

FCC

SAR

TEST REPORT

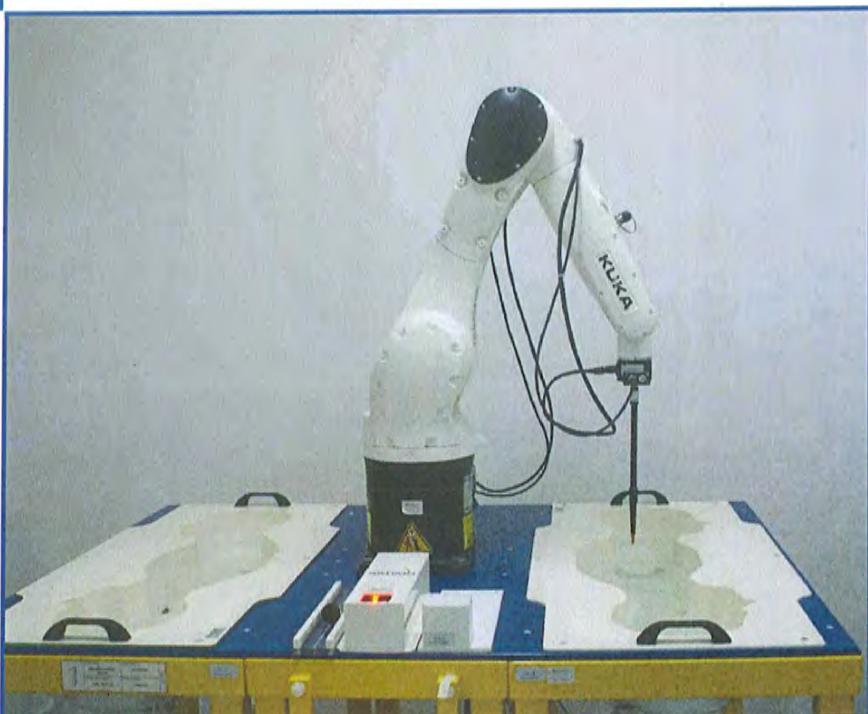
ISSUED BY
Shenzhen BALUN Technology Co., Ltd.



FOR
walkie talkie

ISSUED TO
Amcrest Technologies LLC

16727 Park Row Dr. Houston, TX 77084



Tested by: Tu Lang
Tu Lang
(Engineer)
Date Jul. 7, 2016

Approved by: Wei Yanquan
Wei Yanquan
(Chief Engineer)
Date Jul. 7, 2016

Report No.:	BL-SZ1640195-701
EUT Type:	walkie talkie
Model Name:	ATR-22
Brand Name:	N/A
FCC ID:	ZZ2-ART-22
Test Standard:	FCC 47 CFR Part 2.1093 ANSI C95.1-2005 IEEE 1528-2013
Maximum SAR:	Head: 1.347 W/kg (50% duty cycle) Body: 3.056 W/kg (50% duty cycle)
Test Conclusion:	Pass
Test Date:	May 30, 2016
Date of Issue:	Jul. 7, 2016

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Revision History

Version	Issue Date	Revisions Content
<u>Rev. 01</u>	<u>Jun. 16, 2016</u>	<u>Initial Issue</u>
<u>Rev. 02</u>	<u>Jul. 7, 2016</u>	<u>Added channel description in section 2.6.</u> <u>Added more channels SAR values in section 3.3</u>

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1 GENERAL INFORMATION

1.1 Identification of the Testing Laboratory

Company Name	Shenzhen BALUN Technology Co., Ltd.
Address	Block B, 1st FL, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province, P. R. China
Phone Number	+86 755 6685 0100
Fax Number	+86 755 6182 4271

1.2 Identification of the Responsible Testing Location

Test Location	Shenzhen BALUN Technology Co., Ltd.
Address	Block B, 1st FL, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province, P. R. China
Accreditation Certificate	The laboratory has been listed by Industry Canada to perform electromagnetic emission measurements. The recognition numbers of test site are 11524A-1. The laboratory has been listed by US Federal Communications Commission to perform electromagnetic emission measurements. The recognition numbers of test site are 832625. The laboratory is a testing organization accredited by China National Accreditation Service for Conformity Assessment (CNAS) according to ISO/IEC 17025. The accreditation certificate number is L6791.
Description	All measurement facilities used to collect the measurement data are located at Block B, FL 1, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province, P. R. China 518055

1.3 Test Environment Condition

Ambient Temperature	20 to 22 °C
Ambient Relative Humidity	37 to 48 %
Ambient Pressure	100 to 102 KPa

1.4 Announce

- (1) The test report reference to the report template version v2.3.
- (2) The test report is invalid if not marked with the signatures of the persons responsible for preparing and approving the test report.
- (3) The test report is invalid if there is any evidence and/or falsification.
- (4) The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein.
- (5) This document may not be altered or revised in any way unless done so by BALUN and all revisions are duly noted in the revisions section.
- (6) Content of the test report, in part or in full, cannot be used for publicity and/or promotional purposes without prior written approval from the laboratory.

2 PRODUCT INFORMATION

2.1 Applicant Information

Applicant	Amcrest Technologies LLC
Address	16727 Park Row Dr. Houston, TX 77084

2.2 Manufacturer Information

Manufacturer	PO FUNG ELECTRONIC (HK) INTERNATIONAL GROUP COMPANY
Address	3/F FULOK BLDG 131-133 WING LOK ST SHEUNG WAN HONGKONG

2.3 Factory Information

Factory	N/A
Address	N/A

2.4 General Description for Equipment under Test (EUT)

EUT Type	walkie talkie
Model Under the test	ATR-22
Series Model Name	N/A
Description of Model Name Differentiation	N/A
Hardware Version	N/A
Software Version	N/A
Dimensions (Approx.)	Please refer to "BL-SZ1640195-AW"
Weight (Approx.)	171.76 g (with battery)
Modulation Mode	FM (analog)

2.5 Ancillary Equipment

Ancillary Equipment 1	Battery	
	Brand Name	N/A
	Model No	N/A
	Serial No	N/A
	Capacitance	1800 mA
	Rated Voltage	3.7 V
	Limit Charge Voltage	N/A
Ancillary Equipment 2	AC Adapter (Charger for Battery)	
	Brand Name	N/A
	Model No	N/A
	Serial No	N/A
	Rated Input	110-240 V~, 50/60 Hz
	Rated Output	5V , 500 mA

2.6 Technical Information

The requirement for the following technical information of the EUT was tested in this report:

Operating Mode	Transmitting	
Frequency Range	FM (analog)	406.1MHz ~ 470 MHz
Channels	FM (analog) ^{Note}	Low Channel (406.125 MHz) Lower Channel (416.025 MHz) Middle Channel (439.975 MHz) Higher Channel (448.025 MHz) High Channel (469.975 MHz)
EUT Stage	Portable Device	
Accessories	Belt Clip , Speaker Microphone Attachment	
Antenna Type	External Antenna	
Normal Operation	Face Up and Body-worn	
Exposure Category	Occupational/Controlled Exposure	
Product	Type	
	<input checked="" type="checkbox"/> Production unit	<input type="checkbox"/> Identical prototype

Note:
The manufacturer sets the EUT on the Low Channel (406.125 MHz) as **Channel 1**, the Lower Channel (416.025 MHz) as **Channel 4**, the Middle Channel (439.975 MHz) as **Channel 2**, the Higher Channel (448.025 MHz) as **Channel 5** and the High Channel (469.975 MHz) as **Channel 3**, all channels were tested in this report.

3 SUMMARY OF TEST RESULTS

3.1 Test Standards

No.	Identity	Document Title
1	47 CFR§2.1093	Radiofrequency Radiation Exposure Evaluation: Portable Devices
2	ANSI/IEEE Std. C95.1-2005	IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz
3	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
4	FCC KDB 447498 D01 v06	RF Exposure Procedures and Equipment Authorization Policies for Mobile and Portable Devices
5	FCC KDB 865664 D01 v01r04	SAR Measurement Requirements for 100 MHz to 6 GHz
6	FCC KDB 865664 D02 v01r02	RF Exposure Compliance Reporting and Documentation Considerations
7	FCC KDB 643646 D01 v01r03	SAR Test Reduction Considerations for Occupational PTT Radios

3.2 Device Category and SAR Limit

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 Occupational/Controlled Exposure should be applied for this device, it is 8.0 W/kg as averaged over any 1 gram of tissue.

Table of Exposure Limits:

Body Position	SAR Value (W/Kg)	
	General Population/ Uncontrolled Exposure	Occupational/ Controlled Exposure
Whole-Body SAR (averaged over the entire body)	0.08	0.4
Partial-Body SAR (averaged over any 1 gram of tissue)	1.60	8.0
SAR for hands, wrists, feet and ankles (averaged over any 10 grams of tissue)	4.0	20.0

NOTE:

General Population/Uncontrolled: Locations where there is the exposure of individuals who have no knowledge or control of their exposure. 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.

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

3.3 Summary of SAR Value

Position	Channel	Freq. (MHz)	Maximum Measured SAR (W/kg) 50% duty cycle	Maximum Reported SAR (W/kg)	Limit (W/kg)
Face Up	1	406.125	0.794	0.814	8.0
	2	439.975	0.917	0.962	
	3	469.975	0.475	0.495	
	4	416.025	1.280	1.347	
	5	448.025	0.974	1.018	
Body-worn	1	406.125	2.425	2.487	8.0
	2	439.975	1.240	1.301	
	3	469.975	0.881	0.918	
	4	416.025	2.905	3.056	
	5	448.025	0.999	1.044	
Verdict	Pass				

3.4 SAR Test Uncertainty

3.4.1 Measurement uncertainty evaluation for SAR test

The following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in IEEE 1528: 2013. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2. The system measurement uncertainty frequency range is from 300 MHz to 3 GHz.

Uncertainty Component	Tol (+- %)	Prob. Dist.	Div.	Ci (1g)	Ci (10g)	1g Ui (+-%)	10g Ui (+-%)	Vi
Measurement System								
Probe calibration	5.8	N	1	1	1	5.80	5.80	∞
Axial Isotropy	3.5	R	$\sqrt{3}$	0.7	0.7	1.41	1.41	∞
Hemispherical Isotropy	5.9	R	$\sqrt{3}$	0.7	0.7	2.38	2.38	∞
Boundary effect	1.0	R	$\sqrt{3}$	1	1	0.58	0.58	∞
Linearity	4.7	R	$\sqrt{3}$	1	1	2.71	2.71	∞
System detection limits	1.0	R	$\sqrt{3}$	1	1	0.58	0.58	∞
Readout Electronics	0.5	N	1	1	1	0.50	0.50	∞
Response Time	0.0	R	$\sqrt{3}$	1	1	0.00	0.00	∞
Integration Time	1.4	R	$\sqrt{3}$	1	1	0.81	0.81	∞
RF ambient Conditions - Noise	3.0	R	$\sqrt{3}$	1	1	1.73	1.73	∞
RF ambient Conditions - Reflections	3.0	R	$\sqrt{3}$	1	1	1.73	1.73	∞
Probe positioner Mechanical Tolerance	1.4	R	$\sqrt{3}$	1	1	0.81	0.81	∞
Probe positioning with respect to Phantom Shell	1.4	R	$\sqrt{3}$	1	1	0.81	0.81	∞
Extrapolation, interpolation and integration Algorithms for Max. SAR Evaluation	2.3	R	$\sqrt{3}$	1	1	1.33	1.33	∞
Test sample Related								
Test sample positioning	2.6	N	1	1	1	2.60	2.60	N-1
Device Holder Uncertainty	1.0	N	1	1	1	1.00	1.00	N-1
Output power Variation - SAR drift measurement	5.0	R	$\sqrt{3}$	1	1	2.89	2.89	∞
SAR scaling	2.00	R	$\sqrt{3}$	1	1	1.15	1.15	∞
Phantom and Tissue Parameters								
Phantom Uncertainty (Shape and thickness tolerances)	4.0	R	$\sqrt{3}$	1	1	2.31	2.31	∞
Liquid conductivity (deviation from target values)	2.5	N	$\sqrt{3}$	0.64	0.43	0.92	0.62	∞
Liquid conductivity - measurement uncertainty	5.0	N	1	0.64	0.43	3.20	2.15	M
Liquid permittivity (deviation from target values)	2.5	N	$\sqrt{3}$	0.60	0.49	0.87	0.71	∞
Liquid permittivity - measurement uncertainty	5.0	N	1	0.60	0.49	3.00	2.45	M
Combined Standard Uncertainty		RSS				10.14	9.67	
Expanded Uncertainty (95% Confidence interval)		k				20.29	19.35	

3.4.2 Measurement uncertainty evaluation for system check

This measurement uncertainty budget is suggested by IEEE 1528. The breakdown of the individual uncertainties is as follows:

Uncertainty Component	Tol (+- %)	Prob. Dist.	Div.	Ci (1g)	Ci (10g)	1g Ui (+-%)	10g Ui (+-%)	Vi
Measurement System								
Probe calibration	5.8	N	1	1	1	5.80	5.80	∞
Axial Isotropy	3.5	R	$\sqrt{3}$	0.7	0.7	1.41	1.41	∞
Hemispherical Isotropy	5.9	R	$\sqrt{3}$	0.7	0.7	2.38	2.38	∞
Boundary effect	1.0	R	$\sqrt{3}$	1	1	0.58	0.58	∞
Probe Linearity	4.7	R	$\sqrt{3}$	1	1	2.71	2.71	∞
System detection limits	1.0	R	$\sqrt{3}$	1	1	0.58	0.58	∞
Readout Electronics	0.5	N	1	1	1	0.50	0.50	∞
Response Time	0.0	R	$\sqrt{3}$	1	1	0.00	0.00	∞
Integration Time	1.4	R	$\sqrt{3}$	1	1	0.81	0.81	∞
RF ambient Conditions - Noise	3.0	R	$\sqrt{3}$	1	1	1.73	1.73	∞
RF ambient Conditions - Reflections	3.0	R	$\sqrt{3}$	1	1	1.73	1.73	∞
Probe positioner Mechanical Tolerance	1.4	R	$\sqrt{3}$	1	1	0.81	0.81	∞
Probe positioning with respect to Phantom Shell	1.4	R	$\sqrt{3}$	1	1	0.81	0.81	∞
Extrapolation, interpolation and integration Algorithms for Max. SAR Evaluation	2.3	R	$\sqrt{3}$	1	1	1.33	1.33	∞
Dipole								
Deviation of experimental dipole	5.5	R	$\sqrt{3}$	1	1	3.20	3.20	∞
Dipole axis to liquid distance	2.0	R	1	1	1	1.20	1.20	∞
Power drift	4.7	R	$\sqrt{3}$	1	1	2.70	2.70	∞
Phantom and Tissue Parameters								
Phantom Uncertainty (Shape and thickness tolerances)	4.0	R	$\sqrt{3}$	1	1	2.31	2.31	∞
Liquid conductivity (deviation from target values)	2.5	N	$\sqrt{3}$	0.64	0.43	0.92	0.62	∞
Liquid conductivity - measurement uncertainty	5.0	N	1	0.64	0.43	3.20	2.15	M
Liquid permittivity (deviation from target values)	2.5	N	$\sqrt{3}$	0.60	0.49	0.87	0.71	∞
Liquid permittivity - measurement uncertainty	5.0	N	1	0.60	0.49	3.00	2.45	M
Combined Standard Uncertainty		RSS				10.22	9.75	
Expanded Uncertainty (95% Confidence interval)		k				20.44	19.50	

4 SAR MEASUREMENT SYSTEM

4.1 Definition of Specific Absorption Rate (SAR)

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

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

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

SAR is expressed in units of Watts per kilogram (W/kg) SAR measurement can be related to the electrical field in the tissue by

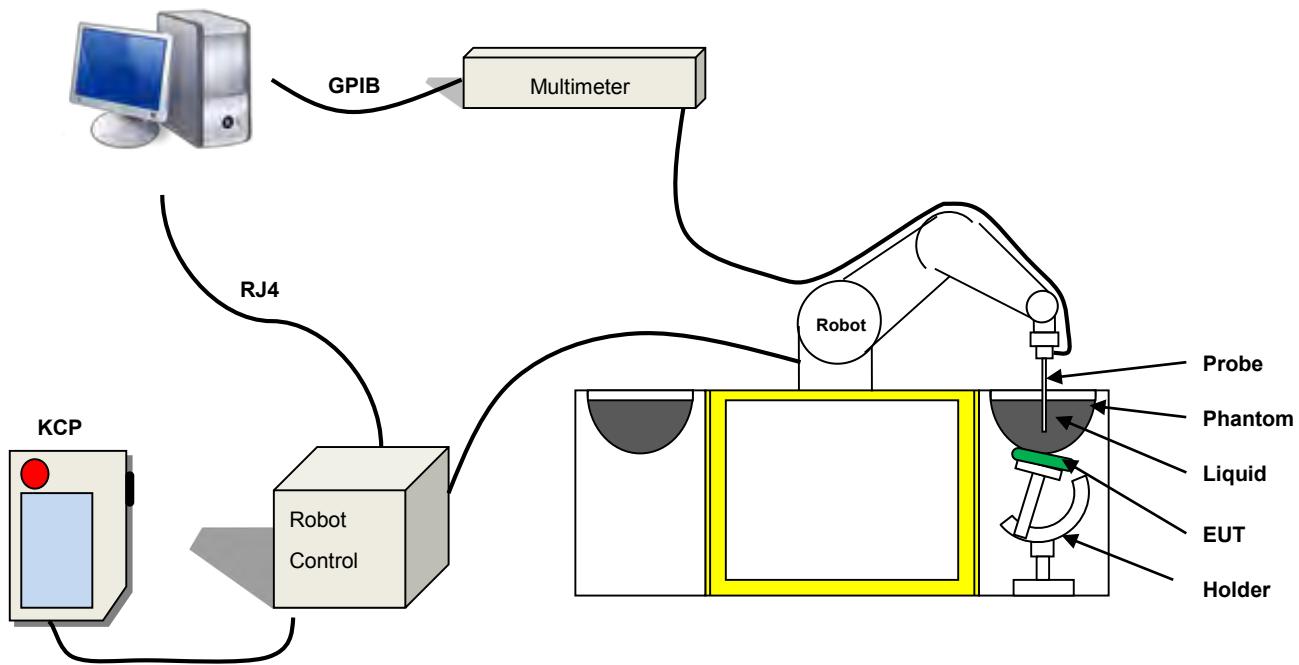
$$\text{SAR} = \frac{\sigma E^2}{\rho}$$

Where: σ is the conductivity of the tissue,

ρ is the mass density of the tissue and E is the RMS electrical field strength.

4.2 SATIMO SAR System

4.2.1 SATIMO SAR System Diagram



These measurements were performed with the automated near-field scanning system OPENSAR from SATIMO. The system is based on a high precision robot (working range: 850 mm), which positions the probes with a positional repeatability of better than ± 0.02 mm. Special E- and H-field probes have been developed for measurements close to material discontinuity, the sensors of which are directly loaded with a Schottky diode and connected via highly resistive lines to the data acquisition unit.

The SAR measurements were conducted with dosimetric probe (manufactured by SATIMO), designed in the classical triangular configuration and optimized for dosimetric evaluation. The probe has been calibrated according to the procedure described in SAR standard with accuracy of better than $\pm 10\%$. The spherical isotropy was evaluated with the procedure described in SAR standard and found to be better than ± 0.25 dB. The phantom used was the SAM Phantom as described in FCC supplement C, IEEE 1528.

4.2.2 Robot

The SATIMO SAR system uses the high precision robots from KUKA. For the 6-axis controller system, the robot controller version (KUKA) from KUKA is used. The KUKA robot series have many features that are important for our application:



- High precision (repeatability ± 0.035 mm)
- High reliability (industrial design)
- Jerk-free straight movements
- Low ELF interference (the closed metallic construction shields against motor control fields)

4.2.3 E-Field Probe

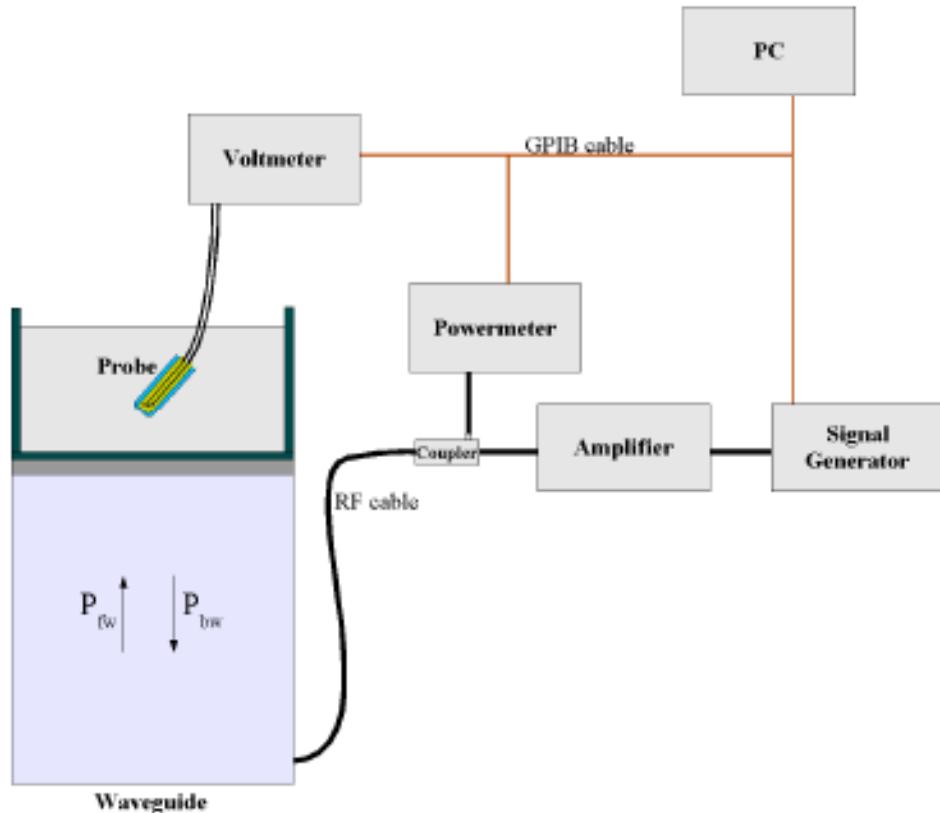
For the measurements the Specific Dosimetric E-Field Probe SN 34/15 EPGO 265 with following specifications is used

- Dynamic range: 0.01-100 W/kg
 - Tip Diameter : 2.5 mm
 - Lower detection limit : 7 mW/kg
(repeatability better than +/- 1mm)
 - Probe linearity: +/- 0.07 dB
 - Calibration range: 450 MHz to 5800 MHz for head & body simulating liquid.
- Angle between probe axis (evaluation axis) and surface normal line: less than 30°



E-Field Probe Calibration Process

Probe calibration is realized, in compliance with CENELEC EN 62209-1/-2 and IEEE 1528 std, with CALISAR, proprietary calibration system. The calibration is performed with the EN 62209-1/2 annexe technique using reference guide.



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

Where :

P_{fw} = Forward Power

P_{bw} = Backward Power

a and b = Waveguide dimensions

l = 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 a NPL calibrated probe, to verify it.

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

$$CF(N) = SAR(N)/V_{lin}(N) \quad (N=1,2,3)$$

The linearised output voltage V_{lin}(N) is obtained from the displayed output voltage V(N) using

$$V_{lin}(N) = V(N) * (1 + V(N)/DCP(N)) \quad (N=1,2,3)$$

Where the DCP is the diode compression point in mV.

4.2.4 Phantoms

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.

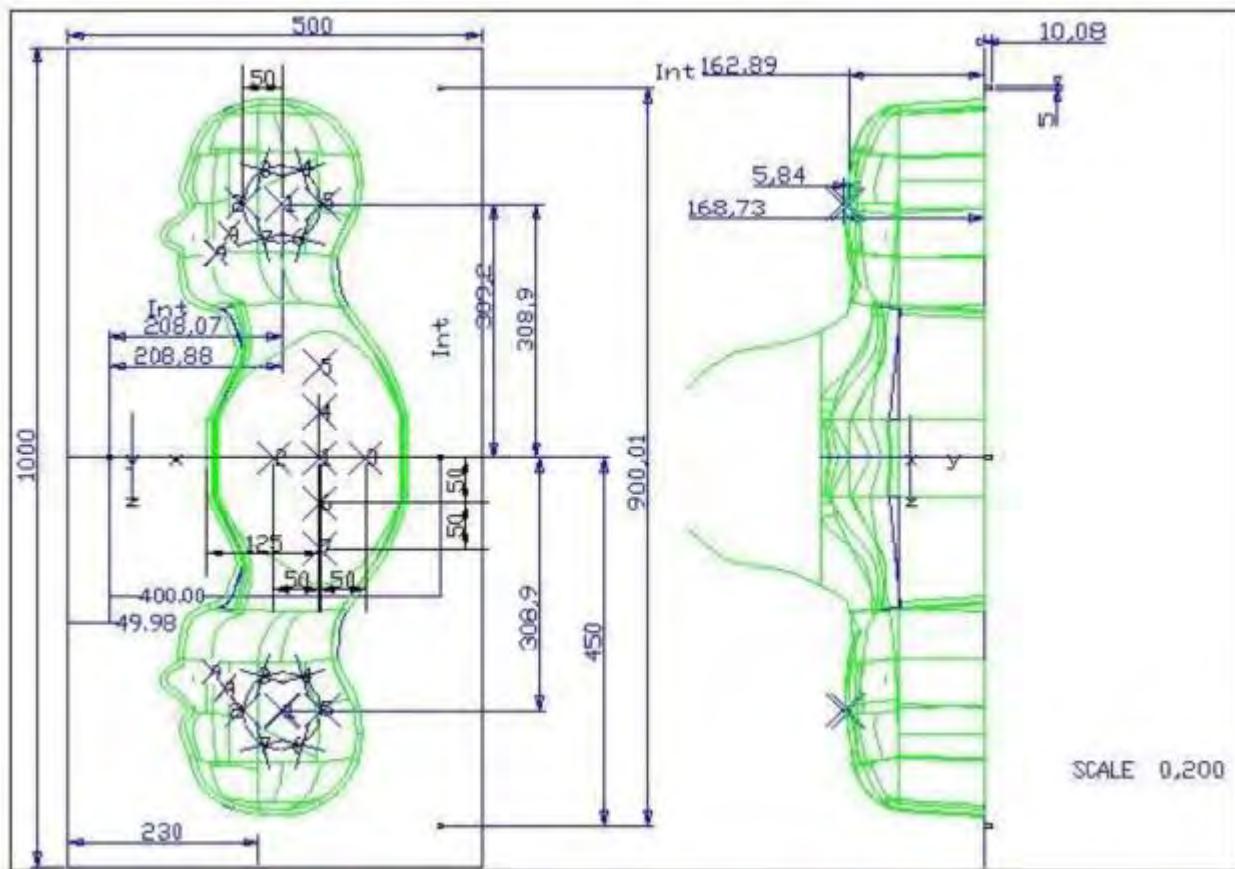
Photo of Phantom SN 30/13 SAM103



Photo of Phantom SN 30/13 SAM104



Serial Number	Positioner Material	Permittivity	Loss Tangent
SN 30/13 SAM103	Gelcoat with fiberglass	3.4	0.02
SN 30/13 SAM104	Gelcoat with fiberglass	3.4	0.02



Serial Number	Left Head		Right Head		Flat Part	
SN 30/13 SAM103	2	2.00	2	2.03	1	2.09
	3	2.02	3	2.05	2	2.10
	4	2.04	4	2.04	3	2.09
	5	2.04	5	2.07	4	2.11
	6	2.02	6	2.07	5	2.11
	7	2.01	7	2.09	6	2.09
	8	2.04	8	2.10	7	2.11
	9	2.02	9	2.09	-	-
SN 30/13 SAM104	2	2.05	2	2.06	1	2.03
	3	2.08	3	2.03	2	2.03
	4	2.05	4	2.03	3	2.01
	5	2.06	5	2.02	4	2.03
	6	2.08	6	2.02	5	2.03
	7	2.06	7	2.04	6	2.00
	8	2.07	8	2.04	7	1.98
	9	2.07	9	2.05	-	-

4.2.5 Device Holder

The SAR in the phantom is approximately inversely proportional to the square of the distance between the source and the liquid surface. For a source at 5 mm distance, a positioning uncertainty of ± 0.5 mm would produce a SAR uncertainty of $\pm 20\%$. Accurate device positioning is therefore crucial for accurate and repeatable measurements. The positions in which the devices must be measured are defined by the standards.

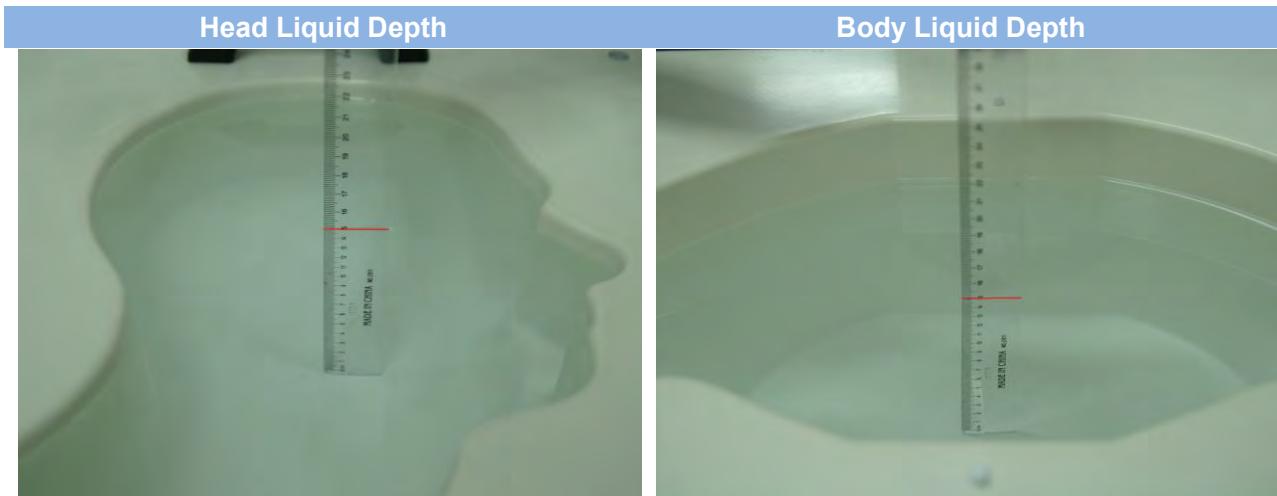


Serial Number	Holder Material	Permittivity	Loss Tangent
SN 25/13 MSH87	Delrin	3.7	0.005
SN 25/13 MSH88	Delrin	3.7	0.005

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

4.2.6 Simulating Liquid

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 15 cm. For head SAR testing, the liquid height from the ear reference point (ERP) of the phantom to the liquid top surface is larger than 15 cm. For body SAR testing, the liquid height from the center of the flat phantom to the liquid top surface is larger than 15 cm. The nominal dielectric values of the tissue simulating liquids in the phantom and the tolerance of 5%.



The following table gives the recipes for tissue simulating liquid and the theoretical Conductivity/Permittivity.

Head (Reference IEEE1528)								
Frequency (MHz)	Water (%)	Sugar (%)	Cellulose (%)	Salt (%)	Preventol (%)	DGBE (%)	Conductivity σ	Permittivity ϵ
450	38.56	56.62	0.98	3.95	0.19	0	0.87	43.5
750	41.1	57.0	0.2	1.4	0.2	0	0.89	41.9
835	40.3	57.9	0.2	1.4	0.2	0	0.90	41.5
900	40.3	57.9	0.2	1.4	0.2	0	0.97	41.5
1800, 1900, 2000	55.2	0	0	0.3	0	44.5	1.4	40.0
2450	55.0	0	0	0.1	0	44.9	1.80	39.2
2600	54.9	0	0	0.1	0	45.0	1.96	39.0
Frequency(MHz)	Water (%)	Hexyl Carbitol (%)			Triton X-100 (%)		Conductivity σ	Permittivity ϵ
5200	62.52	17.24			17.24		4.66	36.0
5800	62.52	17.24			17.24		5.27	35.3
Body (From instrument manufacturer)								
Frequency (MHz)	Water (%)	Sugar (%)	Cellulose (%)	Salt (%)	Preventol (%)	DGBE (%)	Conductivity σ	Permittivity ϵ
450	63.07	0	0	0.72	0	36.22	0.94	55.8
750	51.7	47.2	0	0.9	0.1	0	0.96	55.5
835	50.8	48.2	0	0.9	0.1	0	0.97	55.2
900	50.8	48.2	0	0.9	0.1	0	1.05	55.0
1800, 1900, 2000	70.2	0	0	0.4	0	29.4	1.52	53.3

2450	68.6	0	0	0.1	0	31.3	1.95	52.7
2600	68.2	0	0	0.1	0	31.7	2.16	52.5
Frequency(MHz)	Water	DGBE (%)			Salt (%)		Conductivity	Permittivity
5200	78.60	21.40			/		5.54	47.86
5800	78.50	21.40			0.1		6.0	48.20

5 SYSTEM VERIFICATION

5.1 Antenna Port Test Requirement

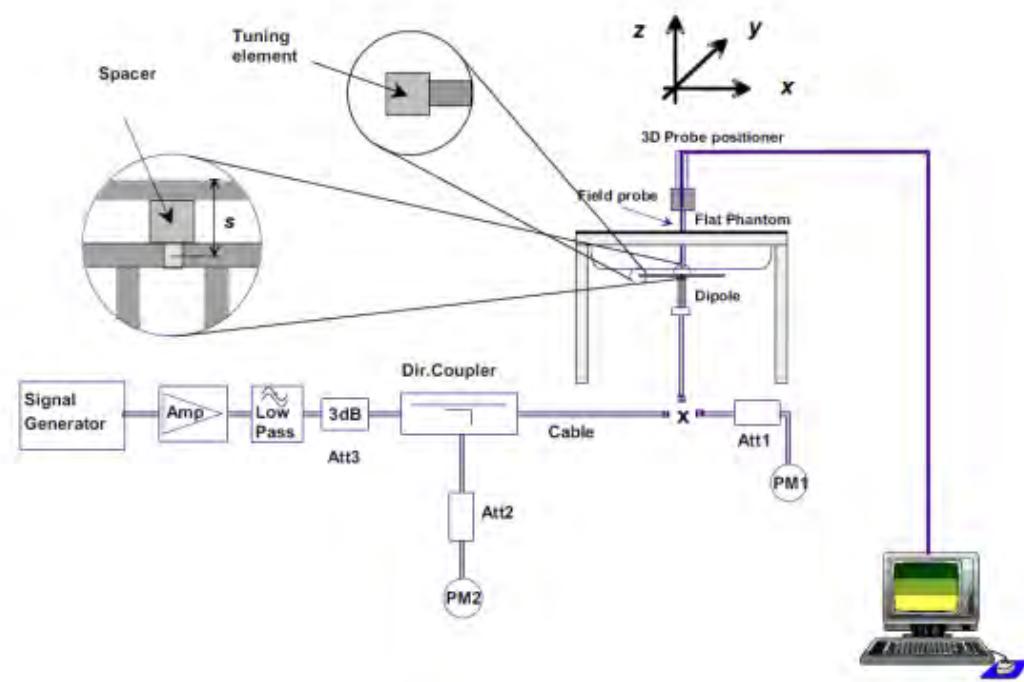
The SATIMO SAR system is equipped with one or more system validation kits. These units together with the predefined measurement procedures within the SATIMO software enable the user to conduct the system performance check and system validation. System validation kit includes a dipole, tripod holder to fix it underneath the flat phantom and a corresponding distance holder.

5.2 Purpose of System Check

The system performance check verifies that the system operates within its specifications. System and operator errors can be detected and corrected. It is recommended that the system performance check be performed prior to any usage of the system in order to guarantee reproducible results. The system performance check uses normal SAR measurements in a simplified setup with a well characterized source. This setup was selected to give a high sensitivity to all parameters that might fail or vary over time. The system check does not intend to replace the calibration of the components, but indicates situations where the system uncertainty is exceeded due to drift or failure.

5.3 System Check Setup

In the simplified setup for system evaluation, the EUT is replaced by a calibrated dipole and the power source is replaced by a continuous wave that 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 equipment setup is shown below:



6 EUT TEST POSITION CONFIGURATIONS

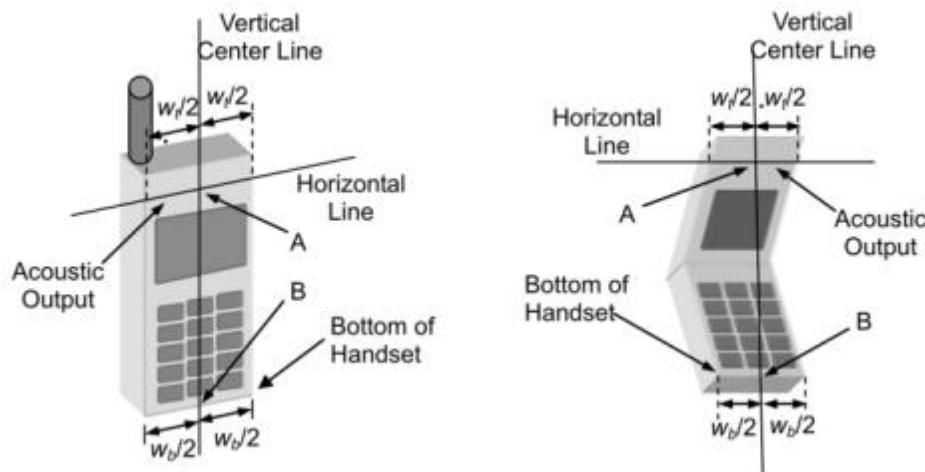
According to KDB 648474 D04 Handset, handsets are tested for SAR compliance in head, body-worn accessory and other use configurations described in the following subsections.

6.1 Head Exposure Conditions

Head exposure is limited to next to the ear voice mode operations. Head SAR compliance is tested according to the test positions defined in IEEE Std 1528-2013 using the SAM phantom illustrated as below.

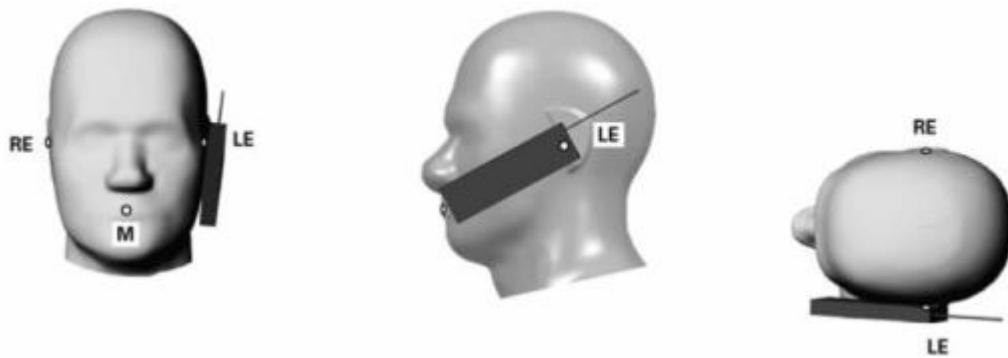
6.1.1 Define two imaginary lines on the handset

- (a) The vertical centerline passes through two points on the front side of the handset - the midpoint of the width w_t of the handset at the level of the acoustic output, and the midpoint of the width w_b of the bottom of the handset.
- (b) The horizontal line is perpendicular to the vertical centerline and passes through the center of the acoustic output. The horizontal line is also tangential to the face of the handset at point A.
- (c) The two lines intersect at point A. Note that for many handsets, point A coincides with the center of the acoustic output; however, the acoustic output may be located elsewhere on the horizontal line. Also note that the vertical centerline is not necessarily parallel to the front face of the handset, especially for clamshell handsets, handsets with flip covers, and other irregularly shaped handsets.



6.1.2 Cheek Position

- (a) To position the device with the vertical center line of the body of the device and the horizontal line crossing the center piece in a plane parallel to the sagittal plane of the phantom. While maintaining the device in this plane, align the vertical center line with the reference plane containing the three ear and mouth reference point (M: Mouth, RE: Right Ear, and LE: Left Ear) and align the center of the ear piece with the line RE-LE.
- (b) To move the device towards the phantom with the ear piece aligned with the line LE-RE until the phone touched the ear. While maintaining the device in the reference plane and maintaining the phone contact with the ear, move the bottom of the phone until any point on the front side is in contact with the cheek of the phantom or until contact with the ear is lost.



6.1.3 Tilted Position

- To position the device in the “cheek” position described above.
- While maintaining the device the reference plane described above and pivoting against the ear, moves it outward away from the mouth by an angle of 15 degrees or until contact with the ear is lost.

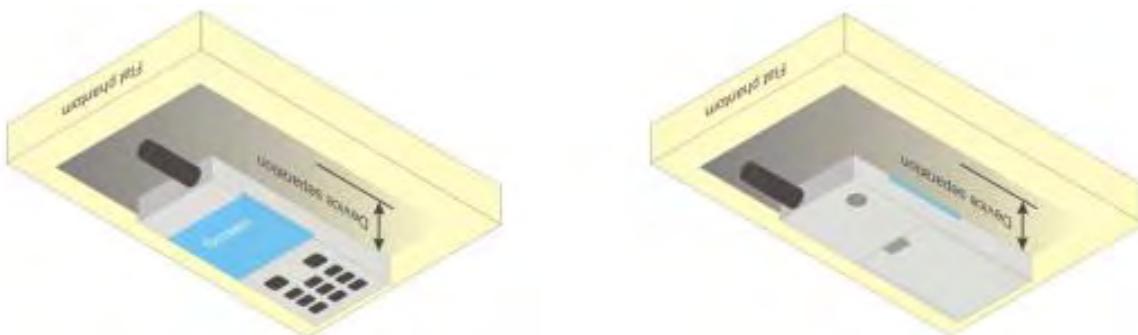


6.2 Body-worn Position Conditions

Body-worn accessory exposure is typically related to voice mode operations when handsets are carried in body-worn accessories. The body-worn accessory procedures in KDB 447498 are used to test for body-worn accessory SAR compliance, without a headset connected to it. This enables the test results for such configuration to be compatible with that required for hotspot mode when the body-worn accessory test separation distance is greater than or equal to that required for hotspot mode. When the reported SAR for a body-worn accessory, measured without a headset connected to the handset, is $> 1.2 \text{ W/kg}$, the highest reported SAR configuration for that wireless mode and frequency band should be repeated for that body-worn accessory with a headset attached to the handset.

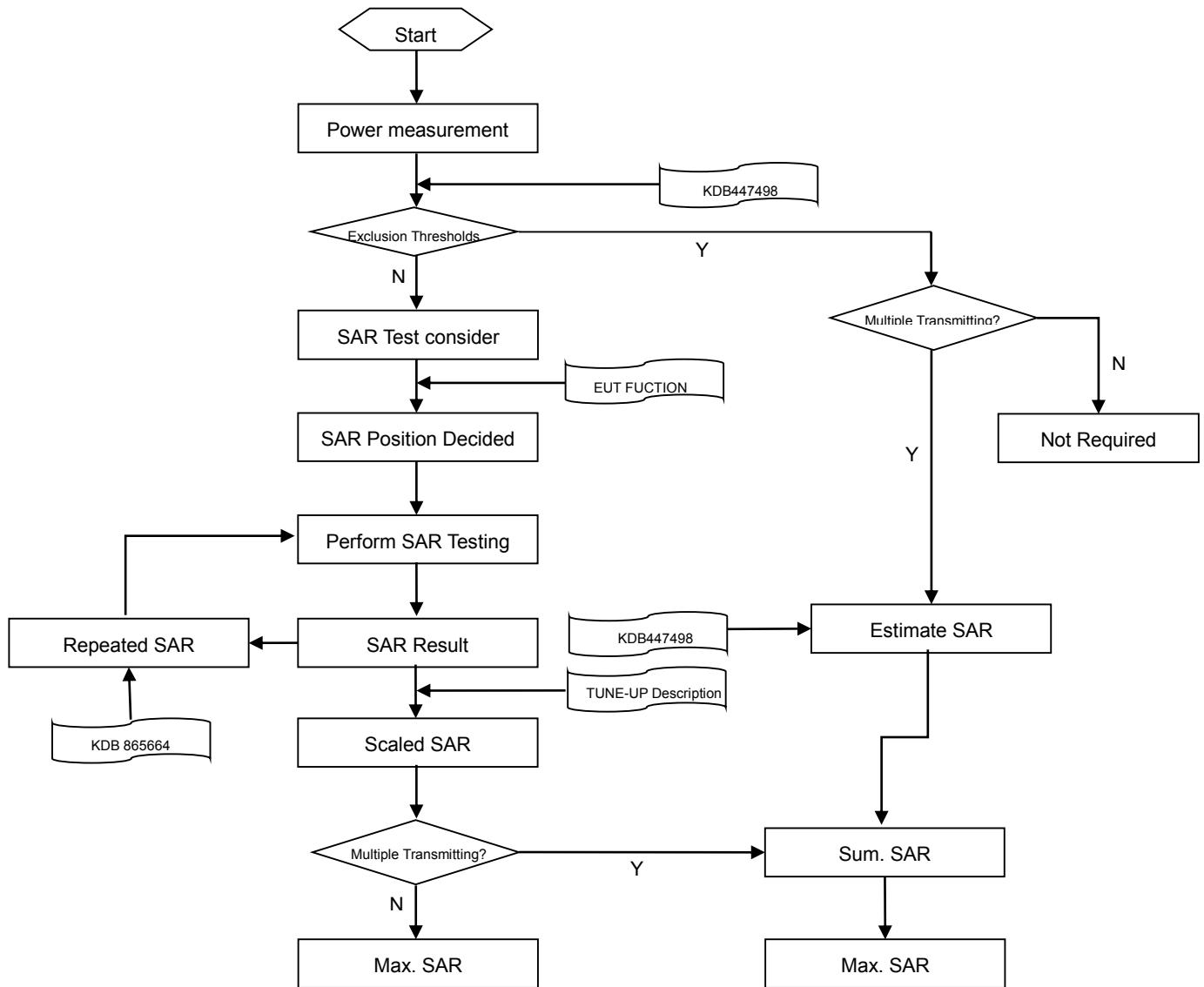
Body-worn accessories that do not contain metallic or conductive components may be tested according to worst-case exposure configurations, typically according to the smallest test separation distance required for the group of body-worn accessories with similar operating and exposure characteristics. All body-worn accessories containing metallic components are tested in conjunction with the host device.

Body-worn accessory SAR compliance is based on a single minimum test separation distance for all wireless and operating modes applicable to each body-worn accessory used by the host, and according to the relevant voice and/or data mode transmissions and operations. If a body-worn accessory supports voice only operations in its normal and expected use conditions, testing of data mode for body-worn compliance is not required. A conservative minimum test separation distance for supporting off-the-shelf body-worn accessories that may be acquired by users of consumer handsets is used to test for body-worn accessory SAR compliance. This distance is determined by the handset manufacturer, according to the requirements of Supplement C 01-01. Devices that are designed to operate on the body of users using lanyards and straps, or without requiring additional body-worn accessories, will be tested using a conservative minimum test separation distance $\leq 5 \text{ mm}$ to support compliance.



7 SAR MEASUREMENT PROCEDURES

7.1 SAR Measurement Process Diagram



7.2 SAR Scan General Requirements

Probe boundary effect error compensation is required for measurements with the probe tip closer than half a probe tip diameter to the phantom surface. Both the probe tip diameter and sensor offset distance must satisfy measurement protocols; to ensure probe boundary effect errors are minimized and the higher fields closest to the phantom surface can be correctly measured and extrapolated to the phantom surface for computing 1-g SAR. Tolerances of the post-processing algorithms must be verified by the test laboratory for the scan resolutions used in the SAR measurements, according to the reference distribution functions specified in IEEE Std 1528-2013.

		$\leq 3\text{GHz}$	$>3\text{GHz}$		
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface		$5 \pm 1 \text{ mm}$	$\frac{1}{2} \cdot \delta \cdot \ln(2) \pm 0.5 \text{ mm}$		
Maximum probe angle from probe axis to phantom surface normal at the measurement location		$30^\circ \pm 1^\circ$	$20^\circ \pm 1^\circ$		
		$\leq 2 \text{ GHz}: \leq 15 \text{ mm}$ $2 - 3 \text{ GHz}: \leq 12 \text{ mm}$	$3 - 4 \text{ GHz}: \leq 12 \text{ mm}$ $4 - 6 \text{ GHz}: \leq 10 \text{ mm}$		
Maximum area scan spatial resolution: $\Delta x \text{ Area}$, $\Delta y \text{ Area}$		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: $\Delta x \text{ Zoom}$, $\Delta y \text{ Zoom}$		$\leq 2 \text{ GHz}: \leq 8 \text{ mm}$ $2 - 3 \text{ GHz}: \leq 5 \text{ mm}^*$	$3 - 4 \text{ GHz}: \leq 5 \text{ mm}^*$ $4 - 6 \text{ GHz}: \leq 4 \text{ mm}^*$		
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z \text{ Zoom (n)}$	$\leq 5 \text{ mm}$	$3 - 4 \text{ GHz}: \leq 4 \text{ mm}$		
			$4 - 5 \text{ GHz}: \leq 3 \text{ mm}$		
			$5 - 6 \text{ GHz}: \leq 2 \text{ mm}$		
	graded grid	$\leq 4 \text{ mm}$	$3 - 4 \text{ GHz}: \leq 3 \text{ mm}$		
			$4 - 5 \text{ GHz}: \leq 2.5 \text{ mm}$		
	$\Delta z \text{ Zoom (n>1)}: \text{between subsequent points}$		$5 - 6 \text{ GHz}: \leq 2 \text{ mm}$		
			$\leq 1.5 \cdot \Delta z \text{ Zoom (n-1)}$		
Minimum zoom scan volume	x, y, z	$\geq 30 \text{ mm}$	$3 - 4 \text{ GHz}: \geq 28 \text{ mm}$		
			$4 - 5 \text{ GHz}: \geq 25 \text{ mm}$		
			$5 - 6 \text{ GHz}: \geq 22 \text{ mm}$		
Note:					
1. δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details.					
2. * When zoom scan is required and the reported SAR from the area scan based 1-g SAR estimation procedures of KDB 447498 is $\leq 1.4 \text{ W/kg}$, $\leq 8 \text{ mm}$, $\leq 7 \text{ mm}$ and $\leq 5 \text{ mm}$ zoom scan resolution may be applied, respectively, for 2 GHz to 3GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.					

7.3 SAR Measurement Procedure

The following steps are used for each test position

- 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
- Measurement of the local E-field value at a fixed location. This value serves as a reference value for calculating a possible power drift.
- Measurement of the SAR distribution with a grid of 8 to 16mm * 8 to 16 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.
- 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.

7.4 Area & Zoom Scan Procedures

First Area Scan is used to locate the approximate location(s) of the local peak SAR value(s). The measurement grid within an Area Scan is defined by the grid extent, grid step size and grid offset. Next, in order to determine the EM field distribution in a three-dimensional spatial extension, Zoom Scan is required. The Zoom Scan is performed around the highest E-field value to determine the averaged SAR-distribution over 10 g. Area scan and zoom scan resolution setting follows KDB 865664 quoted below.

When the 1-g SAR of the highest peak is within 2 dB of the SAR limit, additional zoom scans are required for other peaks within 2 dB of the highest peak that have not been included in any zoom scan to ensure there is no increase in SAR.

7.5 PTT Measurement Procedures

The operating configurations of handheld PTT two-way radios generally require SAR testing for in-front of the face and body-worn accessory exposure conditions. A duty factor of 50% should be applied to determine compliance for radios with maximum operating duty factors $\leq 50\%$. Radios with higher duty factors must apply the maximum duty factor supported by the device to determine compliance. For example, up to 100% duty factor may be required for certain radios that support operator-assisted PSTN calls. A duty factor of 75% may be applied for PTT radios with Bluetooth or voice activated transmission capabilities to avoid the justification required for using a lower duty factor than what is supported by certain features built-in within the radio. When TDMA applies, the time slot inherent duty factor should also be taken into consideration. For PTT radios operating in the 100 MHz to 1 GHz range, according to general population exposure requirements, SAR test exclusion may be applied for in-front-of the face and body-worn accessory exposure conditions, according to the SAR Test Exclusion Threshold conditions and duty factor compensated maximum conducted output power. When a body-worn accessory is not supplied with the PTT radio, a test separation distance ≤ 10 mm must be applied to determine body-worn accessory SAR test exclusion. A test separation distance of 25 mm must be applied for in-front-of the face SAR test exclusion and SAR measurements. When body-worn accessory SAR testing is required, the body-worn accessory requirements in section 4.2.2 should be applied. PTT two-way radios that support held-to-ear operating mode must also be tested according to the exposure configurations required for handsets in KDB 648474 D04. This generally does not apply to cellphones with PTT options that have already been tested in more conservative configurations in applicable wireless modes for SAR compliance at 100% duty factor. When occupational exposure limits apply, the procedures in KDB 643646 are required.

8 CONDUCTED RF OUTPUT POWER

Modulation	Channel	Frequency (MHz)	Peak Power	
			(dBm)	(mW)
Analog	1	406.125	32.19	1655.77
	2	439.975	32.09	1618.08
	3	469.975	32.12	1629.30
	4	416.025	32.08	1614.36
	5	448.025	32.11	1625.55

Tune-up power range (Peak Power)

Modulation	Tune-up power(dBm)	Tune-up power range(dBm)
Analog	32.10 ± 0.2	31.90 ~ 32.30

9 SAR TEST RESULTS

9.1 Test Result (1g value)

Liquid Type	Modulation	Ch.	Freq. (MHz)	Power Drift (%)	Meas. SAR 100% duty cycle (W/Kg)	50% duty cycle (W/Kg)	Meas. Power (dBm)	Max. tune-up Power (dBm)	Scaling Factor	Scaled SAR (W/Kg)	Meas. No.
Face Up (25mm)											
Head Liquid	Analog	1	406.125	-3.94	1.588	0.794	32.19	32.30	1.03	0.814	1#
		2	439.975	-2.99	1.834	0.917	32.09	32.30	1.05	0.962	2#
		3	469.975	-3.12	0.949	0.475	32.12	32.30	1.04	0.495	3#
		4	416.025	-1.6	2.559	1.280	32.08	32.30	1.05	1.347	4#
		5	448.025	-1.07	1.351	0.974	32.11	32.30	1.04	1.018	5#
Body-worn (0mm)											
Body Liquid	Analog	1	406.125	-2.96	4.850	2.425	32.19	32.30	1.03	2.487	6#
		2	439.975	-2.25	2.479	1.240	32.09	32.30	1.05	1.301	7#
		3	469.975	-1.26	1.761	0.881	32.12	32.30	1.04	0.918	8#
		4	416.025	-4.55	5.810	2.905	32.08	32.30	1.05	3.056	9#
		5	448.025	-2.61	1.998	0.999	32.11	32.30	1.04	1.044	10#
Note 1: Refer to ANNEX C for the detailed test data for each test configuration.											

Note:

1. There are just default battery, antenna and body-worn accessory in this project;
2. During the test, EUT is configured with 100% duty cycle. 50% duty cycle applies to FM Modulation;
3. This handheld PTT two-way radios has only a mechanical PTT button and no other operating modes;
4. The number of test channels is determined by the number-of-test-channels formula in KDB 447498 D01.
5. Refer to KDB 447498 D01, handheld PTT two-way radios generally require SAR testing for in-front-of the face and body-worn accessory exposure conditions;

According to KDB 643646 D01, when testing antennas with the default battery:

1. When the SAR ≤ 3.5 W/kg, testing of all other required channels is not necessary for that antenna;
2. When the SAR > 3.5 W/kg and ≤ 4.0 W/kg, testing of the required immediately adjacent channel(s) is not necessary, testing of the other required channels may still be required;
3. When the SAR > 4.0 W/kg and ≤ 6.0 W/kg, SAR should be measured for that antenna on the required immediately adjacent channels, testing of the other required channels still needs consideration;
4. When the SAR > 6.0 W/kg, test all required channels for that antenna;
5. When the highest measured SAR is ≤ 6.0 W/kg, PAG is not required.

9.2 SAR Measurement Variability

According to KDB 865664, SAR measurement variability was assessed for each frequency band, which is determined by the SAR probe calibration point and tissue-equivalent medium used for the device measurements. When both head and body tissue-equivalent media are required for SAR measurements in a frequency band, the variability measurement procedures should be applied to the tissue medium with the highest measured SAR, using the highest measured SAR configuration for that tissue-equivalent medium. Alternatively, if the highest measured SAR for both head and body tissue-equivalent media are $\leq 1.45 \text{ W/kg}$ and the ratio of these highest SAR values, i.e., largest divided by smallest value, is ≤ 1.10 , the highest SAR configuration for either head or body tissue-equivalent medium may be used to perform the repeated measurement. 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.

SAR repeated measurement procedure:

1. When the highest measured SAR is $< 0.80 \text{ W/kg}$, repeated measurement is not required.
2. When the highest measured SAR is $\geq 0.80 \text{ W/kg}$, repeat that measurement once.
3. 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 $\geq 1.45 \text{ W/kg}$, perform a second repeated measurement.
4. If the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20 , and the original, first or second repeated measurement is $\geq 1.5 \text{ W/kg}$, perform a third repeated measurement.

The same procedures should be adapted for measurements according to extremity and occupational exposure limits by applying a factor of 2.5 for extremity exposure and a factor of 5 for occupational exposure to the corresponding SAR thresholds.

Note:

The highest measured 50% duty cycle SAR is $2.905 < 4.0 \text{ W/kg}$, repeated measurement is not required.

10 TEST EQUIPMENTS LIST

Description	Manufacturer	Model	Serial No.	Cal. Date	Cal. Due
PC	Dell	N/A	N/A	N/A	N/A
450MHz Dipole	SATIMO	SID450	S/N 25/13 DIP 0G450-252	2015/03/16	2018/03/15
E-Field Probe	MVG	SSE2	S/N 34/15 EPGO 265	2015/10/12	2016/10/11
Antenna	SATIMO	ANTA3	SN 17/13 ZNTA45	N/A	N/A
Phantom1	SATIMO	SAM	SN 30/13 SAM013	N/A	N/A
Phantom2	SATIMO	SAM	SN 30/13 SAM014	N/A	N/A
Dielectric Probe Kit	SATIMO	SCLMP	SN 25/13 OCPG56	2015/08/17	2016/08/16
MultiMeter	Keithley	MultiMeter 2000	4024022	2015/07/17	2016/07/16
Signal Generator	R&S	SMBV100A	260592	2015/07/16	2016/07/15
Power Meter	Agilent	E4419B	GB40201833	2015/10/14	2016/10/13
Power Sensor	R&S	NRP-Z21	103971	2015/07/21	2016/07/20
Power Amplifier	SATIMO	6552B	22374	2016/05/18	2017/05/19
Network Analyzer	R&S	ZVL-6	101380	2015/07/16	2016/07/15
Attenuator	COM-MW	ZA-S1-31	1305003187	N/A	N/A
Directional coupler	AA-MCS	AAMCS-UDC	000272	N/A	N/A

Note: Per KDB 865664 D01, Dipole SAR Validation Verification, BALUN LAB has adopted 3 years calibration intervals. On annual basis, every measurement dipole has been evaluated and is in compliance with the following criteria:

1. There is no physical damage on the dipole;
2. System validation with specific dipole is within 10% of calibrated value;
3. Return-loss is within 20% of calibrated measurement.

ANNEX A SIMULATING LIQUID VERIFICATION RESULT

The dielectric parameters of the liquids were verified prior to the SAR evaluation using an SATIMO SCLMP Dielectric Probe Kit.

Date	Liquid Type	Freq. (MHz)	Temp. (°C)	Meas. Conductivity (σ)	Meas. Permittivity (ϵ)	Target conductivity (σ)	Target Permittivity (ϵ)	Conductivity tolerance (%)	Permittivity tolerance (%)
2016.05.30	Head	450	20.3	0.87	44.07	0.87	43.50	-1.11	0.05
2016.05.30	Body	450	20.3	0.95	56.70	0.94	56.70	1.46	-3.62

Note: The tolerance limit of Conductivity and Permittivity is $\pm 5\%$.

ANNEX B SYSTEM CHECK RESULT

Comparing to the original SAR value provided by SATIMO, the validation data should be within its specification of 10 % (for 1g).

Date	Liquid Type	Freq. (MHz)	Power (mW)	Measured SAR (W/kg)	Normalized SAR (W/kg)	Dipole SAR (W/kg)	Tolerance (%)	Targeted SAR(W/kg)	Tolerance (%)
2016.05.30	Head	450	100	0.469	4.69	4.73	-0.85	4.58	2.40
2016.05.30	Body	450	100	0.479	4.79	4.81	-0.42	4.58	4.59

Note: The tolerance limit of System validation is ±10%.

System Performance Check Data(450MHz Head)

Type: Phone measurement (Complete)

E-Field Probe: SN 34/15 SSE2 EPGO265

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

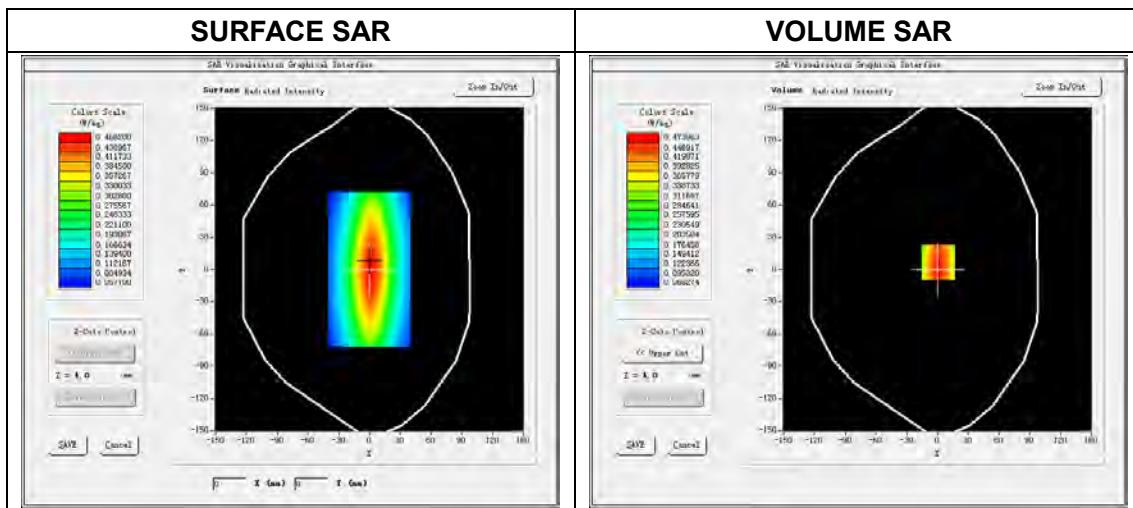
Zoom scan resolution: dx=8mm, dy=8mm, dz=5mm

Date of measurement: 2016.05.30

Measurement duration: 13 minutes 54 seconds

Experimental conditions.

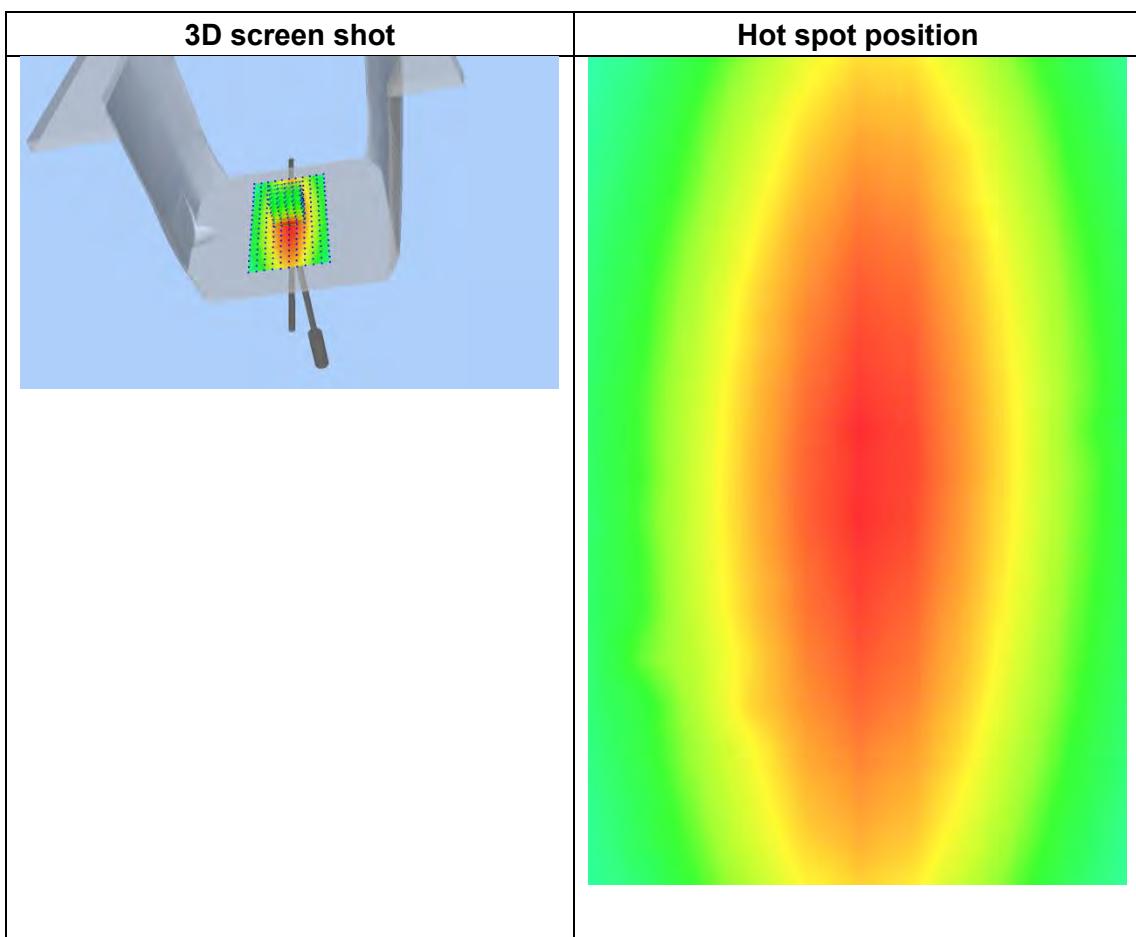
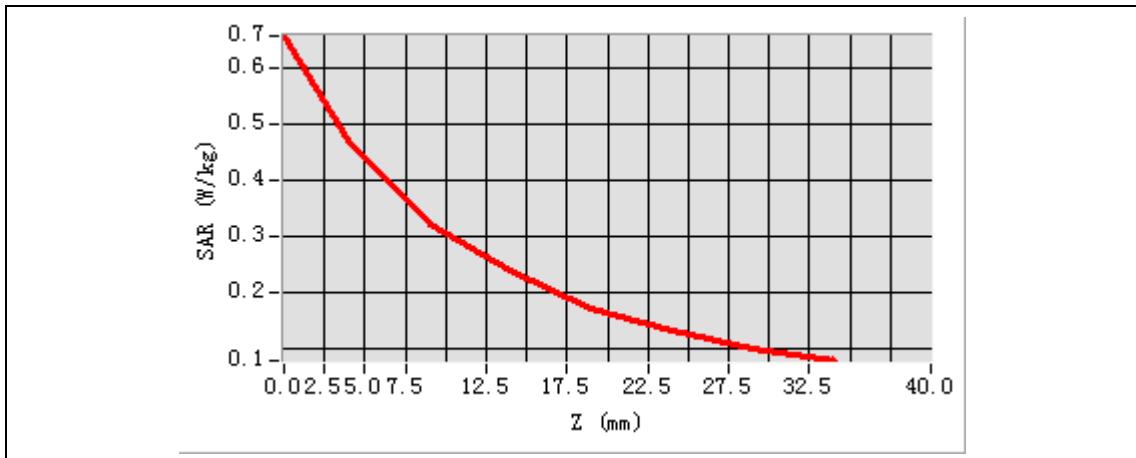
Phantom File	surf_sam_plan.txt
Phantom	Validation plane
Band	450MHz
Signal	CW
Frequency (MHz)	450 MHz
Relative permittivity (real part)	44.072216
Conductivity (S/m)	0.874515
Power drift (%)	0.220000
Ambient Temperature:	21.6°C
Liquid Temperature:	20.3°C
ConvF:	1.85
Crest factor:	1:1



Maximum location: X=1.00, Y=7.00
SAR Peak: 0.63 W/kg

SAR 10g (W/Kg)	0.315630
SAR 1g (W/Kg)	0.469289

Z Axis Scan



System Performance Check Data(450MHz Body)

Type: Phone measurement (Complete)

E-Field Probe: SN 34/15 SSE2 EPGO265

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

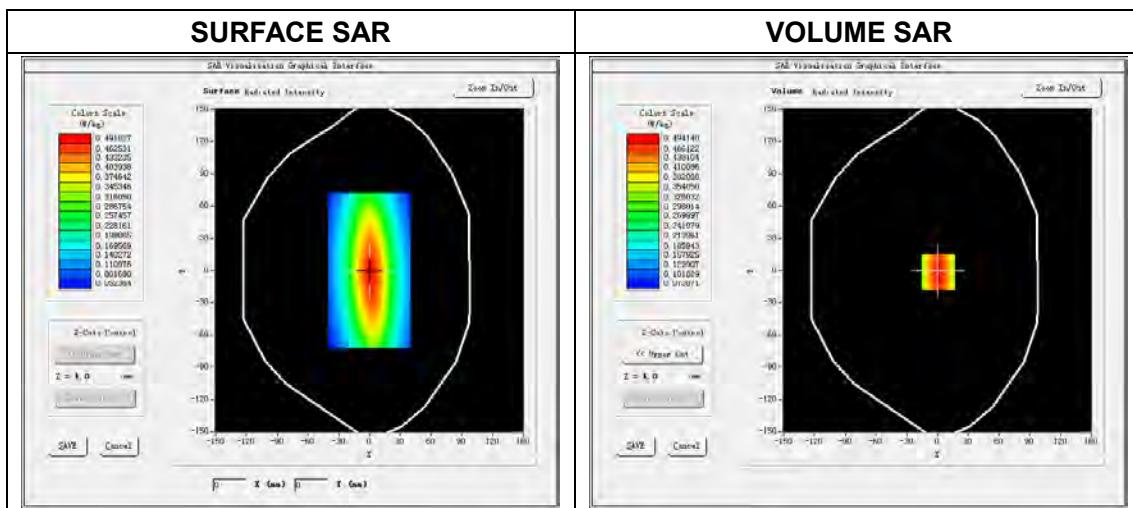
Zoom scan resolution: dx=8mm, dy=8mm, dz=5mm

Date of measurement: 2016.05.30

Measurement duration: 13 minutes 46 seconds

Experimental conditions.

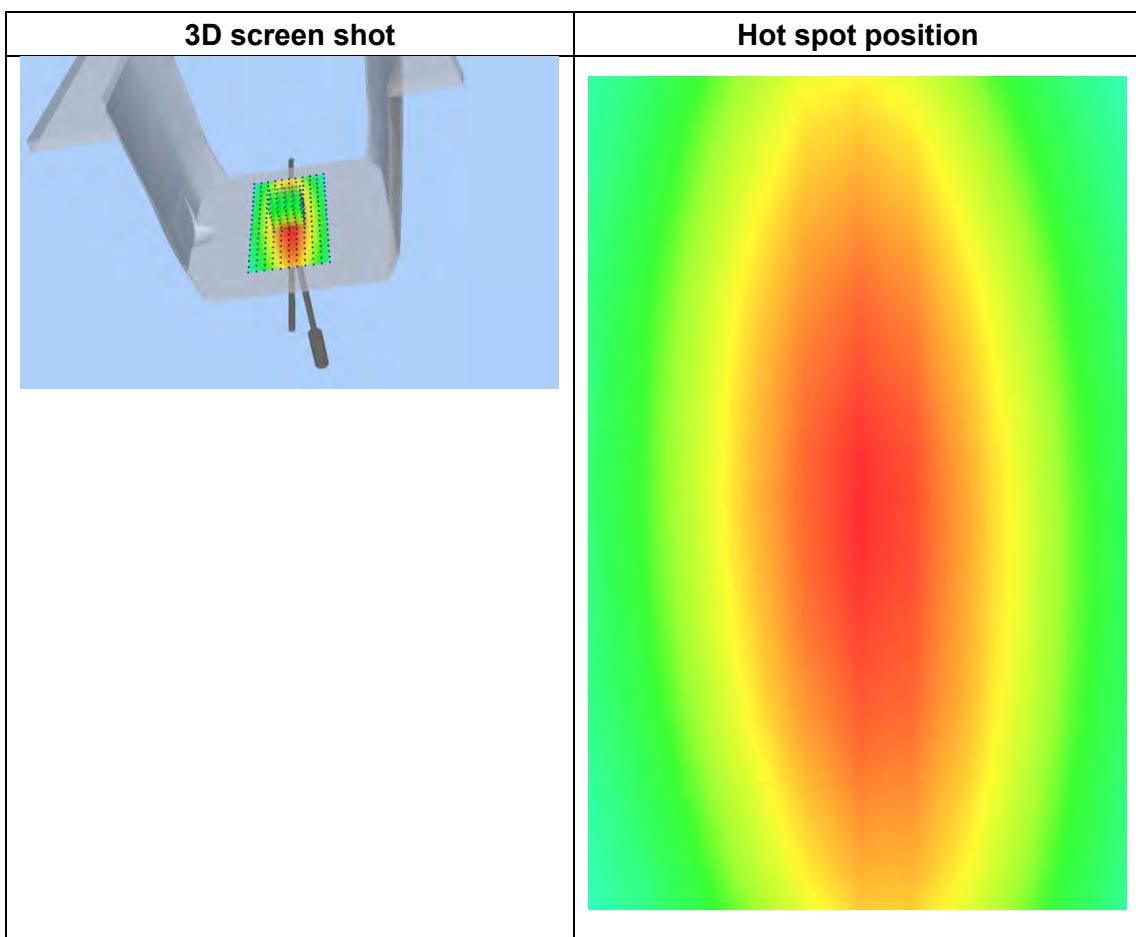
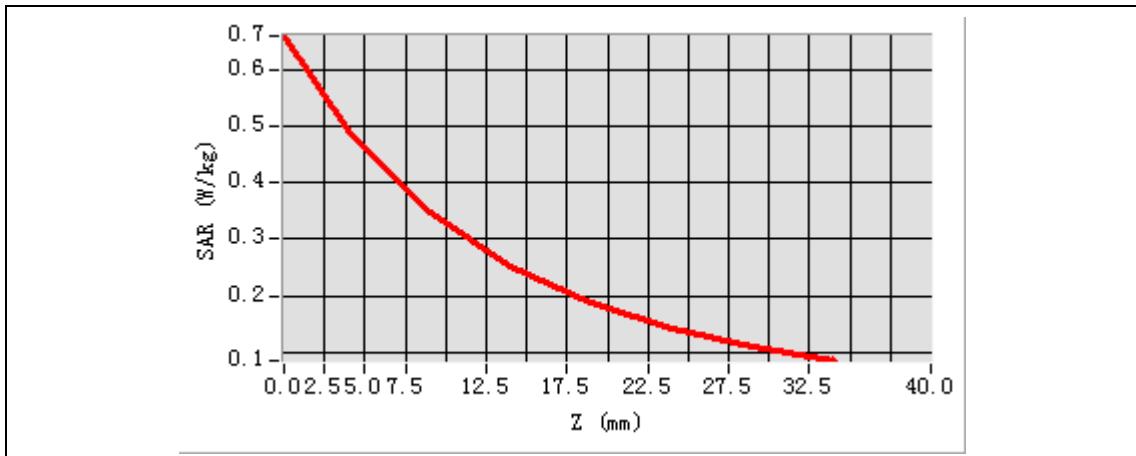
Phantom File	surf_sam_plan.txt
Phantom	Validation plane
Band	450MHz
Signal	CW
Frequency (MHz)	450 MHz
Relative permittivity (real part)	56.695342
Conductivity (S/m)	0.954490
Power drift (%)	-1.370000
Ambient Temperature:	21.6°C
Liquid Temperature:	20.3°C
ConvF:	1.90
Crest factor:	1:1



Maximum location: X=1.00, Y=-1.00
SAR Peak: 0.66 W/kg

SAR 10g (W/Kg)	0.318542
SAR 1g (W/Kg)	0.478889

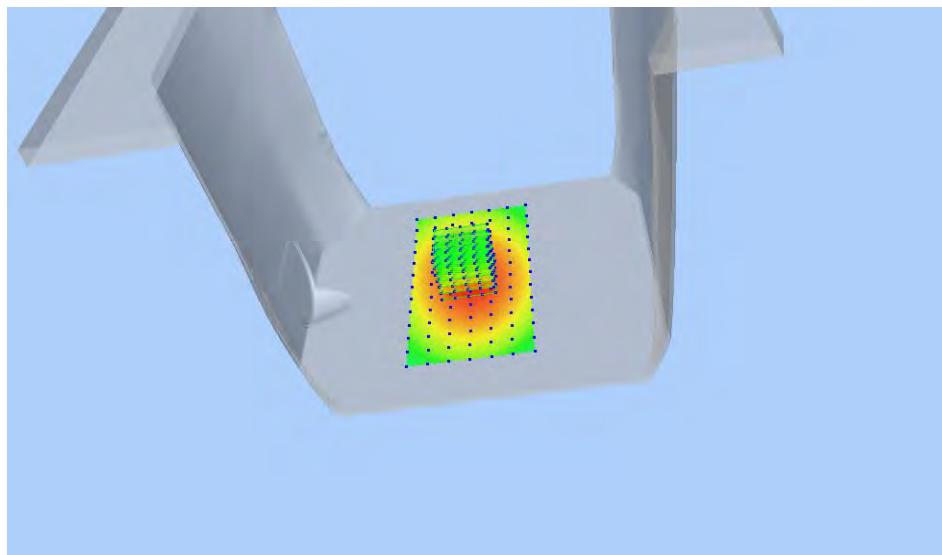
Z Axis Scan



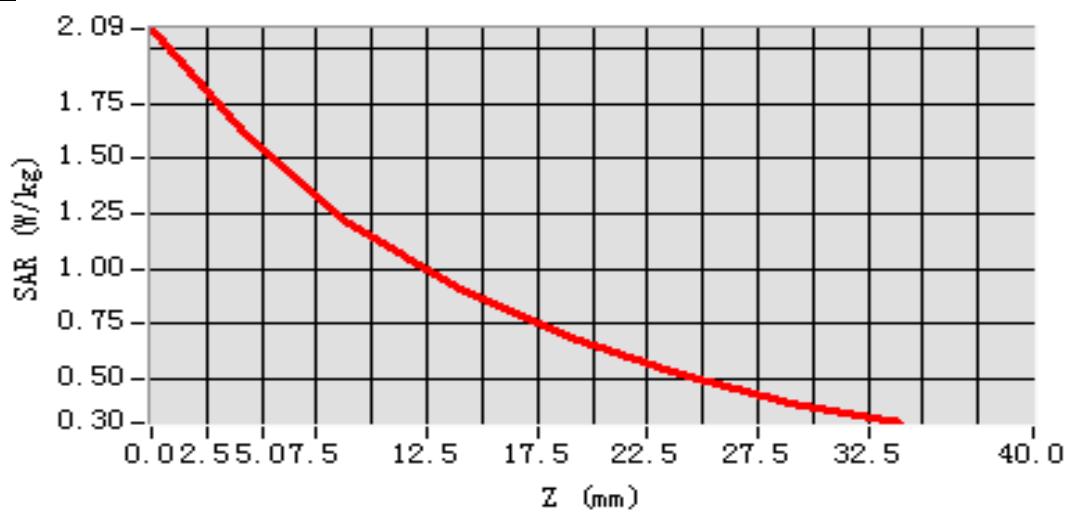
ANNEX C TEST DATA

MEAS. 1 Body Plane with Front of Face on Channel 1 in FM mode

Test Date: 30/5/2016
Measurement duration: 10 minutes 2 seconds
Signal: FM, f=406.125 MHz, Duty Cycle: 1:1.0
Liquid Parameters: Permittivity: 44.95; Conductivity: 0.83 S/m
Test condition: Ambient Temperature: 21.6°C, Liquid Temperature: 20.3°C
Probe: SN 34/15 SSE2 EPGO265, ConvF: 1.85
Area Scan: sam_direct_droit2_surf12mm.txt, h= 5.00 mm
Zoom Scan: 5x5x7,dx=8mm, dy=8mm, dz=5mm,Complete
Maximum location: X=-4.000000, Y=0.000000
SAR 10g (W/Kg): 1.148452
SAR 1g (W/Kg): 1.588124
Power drift (%): -3.94
3D screen shot

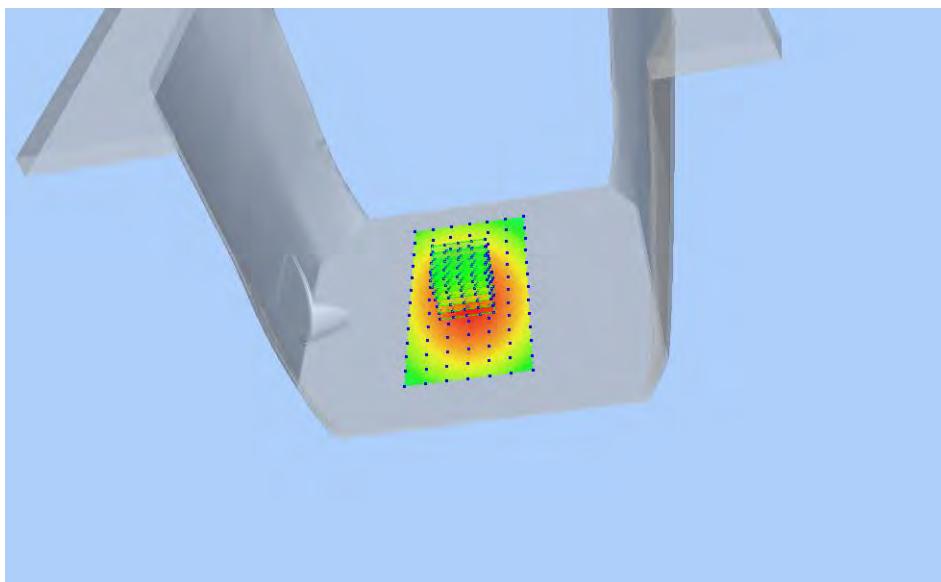


Z Axis Scan

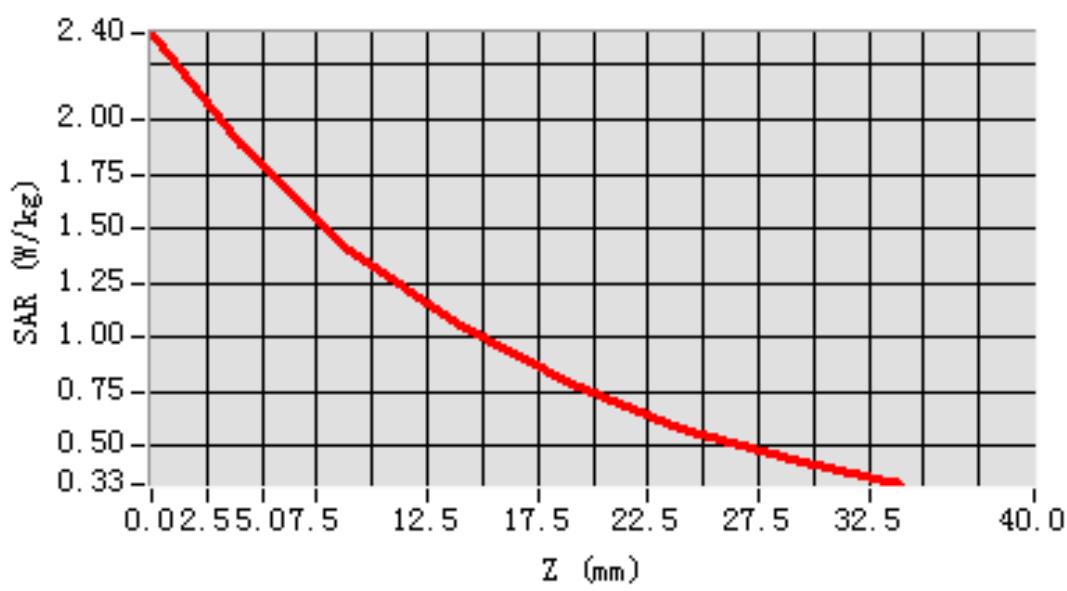


MEAS. 2 Body Plane with Front of Face on Channel 2 in FM mode

Test Date: 30/5/2016
Measurement duration: 10 minutes 3 seconds
Signal: FM, f=439.975 MHz, Duty Cycle: 1:1.0
Liquid Parameters: Permittivity: 44.65; Conductivity: 0.86 S/m
Test condition: Ambient Temperature: 21.6°C, Liquid Temperature: 20.3°C
Probe: SN 34/15 SSE2 EPGO265, ConvF: 1.85
Area Scan: sam_direct_droit2_surf12mm.txt, h= 5.00 mm
Zoom Scan: 5x5x7,dx=8mm, dy=8mm, dz=5mm,Complete
Maximum location: X=-4.000000, Y=0.000000
SAR 10g (W/Kg): 1.327222
SAR 1g (W/Kg): 1.833678
Power drift (%): -2.99
3D screen shot

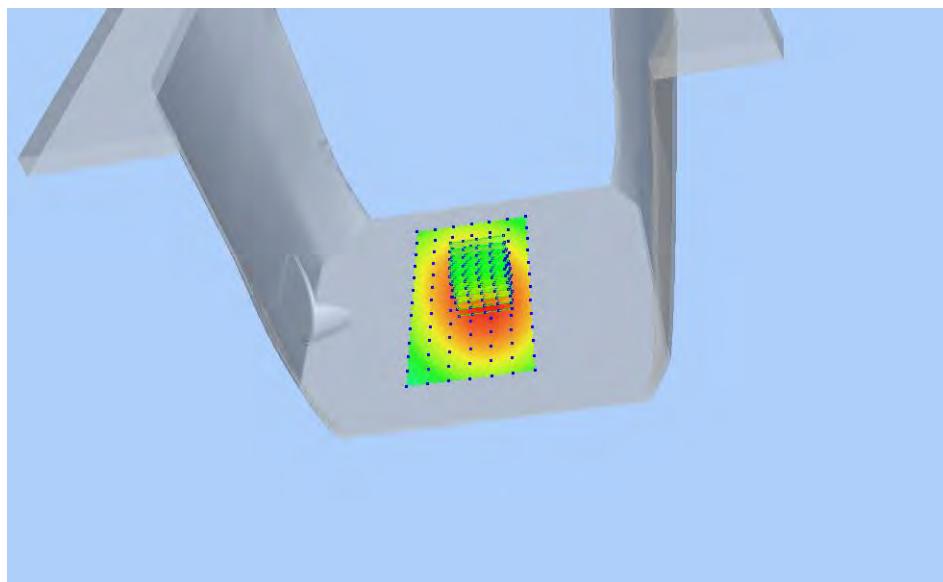


Z Axis Scan

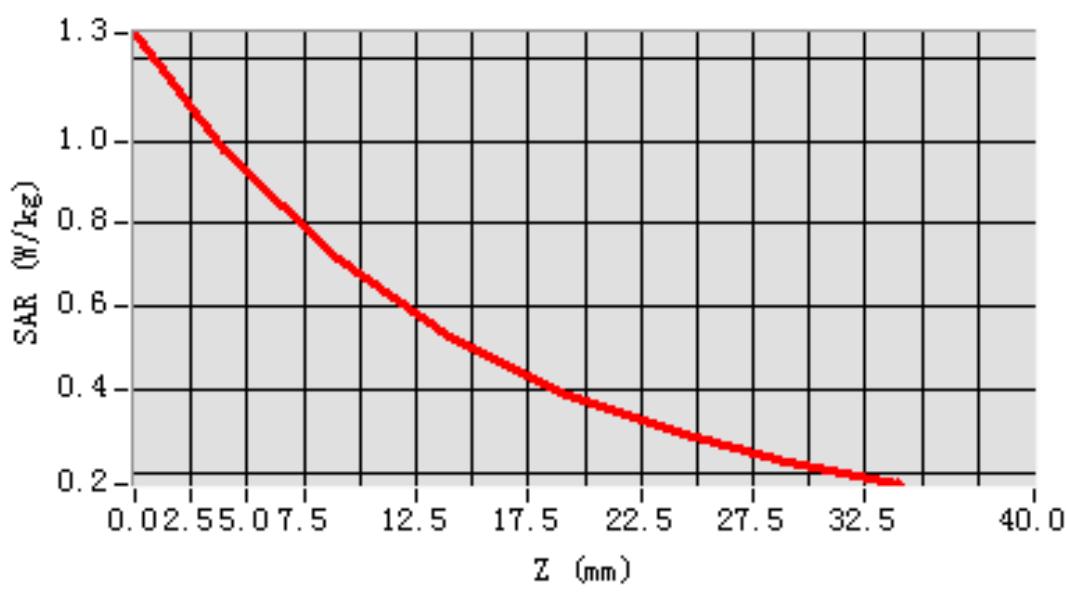


MEAS. 3 Body Plane with Front of Face on Channel 3 in FM mode

Test Date: 30/5/2016
Measurement duration: 11 minutes 32 seconds
Signal: FM, f=469.975 MHz, Duty Cycle: 1:1.0
Liquid Parameters: Permittivity: 43.68; Conductivity: 0.88 S/m
Test condition: Ambient Temperature: 21.6°C, Liquid Temperature: 20.3°C
Probe: SN 34/15 SSE2 EPGO265, ConvF: 1.85
Area Scan: sam_direct_droit2_surf12mm.txt, h= 5.00 mm
Zoom Scan: 5x5x7,dx=8mm, dy=8mm, dz=5mm,Complete
Maximum location: X=8.000000, Y=0.000000
SAR 10g (W/Kg): 0.679443
SAR 1g (W/Kg): 0.948667
Power drift (%): -3.12
3D screen shot

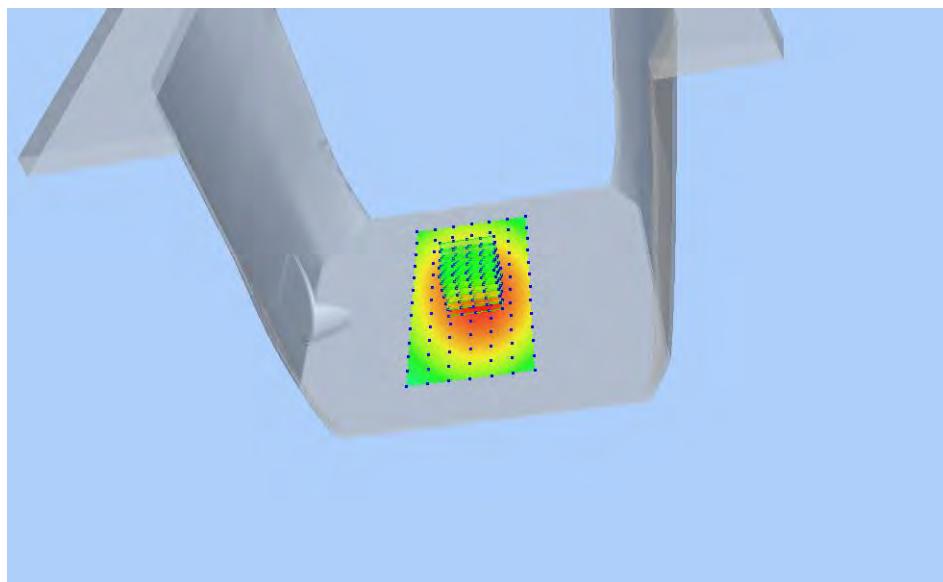


Z Axis Scan

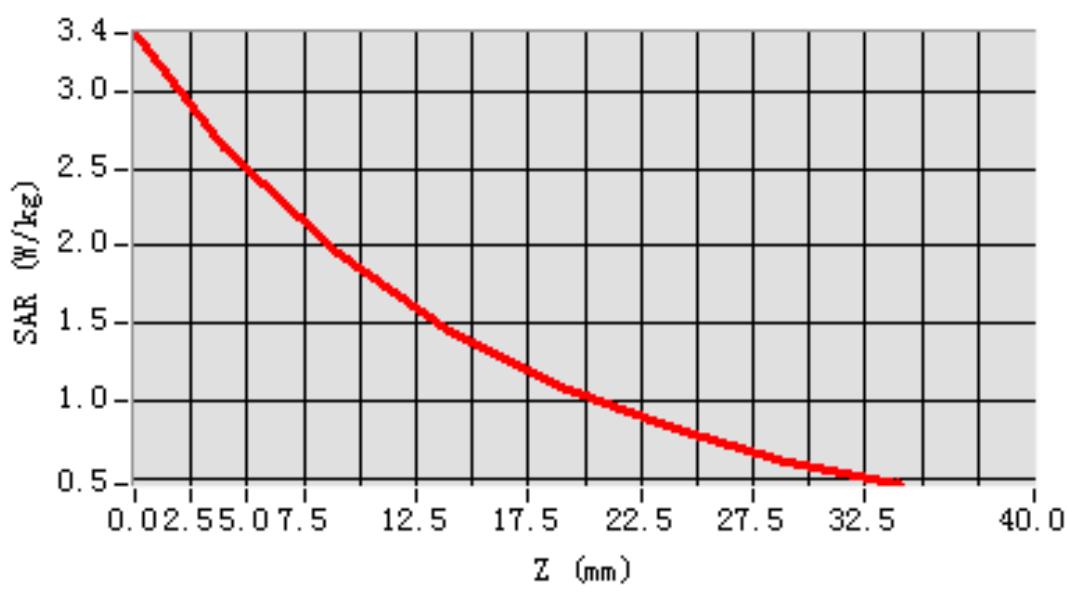


MEAS. 4 Body Plane with Front of Face on Channel 4 in FM mode

Test Date: 30/5/2016
Measurement duration: 10 minutes 34 seconds
Signal: FM, f=416.025 MHz, Duty Cycle: 1:1.0
Liquid Parameters: Permittivity: 44.87; Conductivity: 0.85 S/m
Test condition: Ambient Temperature: 21.6°C, Liquid Temperature: 20.3°C
Probe: SN 34/15 SSE2 EPGO265, ConvF: 1.85
Area Scan: sam_direct_droit2_surf12mm.txt, h= 5.00 mm
Zoom Scan: 5x5x7,dx=8mm, dy=8mm, dz=5mm,Complete
Maximum location: X=-4.000000, Y=0.000000
SAR 10g (W/Kg): 1.841146
SAR 1g (W/Kg): 2.559035
Power drift (%): -1.60
3D screen shot

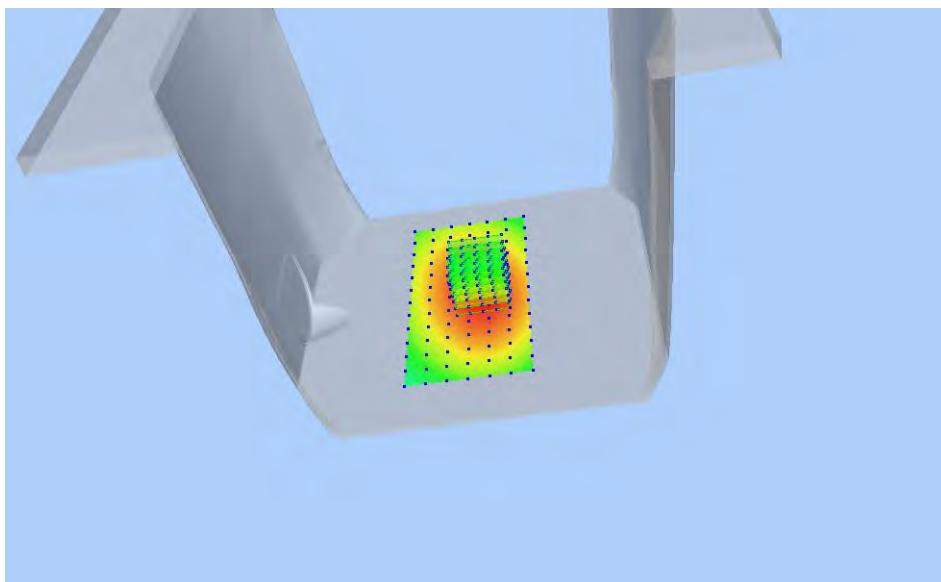


Z Axis Scan

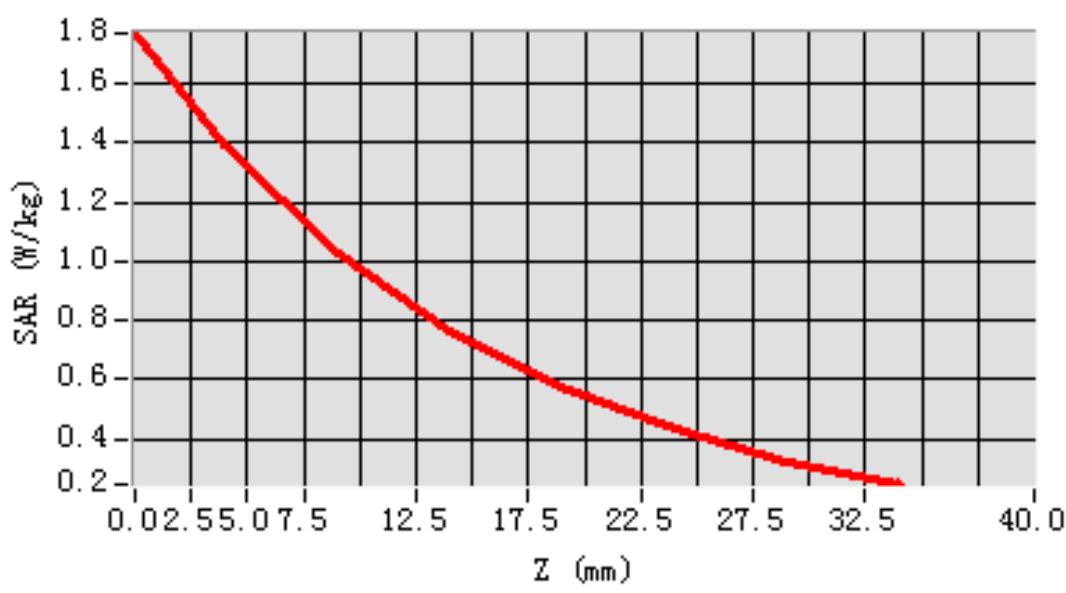


MEAS. 5 Body Plane with Front of Face on Channel 5 in FM mode

Test Date: 30/5/2016
Measurement duration: 11 minutes 30 seconds
Signal: FM, f=448.025 MHz, Duty Cycle: 1:1.0
Liquid Parameters: Permittivity: 44.14; Conductivity: 0.87 S/m
Test condition: Ambient Temperature: 21.6°C, Liquid Temperature: 20.3°C
Probe: SN 34/15 SSE2 EPGO265, ConvF: 1.85
Area Scan: sam_direct_droit2_surf12mm.txt, h= 5.00 mm
Zoom Scan: 5x5x7,dx=8mm, dy=8mm, dz=5mm,Complete
Maximum location: X=8.000000, Y=0.000000
SAR 10g (W/Kg): 0.974081
SAR 1g (W/Kg): 1.350962
Power drift (%): -1.07
3D screen shot

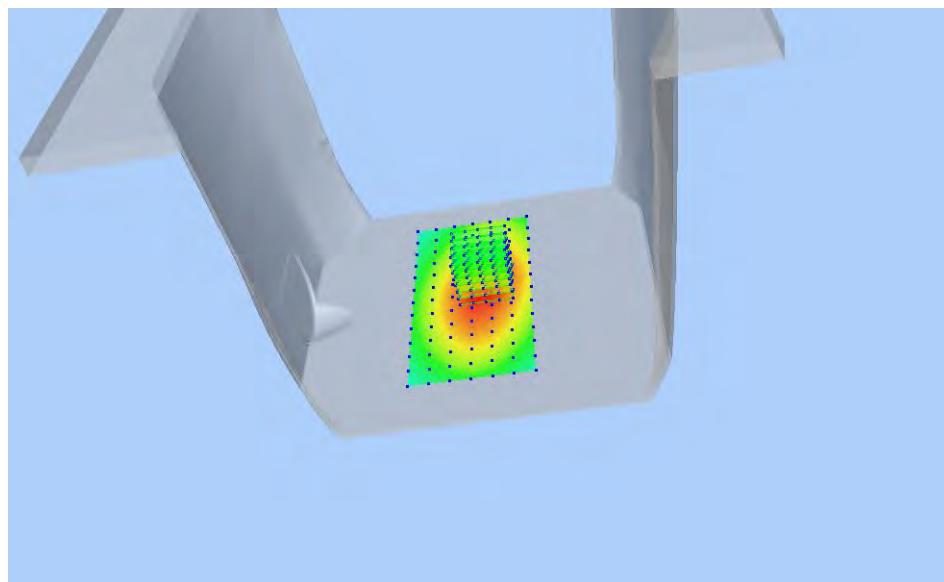


Z Axis Scan

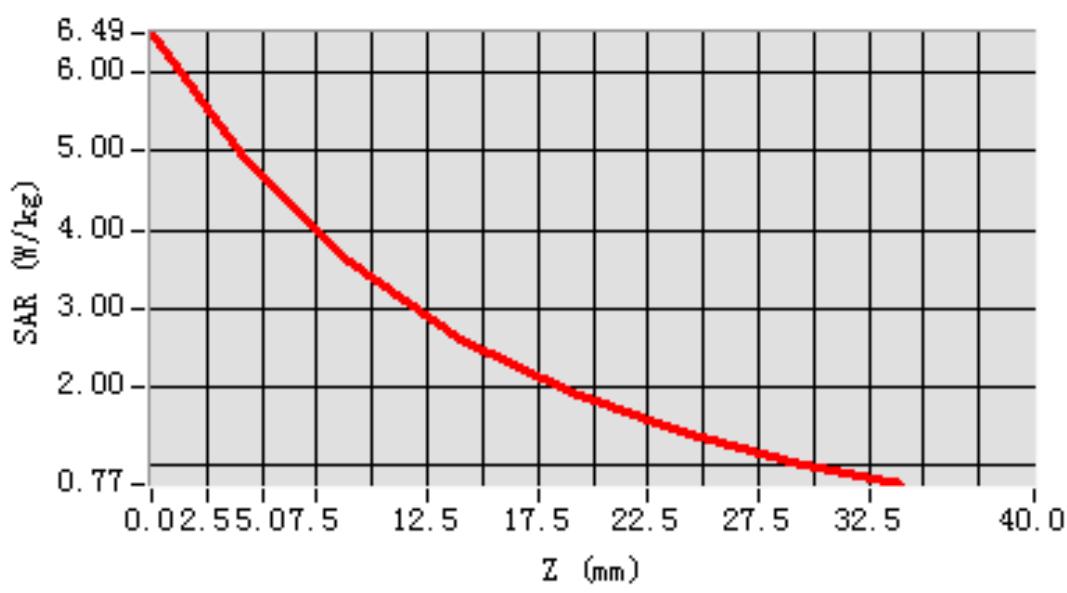


MEAS. 6 Body Plane with Body-worn on Channel 1 in FM mode

Test Date: 30/5/2016
Measurement duration: 11 minutes 39 seconds
Signal: FM, f=406.125 MHz, Duty Cycle: 1:1.0
Liquid Parameters: Permittivity: 57.76; Conductivity: 0.92 S/m
Test condition: Ambient Temperature: 21.6°C, Liquid Temperature: 20.3°C
Probe: SN 34/15 SSE2 EPGO265, ConvF: 1.90
Area Scan: sam_direct_droit2_surf12mm.txt, h= 5.00 mm
Zoom Scan: 5x5x7,dx=8mm, dy=8mm, dz=5mm,Complete
Maximum location: X=8.000000, Y=12.000000
SAR 10g (W/Kg): 3.388365
SAR 1g (W/Kg): 4.850330
Power drift (%): -2.96
3D screen shot

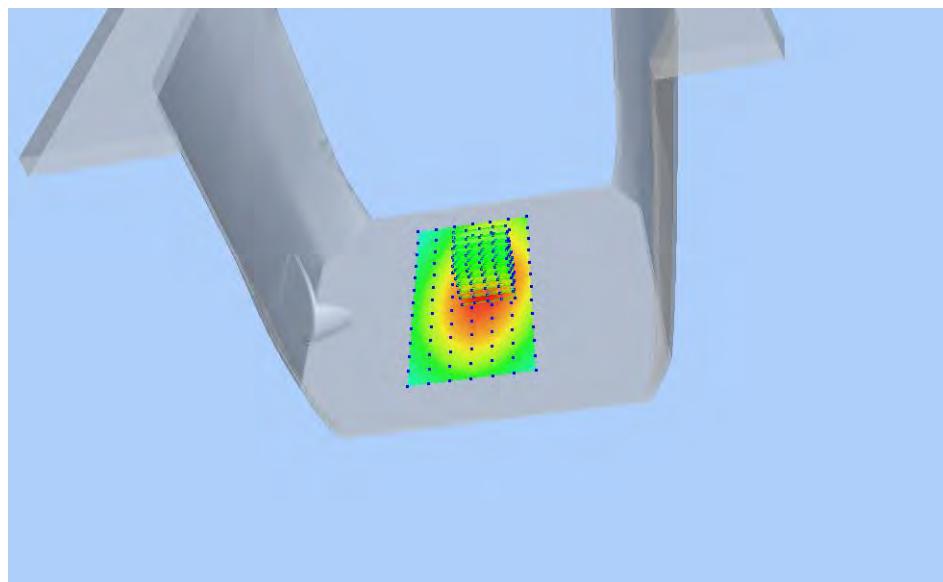


Z Axis Scan

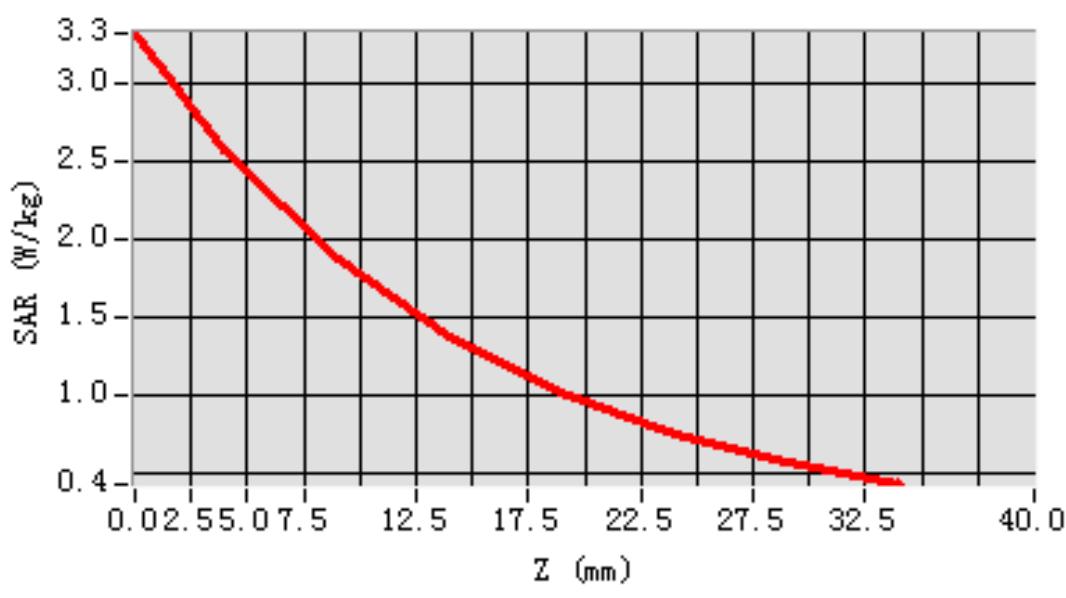


MEAS. 7 Body Plane with Body-worn on Channel 2 in FM mode

Test Date: 30/5/2016
Measurement duration: 11 minutes 42 seconds
Signal: FM, f=439.975 MHz, Duty Cycle: 1:1.0
Liquid Parameters: Permittivity: 57.30; Conductivity: 0.94 S/m
Test condition: Ambient Temperature: 21.6°C, Liquid Temperature: 20.3°C
Probe: SN 34/15 SSE2 EPGO265, ConvF: 1.90
Area Scan: sam_direct_droit2_surf12mm.txt, h= 5.00 mm
Zoom Scan: 5x5x7,dx=8mm, dy=8mm, dz=5mm,Complete
Maximum location: X=8.000000, Y=12.000000
SAR 10g (W/Kg): 1.747158
SAR 1g (W/Kg): 2.478807
Power drift (%): -2.25
3D screen shot

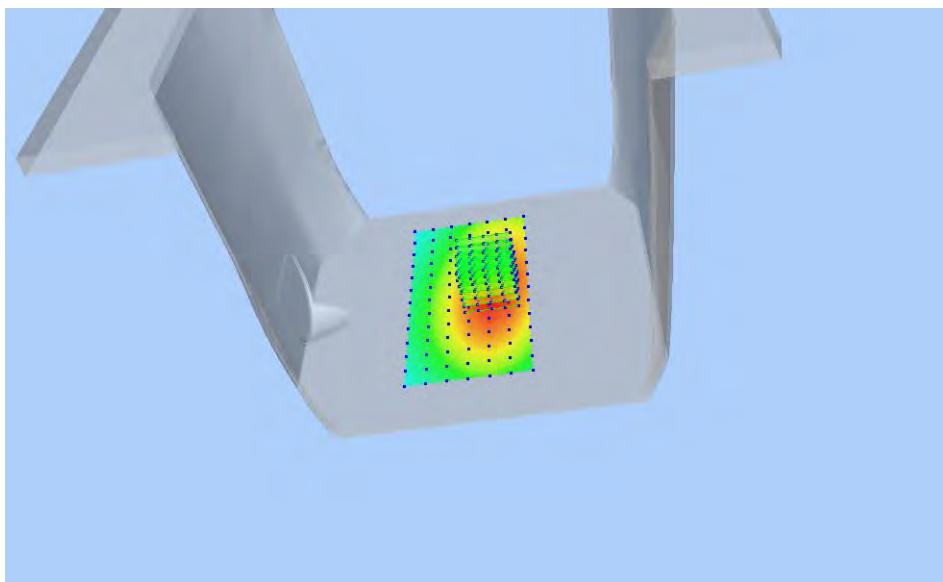


Z Axis Scan

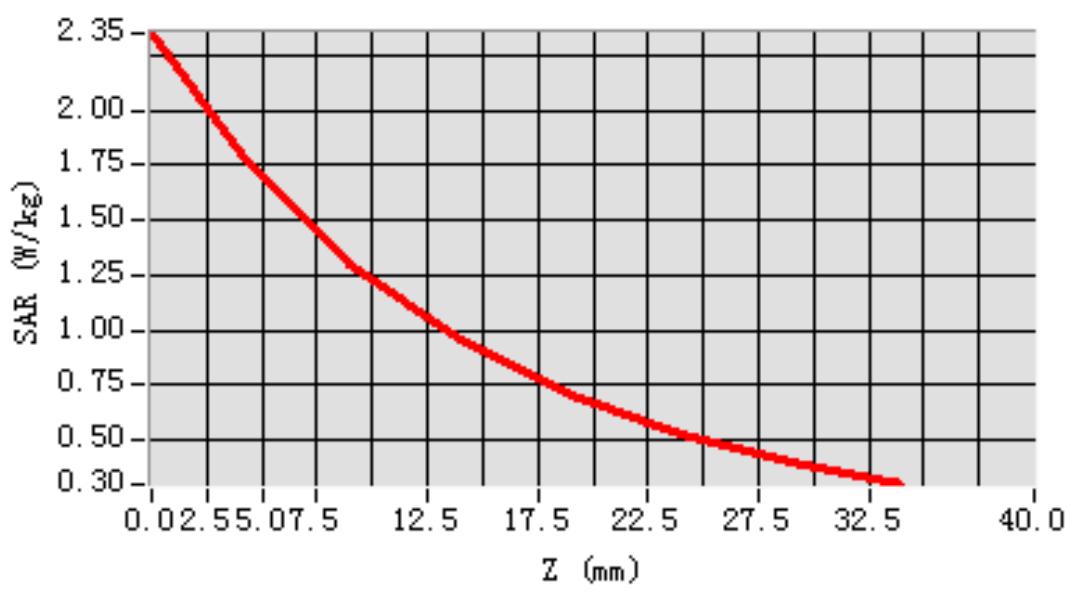


MEAS. 8 Body Plane with Body-worn on Channel 3 in FM mode

Test Date: 30/5/2016
Measurement duration: 12 minutes 9 seconds
Signal: FM, f=469.975 MHz, Duty Cycle: 1:1.0
Liquid Parameters: Permittivity: 56.44; Conductivity: 0.96 S/m
Test condition: Ambient Temperature: 21.6°C, Liquid Temperature: 20.3°C
Probe: SN 34/15 SSE2 EPGO265, ConvF: 1.90
Area Scan: sam_direct_droit2_surf12mm.txt, h= 5.00 mm
Zoom Scan: 5x5x7,dx=8mm, dy=8mm, dz=5mm,Complete
Maximum location: X=8.000000, Y=0.000000
SAR 10g (W/Kg): 1.234827
SAR 1g (W/Kg): 1.760678
Power drift (%): -1.26
3D screen shot

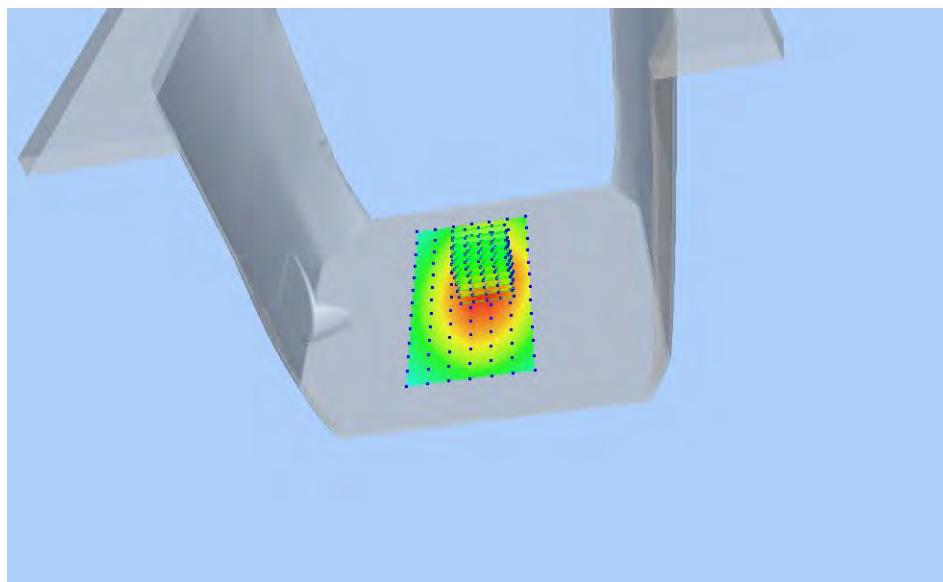


Z Axis Scan

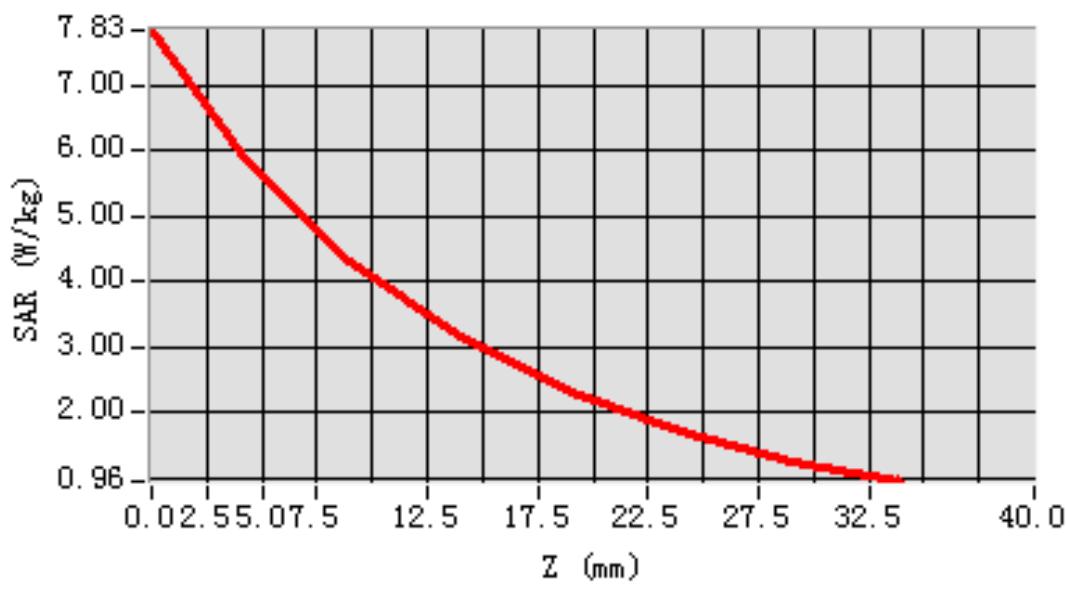


MEAS. 9 Body Plane with Body-worn on Channel 4 in FM mode

Test Date: 30/5/2016
Measurement duration: 11 minutes 42 seconds
Signal: FM, f=416.025 MHz, Duty Cycle: 1:1.0
Liquid Parameters: Permittivity: 57.72 Conductivity: 0.93 S/m
Test condition: Ambient Temperature: 21.6°C, Liquid Temperature: 20.3°C
Probe: SN 34/15 SSE2 EPGO265, ConvF: 1.90
Area Scan: sam_direct_droit2_surf12mm.txt, h= 5.00 mm
Zoom Scan: 5x5x7,dx=8mm, dy=8mm, dz=5mm,Complete
Maximum location: X=8.000000, Y=12.000000
SAR 10g (W/Kg): 4.054831
SAR 1g (W/Kg): 5.810064
Power drift (%): -4.55
3D screen shot

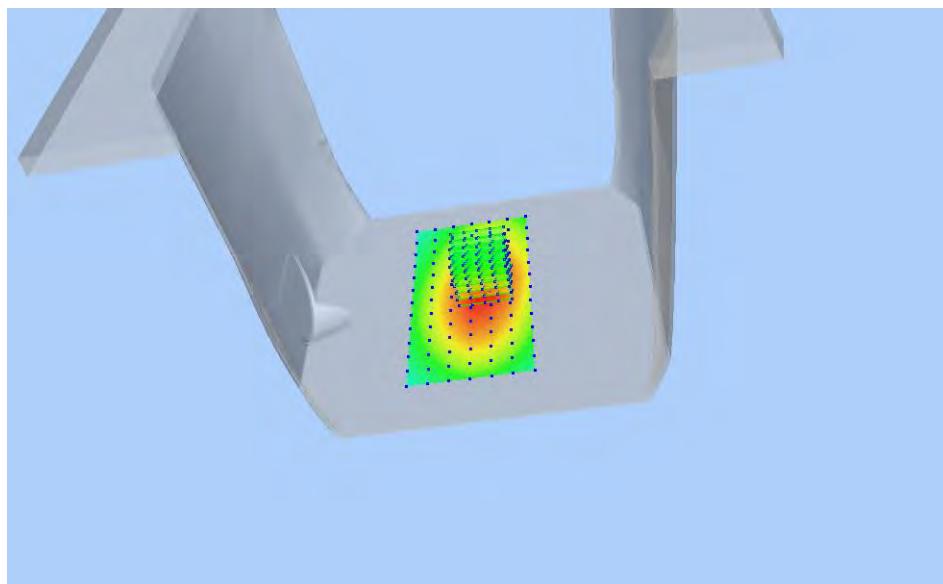


Z Axis Scan

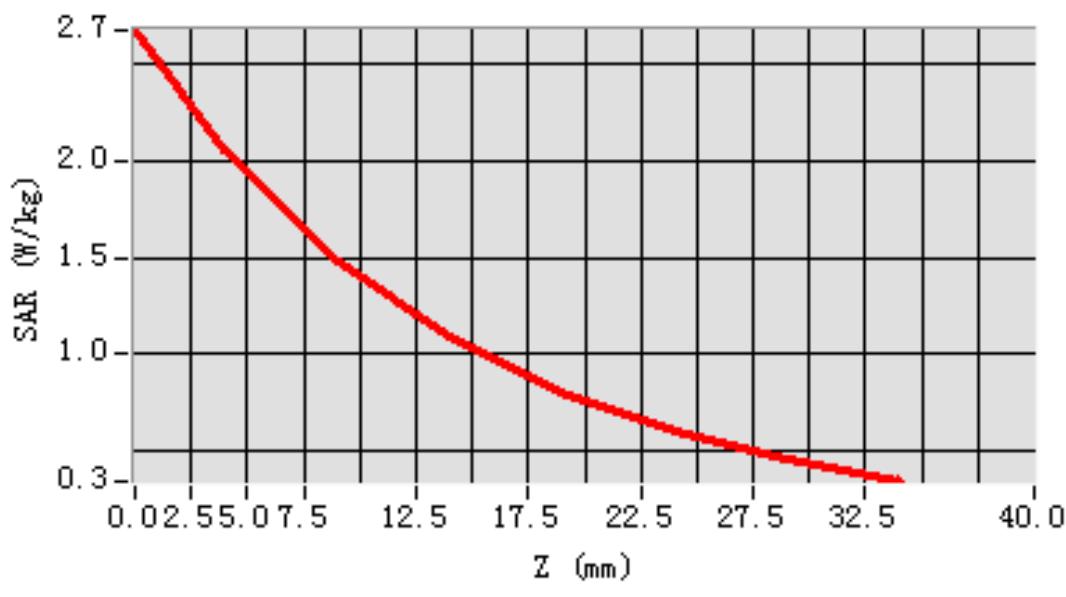


MEAS. 10 Body Plane with Body-worn on Channel 5 in FM mode

Test Date: 30/5/2016
Measurement duration: 11 minutes 35 seconds
Signal: FM, f=448.025 MHz, Duty Cycle: 1:1.0
Liquid Parameters: Permittivity: 56.95; Conductivity: 0.95 S/m
Test condition: Ambient Temperature: 21.6°C, Liquid Temperature: 20.3°C
Probe: SN 34/15 SSE2 EPGO265, ConvF: 1.90
Area Scan: sam_direct_droit2_surf12mm.txt, h= 5.00 mm
Zoom Scan: 5x5x7,dx=8mm, dy=8mm, dz=5mm,Complete
Maximum location: X=8.000000, Y=12.000000
SAR 10g (W/Kg): 1.399356
SAR 1g (W/Kg): 1.998278
Power drift (%): -2.61
3D screen shot



Z Axis Scan



ANNEX D EUT EXTERNAL PHOTOS

Please refer the document “BL-SZ1640195-AW.pdf”.

ANNEX E SAR TEST SETUP PHOTOS

Please refer the document “BL-SZ1640195-AS.pdf”.

ANNEX F CALIBRATION FOR PROBE AND DIPOLE

F.1 E-Field Probe



COMOSAR E-Field Probe Calibration Report

Ref : ACR.299.1.15.SATU.A

SHENZHEN BALUN TECHNOLOGY CO.,LTD.
BLOCK B, FL 1, BAISHA SCIENCE AND TECHNOLOGY
PARK, SHAHE XI ROAD,
NANSHAN DISTRICT, SHENZHEN, GUANGDONG
PROVINCE, P.R. CHINA 518055

MVG COMOSAR DOSIMETRIC E-FIELD PROBE
SERIAL NO.: SN 34/15 EPGO265

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



Calibration Date: 10/12/2015

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.



COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref. ACR.299.1.15.SATU A

	Name	Function	Date	Signature
Prepared by :	Jérôme LUC	Product Manager	10/26/2015	
Checked by :	Jérôme LUC	Product Manager	10/26/2015	
Approved by :	Kim RUTKOWSKI	Quality Manager	10/26/2015	

Distribution :	Customer Name
	SHENZHEN BALUN TECHNOLOGY Co.,Ltd.

Issue	Date	Modifications
A	10/26/2015	Initial release

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COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.299.1.15.SATU.A

1 DEVICE UNDER TEST

Device Under Test	
Device Type	COMOSAR DOSIMETRIC E FIELD PROBE
Manufacturer	MVG
Model	SSE2
Serial Number	SN 34/15 EPGO265
Product Condition (new / used)	New
Frequency Range of Probe	0.45 GHz-6GHz
Resistance of Three Dipoles at Connector	Dipole 1: R1=0.192 MΩ Dipole 2: R2=0.230 MΩ Dipole 3: R3=0.205 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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COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.299.1.15.SATU.A

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 %	

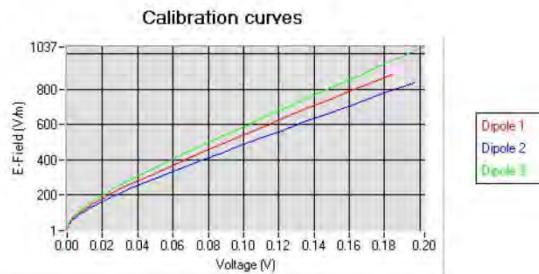
5.1 SENSITIVITY IN AIR

Normx dipole 1 ($\mu\text{V}/(\text{V}/\text{m})^2$)	Normy dipole 2 ($\mu\text{V}/(\text{V}/\text{m})^2$)	Normz dipole 3 ($\mu\text{V}/(\text{V}/\text{m})^2$)
0.72	0.81	0.85

DCP dipole 1 (mV)	DCP dipole 2 (mV)	DCP dipole 3 (mV)
92	90	95

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

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



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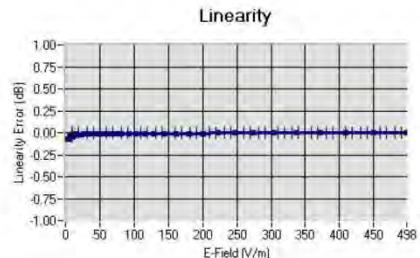
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COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.299.1.15.SATU.A

5.2 LINEARITY



Linearity +/-1.61% (+/-0.07dB)

5.3 SENSITIVITY IN LIQUID

Liquid	Frequency (MHz +/- 100MHz)	Permittivity	Epsilon (S/m)	ConvF
HL450	450	44.12	0.88	1.85
BL450	450	58.92	1.00	1.90
HL750	750	42.24	0.90	1.81
BL750	750	56.85	0.99	1.88
HL850	835	43.02	0.90	2.04
BL850	835	53.72	0.98	2.12
HL900	900	42.47	0.99	1.86
BL900	900	56.97	1.09	1.92
HL1800	1800	42.24	1.40	2.04
BL1800	1800	53.53	1.53	2.08
HL1900	1900	40.79	1.42	2.35
BL1900	1900	54.47	1.57	2.42
HL2000	2000	40.52	1.44	2.23
BL2000	2000	54.18	1.56	2.32
HL2450	2450	38.73	1.81	2.47
BL2450	2450	53.23	1.96	2.55
HL2600	2600	38.54	1.95	2.36
BL2600	2600	52.07	2.23	2.43
HL5200	5200	36.80	4.84	1.81
BL5200	5200	51.21	5.16	1.85
HL5400	5400	36.35	4.96	2.04
BL5400	5400	50.51	5.70	2.11
HL5600	5600	35.57	5.23	2.08
BL5600	5600	49.83	5.91	2.15
HL5800	5800	35.30	5.47	1.88
BL5800	5800	49.03	6.28	1.93

LOWER DETECTION LIMIT: 7mW/kg

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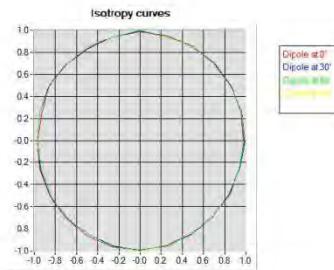


COMOSAR E-FIELD PROBE CALIBRATION REPORT

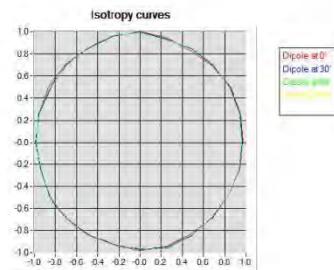
Ref: ACR.299.1.15.SATU.A

5.4 ISOTROPY**HL900 MHz**

- Axial isotropy: 0.04 dB
- Hemispherical isotropy: 0.06 dB

**HL1800 MHz**

- Axial isotropy: 0.04 dB
- Hemispherical isotropy: 0.06 dB



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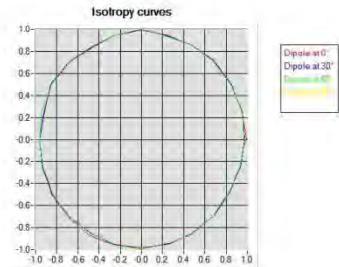


COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.299.1.15.SATU.A

HL5600 MHz

- Axial isotropy: 0.06 dB
- Hemispherical isotropy: 0.09 dB



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COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.299.1.15.SATU.A

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	02/2013	02/2016
Reference Probe	MVG	EP 94 SN 37/08	10/2015	10/2016
Multimeter	Keithley 2000	1188656	12/2013	12/2016
Signal Generator	Agilent E4438C	MY49070581	12/2013	12/2016
Amplifier	Aethercomm	SN 046	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	HP E4418A	US38261498	12/2013	12/2016
Power Sensor	HP ECP-E26A	US37181460	12/2013	12/2016
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.

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F.2 450MHz Dipole

**SAR Reference Dipole Calibration Report**

Ref : ACR.75.6.15.SATU.A

SHENZHEN BALUN TECHNOLOGY CO.,LTD.
BLOCK B, FL 1, BAISHA SCIENCE AND TECHNOLOGY
PARK, SHAHE XI ROAD,
NANSHAN DISTRICT, SHENZHEN, GUANGDONG
PROVINCE, P.R. CHINA 518055
MVG COMOSAR REFERENCE DIPOLE
FREQUENCY: 450 MHZ
SERIAL NO.: SN 25/13 DIP 0G450-252

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



03/16/2015

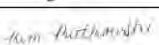
Summary:

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.



SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.75.6.15.SATU.A

	Name	Function	Date	Signature
Prepared by :	Jérôme LUC	Product Manager	3/16/2015	
Checked by :	Jérôme LUC	Product Manager	3/16/2015	
Approved by :	Kim RUTKOWSKI	Quality Manager	3/16/2015	

Distribution :	Customer Name
	SHENZHEN BALUN TECHNOLOGY Co.,Ltd.

Issue	Date	Modifications
A	3/16/2015	Initial release

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SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.75.6.15.SATU.A

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 450 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SID450
Serial Number	SN 25/13 DIP 0G450-252
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 constituted 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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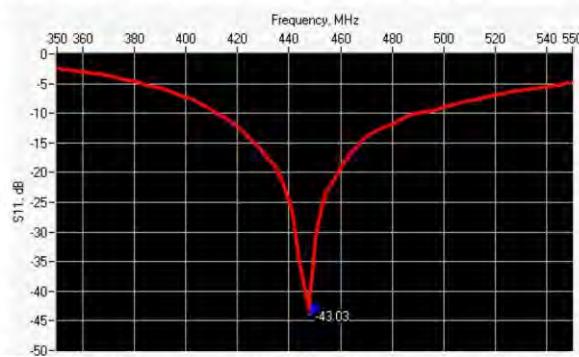
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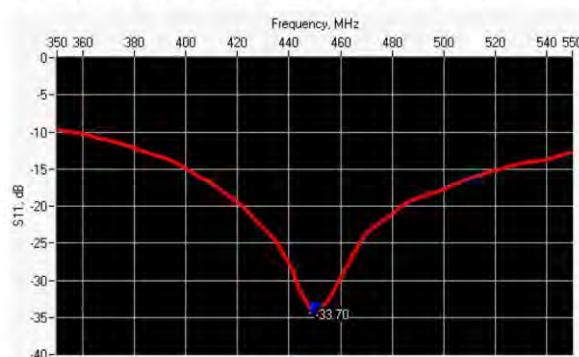
SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.75.6.15.SATU.A

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
450	-43.03	-20	$49.7 \Omega - 0.6 j\Omega$

6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID

Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
450	-33.70	-20	$47.6 \Omega - 0.4 j\Omega$

6.3 MECHANICAL DIMENSIONS

Frequency MHz	L mm		h mm		d mm	
	required	measured	required	measured	required	measured
300	$420.0 \pm 1 \%$		$250.0 \pm 1 \%$		$6.35 \pm 1 \%$	

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450	290.0 \pm 1 %.	PASS	166.7 \pm 1 %.	PASS	6.35 \pm 1 %.	PASS
750	176.0 \pm 1 %.		100.0 \pm 1 %.		6.35 \pm 1 %.	
835	161.0 \pm 1 %.		89.8 \pm 1 %.		3.6 \pm 1 %.	
900	149.0 \pm 1 %.		83.3 \pm 1 %.		3.6 \pm 1 %.	
1450	89.1 \pm 1 %.		51.7 \pm 1 %.		3.6 \pm 1 %.	
1500	80.5 \pm 1 %.		50.0 \pm 1 %.		3.6 \pm 1 %.	
1640	79.0 \pm 1 %.		45.7 \pm 1 %.		3.6 \pm 1 %.	
1750	75.2 \pm 1 %.		42.9 \pm 1 %.		3.6 \pm 1 %.	
1800	72.0 \pm 1 %.		41.7 \pm 1 %.		3.6 \pm 1 %.	
1900	68.0 \pm 1 %.		39.5 \pm 1 %.		3.6 \pm 1 %.	
1950	66.3 \pm 1 %.		38.5 \pm 1 %.		3.6 \pm 1 %.	
2000	64.5 \pm 1 %.		37.5 \pm 1 %.		3.6 \pm 1 %.	
2100	61.0 \pm 1 %.		35.7 \pm 1 %.		3.6 \pm 1 %.	
2300	55.5 \pm 1 %.		32.6 \pm 1 %.		3.6 \pm 1 %.	
2450	51.5 \pm 1 %.		30.4 \pm 1 %.		3.6 \pm 1 %.	
2600	48.5 \pm 1 %.		28.8 \pm 1 %.		3.6 \pm 1 %.	
3000	41.5 \pm 1 %.		25.0 \pm 1 %.		3.6 \pm 1 %.	
3500	37.0 \pm 1 %.		26.4 \pm 1 %.		3.6 \pm 1 %.	
3700	34.7 \pm 1 %.		26.4 \pm 1 %.		3.6 \pm 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 \pm 5 %		0.87 \pm 5 %	
450	43.5 \pm 5 %	PASS	0.87 \pm 5 %	PASS
750	41.9 \pm 5 %		0.89 \pm 5 %	
835	41.5 \pm 5 %		0.90 \pm 5 %	
900	41.5 \pm 5 %		0.97 \pm 5 %	
1450	40.5 \pm 5 %		1.20 \pm 5 %	
1500	40.4 \pm 5 %		1.23 \pm 5 %	
1640	40.2 \pm 5 %		1.31 \pm 5 %	
1750	40.1 \pm 5 %		1.37 \pm 5 %	

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SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.75.6.15.SATU.A

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 %		1.80 ±5 %	
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: $\epsilon_{\text{pr}}^{\prime\prime}$: 43.7 sigma : 0.87
Distance between dipole center and liquid	15.0 mm
Area scan resolution	dx=8mm/dy=8mm
Zoon Scan Resolution	dx=8mm/dy=8m/dz=5mm
Frequency	450 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	4.73 (0.47)	3.06	3.04 (0.30)
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	

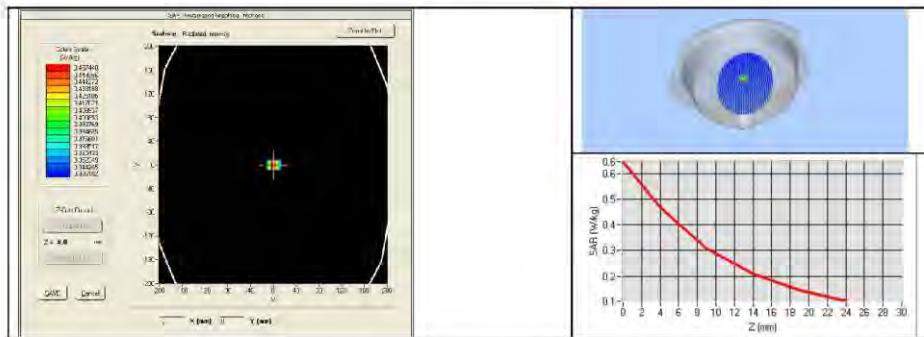
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SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.75.6.15.SATU.A

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		24	
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 %	PASS	0.94 ±5 %	PASS
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 %		1.95 ±5 %	

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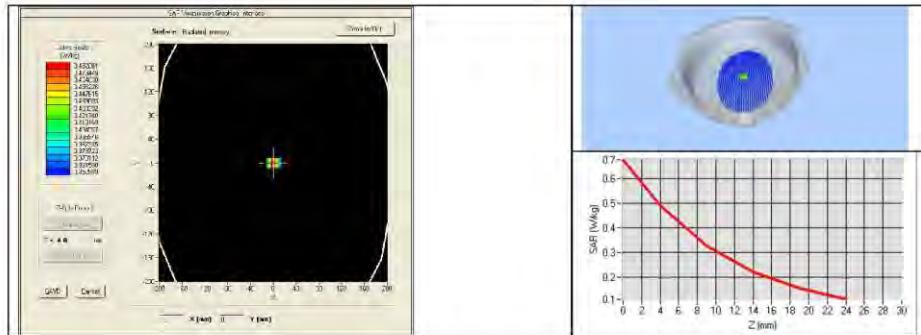
Ref: ACR.75.6.15.SATU.A

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: $\epsilon_s' : 58.3$ sigma : 0.99
Distance between dipole center and liquid	15.0 mm
Area scan resolution	dx=8mm/dy=8mm
Zoon Scan Resolution	dx=8mm/dy=8m/dz=5mm
Frequency	450 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
450	4.81 (0.48)	3.11 (0.31)



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SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.75.6.15.SATU.A

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	02/2013	02/2016
Calipers	Carrera	CALIPER-01	12/2013	12/2016
Reference Probe	MVG	EPG122 SN 18/11	10/2014	10/2015
Multimeter	Keithley 2000	1188656	12/2013	12/2016
Signal Generator	Agilent E4438C	MY49070581	12/2013	12/2016
Amplifier	Aethercomm	SN 046	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	HP E4418A	US38261498	12/2013	12/2016
Power Sensor	HP ECP-E26A	US37181460	12/2013	12/2016
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	11-661-9	8/2012	8/2015

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F.3 Dielectric Probe

**Dielectric Probe Calibration Report**

Ref : ACR.219.12.13.SATU.A

SHENZHEN BALUN TECHNOLOGY CO., LTD.
ROOM 601, EAST TOWER, NANSHAN SOFTWARE PARK,
10128 SHENNAN ROAD, SHENZHEN, 518084, CHINA

SATIMO LIMESAR DIELECTRIC PROBE

FREQUENCY: 0.3-6 GHZ

SERIAL NO.: SN 25/13 OCPG56

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



17/08/2015

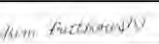
Summary:

This document presents the method and results from an accredited Dielectric Probe calibration performed in SATIMO USA using the LIMESAR test bench. All calibration results are traceable to national metrology institutions.



SAR DIELECTRIC PROBE CALIBRATION REPORT

Ref: ACR-219.12.13.SAT.UA

	Name	Function	Date	Signature
Prepared by :	Jérôme LUC	Product Manager	8/17/2015	
Checked by :	Jérôme LUC	Product Manager	8/17/2015	
Approved by :	Kim RUTKOWSKI	Quality Manager	8/17/2015	 Kim RUTKOWSKI

	Customer Name
Distribution :	Shenzhen BALUN Technology Co., Ltd.

Issue	Date	Modifications
A	8/17/2015	Initial release

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1 INTRODUCTION

This document contains a summary of the suggested methods and requirements set forth by the IEEE 1528 and CEI/IEC 62209 standards for liquid permittivity measurements 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	LIMESAR DIELECTRIC PROBE
Manufacturer	Satimo
Model	SCLMP
Serial Number	SN 25/13 OCPG56
Product Condition (new / used)	New

A yearly calibration interval is recommended.

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

Satimo's Dielectric Probes are built in accordance to the IEEE 1528 and CEI/IEC 62209 standards. The product is designed for use with the LIMESAR test bench only.



Figure 1 – Satimo LIMESAR Dielectric Probe

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4 MEASUREMENT METHOD

The IEEE 1528-2003, OET 65 Bulletin C and CEI/IEC 62209-1 & 2 standards outline techniques for dielectric property measurements. The LIMESAR test bench employs one of the methods outlined in the standards, using a contact probe or open-ended coaxial transmission-line probe and vector network analyzer. The standards recommend the measurement of two reference materials that have well established and stable dielectric properties to validate the system, one for the calibration and one for checking the calibration. The LIMESAR test bench uses De-ionized water as the reference for the calibration and either DMS or Methanol as the reference for checking the calibration. The following measurements were performed to verify that the product complies with the fore mentioned standards.

4.1 LIQUID PERMITTIVITY MEASUREMENTS

The permittivity of a liquid with well established dielectric properties was measured and the measurement results compared to the values provided in the fore mentioned standards.

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 DIELECTRIC PERMITTIVITY MEASUREMENT

The following uncertainties apply to the Dielectric Permittivity measurement:

Uncertainty analysis of Permittivity Measurement					
ERROR SOURCES	Uncertainty value (+/-%)	Probability Distribution	Divisor	ci	Standard Uncertainty (+/-%)
Repeatability (n repeats, mid-band)	4.00%	N	1	1	4.000%
Deviation from reference liquid	5.00%	R	$\sqrt{3}$	1	2.887%
Network analyser-drift, linearity	2.00%	R	$\sqrt{3}$	1	1.155%
Test-port cable variations	0.00%	U	$\sqrt{2}$	1	0.000%
Combined standard uncertainty					5.066%
Expanded uncertainty (confidence level of 95%, k = 2)					10.0%

Uncertainty analysis of Conductivity Measurement					
ERROR SOURCES	Uncertainty value (+/-%)	Probability Distribution	Divisor	ci	Standard Uncertainty (+/-%)
Repeatability (n repeats, mid-band)	3.50%	N	1	1	3.500%
Deviation from reference liquid	3.00%	R	$\sqrt{3}$	1	1.732%
Network analyser-drift, linearity	2.00%	R	$\sqrt{3}$	1	1.155%
Test-port cable variations	0.00%	U	$\sqrt{2}$	1	0.000%
Combined standard uncertainty					4.072%
Expanded uncertainty (confidence level of 95%, k = 2)					8.1%

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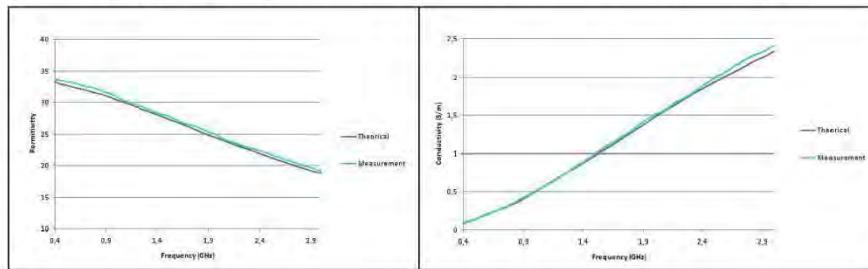
6 CALIBRATION MEASUREMENT RESULTS

Measurement Condition

Software	LIMESAR
Liquid Temperature	21°C
Lab Temperature	21°C
Lab Humidity	44%

6.1 LIQUID PERMITTIVITY MEASUREMENT

A liquid of known characteristics (methanol at 20°C) is measured with the probe and the results (complex permittivity $\epsilon' + j\epsilon''$) are compared with the well-known theoretical values for this liquid.



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**7 LIST OF EQUIPMENT**

Equipment Summary Sheet				
Equipment Description	Manufacturer / Model	Identification No.	Current Calibration Date	Next Calibration Date
LIMESAR Test Bench	Version 3	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rhode & Schwarz ZVA	SN100132	02/2012	02/2015
Methanol CAS 67-56-1	Alpha Aesar	Lot D13W011	Validated. No cal required.	Validated. No cal required.
Temperature and Humidity Sensor	Control Company	11-661-9	3/2015	3/2017

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**--END OF REPORT--**