dipole waveguide and liquid	0 mm
Area scan resolution	dx=8mm/dy=8mm
Zoon Scan Resolution	dx=4mm/dy=4m/dz=2mm
Frequency	5200 MHz 5400 MHz 5600 MHz 5800 MHz
Input power	20 dBm
Liquid Temperature	21 °C
Lab Temperature	21 °C
Lab Humidity	45 %

Frequency (MHz)	1 g SAR (W/kg)	10 g SAR (W/kg)
	measured	measured
5200	163.36 (16.34)	57.09 (5.71)
5400	166.22 (16.62)	57.22 (5.72)
5600	172.11 (17.21)	58.61 (5.86)
5800	177.10 (17.71)	59.95 (5.99)

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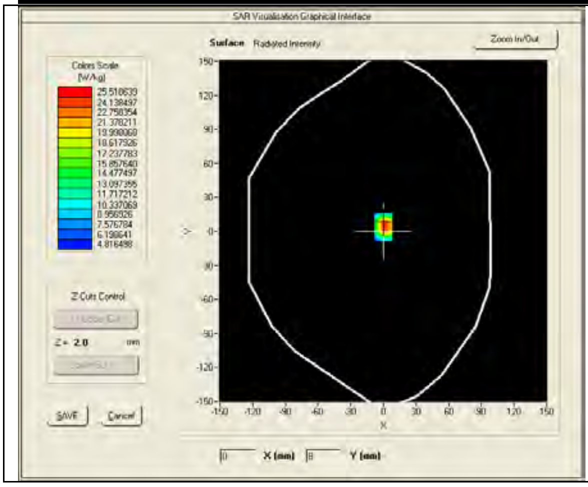
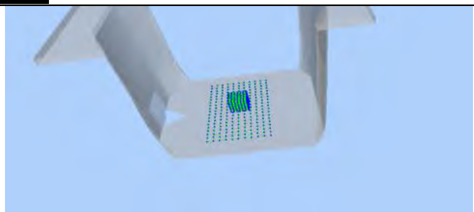
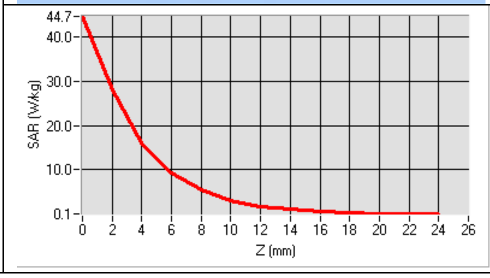
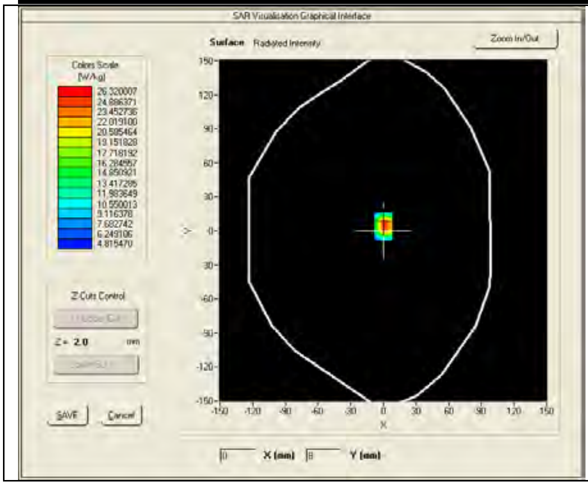
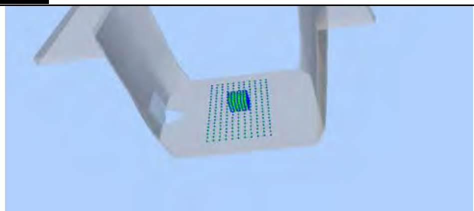
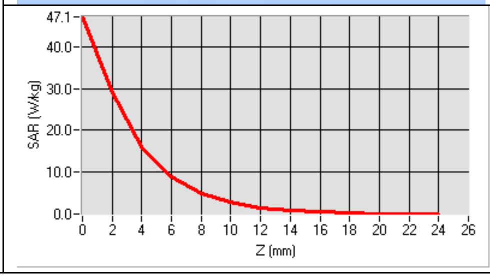
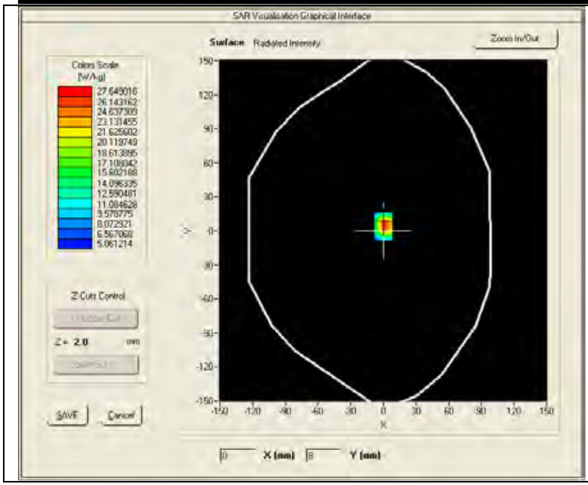
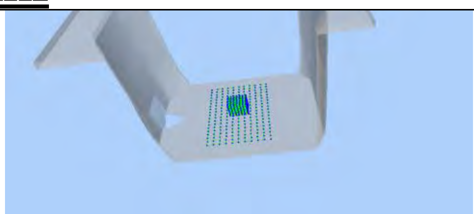
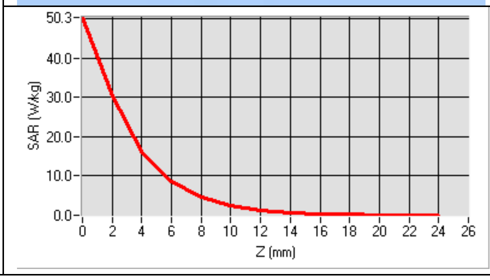
BODY SAR MEASUREMENT PLOTS @ 5200 MHz

BODY SAR MEASUREMENT PLOTS @ 5400 MHz

BODY SAR MEASUREMENT PLOTS @ 5600 MHz

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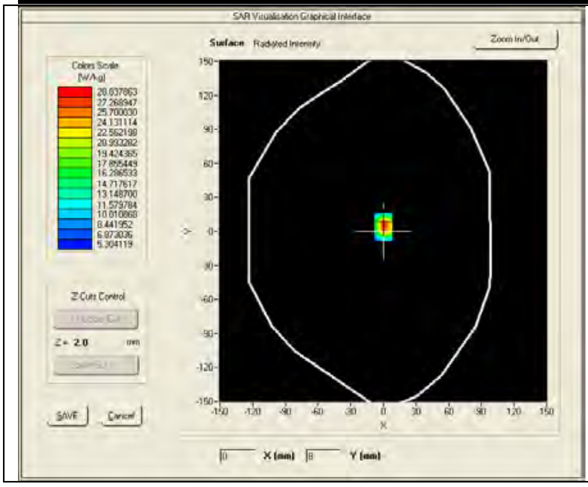
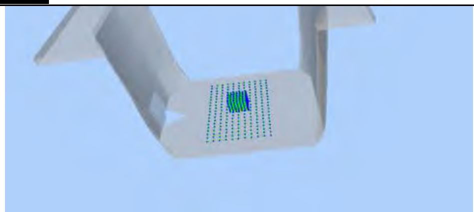
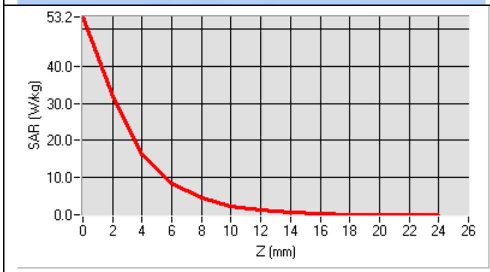
BODY SAR MEASUREMENT PLOTS @ 5800 MHz







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8 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	**Manufacturer / Model**	**Identification No.**	**Current Calibration Date**	**Next Calibration Date**
Flat Phantom	MVG	SN-20/09-SAM71	Validated. No cal required.	Validated. No cal required.
COMOSAR Test Bench	Version 3	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rhode & Schwarz ZVA	SN100132	02/2016	02/2019
Calipers	Carrera	CALIPER-01	12/2016	12/2019
Reference Probe	MVG	EPG122 SN 18/11	10/2016	10/2017
Multimeter	Keithley 2000	1188656	12/2016	12/2019
Signal Generator	Agilent E4438C	MY49070581	12/2016	12/2019
Amplifier	Aethercomm	SN 046	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	HP E4418A	US38261498	12/2016	12/2019
Power Sensor	HP ECP-E26A	US37181460	12/2016	12/2019
Directional Coupler	Narda 4216-20	01386	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Temperature and Humidity Sensor	Control Company	150798832	10/2015	10/2017

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