SAR TEST REPORT

Report No.: FCC-IC_SAR_SL16110101-BSS-004_Rev2.0
Supersede Report No.: FCC-IC_SAR_SL16110101-BSS-004_Rev1.0

Applicant	Bosch Security Systems, Inc
Host Model No.	Roameo Beltpack
Model No.	TR-1800
Test Standard	47CFR 2.1093, IEEE C95.1-2005 RSS 102 Issue 5.0, IEEE 1528: 2013, IEC 62209-2: 2010
Test Method	IEEE 1528: 2013, IEC 62209-2: 2010 KDB 447498 D01 General RF Exposure Guidance v09 KDB 865664 D01 SAR Measurement 100MHz to 6 GHz v01r04 KDB 941225 D09 Hot Spot SAR v02r01
FCC ID	B5DM535
IC ID	1321A-TR1800
Date of test	03/01/2017 - 03/10/2017
Issue Date	4/20/2017
Test Result	Pass Fail
Equipment complied with the specification	[x]
Equipment did not comply with the specification	[ ]

Arthur Tie	Rachana Khanduri
Test Engineer	Engineer Reviewer

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Test result presented in this test report is applicable to the tested sample only

Issued By:
SIEMIC Laboratories
775 Montague Expressway, Milpitas, 95035 CA

TESTING CERT # 2742-01

Laboratory Introduction

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Accreditations for Conformity Assessment

Country/Region	Accreditation Body	Scope
USA	FCC, A2LA	EMC , RF/Wireless , Telecom
Canada	IC, A2LA, NIST	EMC, RF/Wireless , Telecom
Taiwan	BSMI , NCC , NIST	EMC, RF, Telecom , Safety
Hong Kong	OFTA , NIST	RF/Wireless ,Telecom
Australia	NATA, NIST	EMC, RF, Telecom , Safety
Korea	KCC/RRA, NIST	EMI, EMS, RF , Telecom, Safety
Japan	VCCI, JATE, TELEC, RFT	EMI, RF/Wireless, Telecom
Mexico	NOM, COFETEL, Caniety	Safety, EMC , RF/Wireless, Telecom
Europe	A2LA, NIST	EMC, RF, Telecom , Safety
Israel	MOC, NIST	EMC, RF, Telecom, Safety

Accreditations for Product Certifications

Country	Accreditation Body	Scope
USA	FCC TCB, NIST	EMC , RF , Telecom
Canada	IC FCB , NIST	EMC , RF , Telecom
Singapore	iDA, NIST	EMC , RF , Telecom
EU	NB	EMC & R&TTE Directive
Japan	MIC (RCB 208)	RF , Telecom
Hong Kong	OFTA (US002)	RF , Telecom

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1 Report Revision History

Report No.	Report Version	Description	Issue Date
FCC-IC_SAR_SL16110101-BSS-004	Original	Original	4/14/2017
FCC-IC_SAR_SL16110101-BSS-004_Rev1.0	Rev1.0	Corrected Plot for Siemic Accreditation Information; Corrected the Crest Factor to 1:24.	4/19/2017
FCC-IC_SAR_SL16110101-BSS-004_Rev2.0	Rev2.0	Corrected the SAR information in test result	4/20/2017

2 Executive Summary

The purpose of this test program was to demonstrate compliance of following product

Company:	Bosch Security Systems, Inc
Product:	Roameo Beltpack
Model:	TR-1800

against the current Stipulated Standards. The specified model product stated above has demonstrated compliance as a spot check with the Stipulated Standard listed on 1st page. The derived result is summarized in following table,

		Mode	Highest 1g SAR
Rated, Measured conducted RF output Power and SAR	:	**1921.536MHz**	**0.3506 W/Kg(body)**

3 Customer information

Applicant Name	Bosch Security Systems, Inc.
Applicant Address	8601 East Cornhusker Hwy. Lincoln, Nebraska 68507
Manufacturer Name	Bosch Security Systems S.A.
Manufacturer Address	EN 109 Lugar Da Pardala, Zona Industrial de Ovar 3880-728 Ovar Portugal

4 Test site information

Lab performing tests	SIEMIC Laboratories
Lab Address	775 Montague Expressway, Milpitas, CA 95035
FCC Test Site No.	881796
IC Test Site No.	4842D-2
VCCI Test Site No.	A0133

5 Modification

Index	Item	Description	Note
-	-	-	-

6 EUT Information

6.1 EUT Description

Product Name	Roameo beltpack
Model No.	TR-1800
Trade Name	RTS
Serial No.	045250365915051009
Host Model No.	-
Input Power	7.5 VDC @ 150mA (Battery Powered)
Hardware version	B2
Software version	0.0.342
Date of EUT received	03/01/2017
Equipment Class/ Category	DECT
Clock Frequencies	24.576 MHz, 13.824 MHz, 49.152 MHz
Port/Connectors	1 x 5-pin XLR, 1 x 3.5mm Jack, 1 x 2.5mm by 5.5mm Jack, 1 x USB type A

6.2 Radio Description

Spec for DECT

Radio Type	DECT
Operating Frequency	1921.536 MHz-1928.448 MHz
Modulation	GFSK
Channel Spacing	1.728 MHz
Number of Channels	5
Antenna Type	PCB ANTENNA
Antenna Gain	0
Antenna Connector Type	N/A
Note	N/A

EUT Power level setting

Mode	Frequency (MHz)	Power setting
CH00	1928.448	Default
CH01	1926.720	Default
CH02	1924.992	Default
CH03	1923.264	Default
20CH04	1921.536	Default

6.3 EUT Photos - External

EUT – Front View

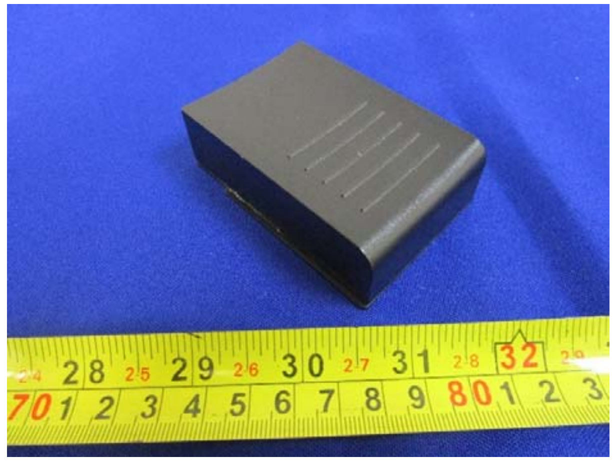
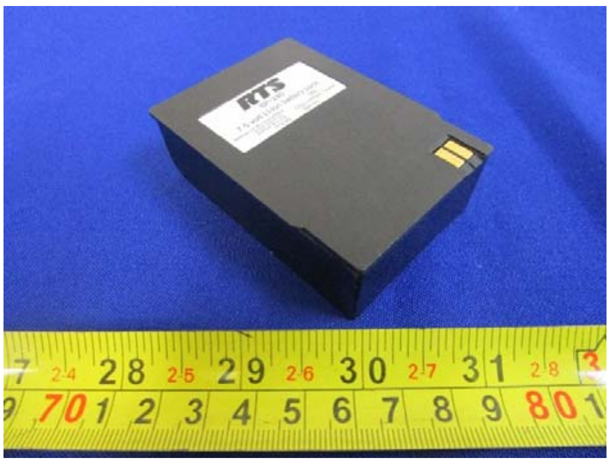
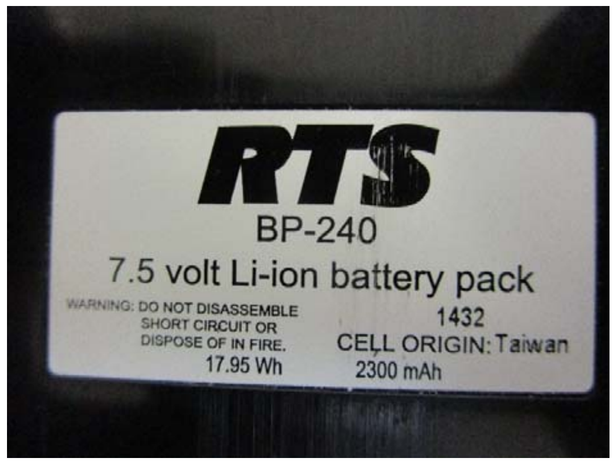
EUT – Rear View

EUT – Left View

EUT – Right View

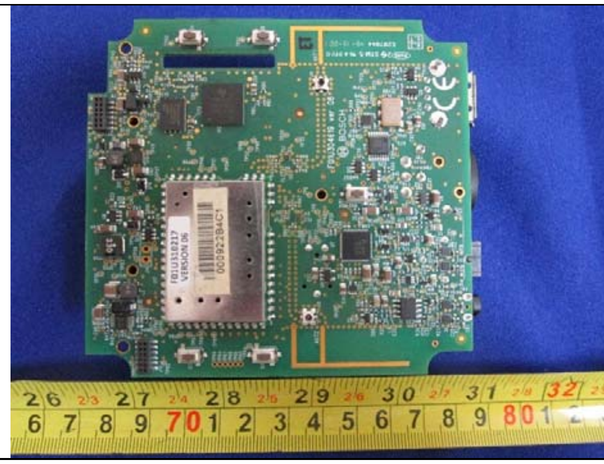
EUT – Top View

EUT – Bottom View

	
EUT ans Accessories View	**Battery View 1**
	
Battery View 2	**Battery Label View**

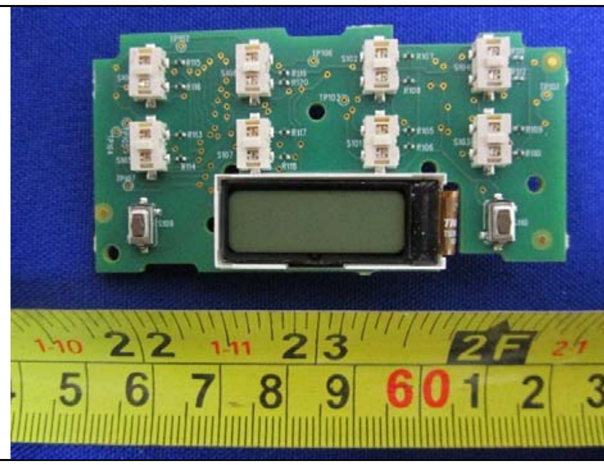
6.4 EUT Photos - Internal

Eut Cover Off View



Main PCB– Top View

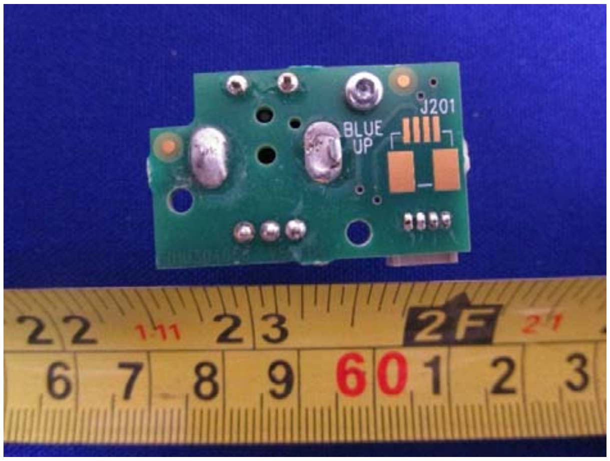
Main PCB – Bottom View



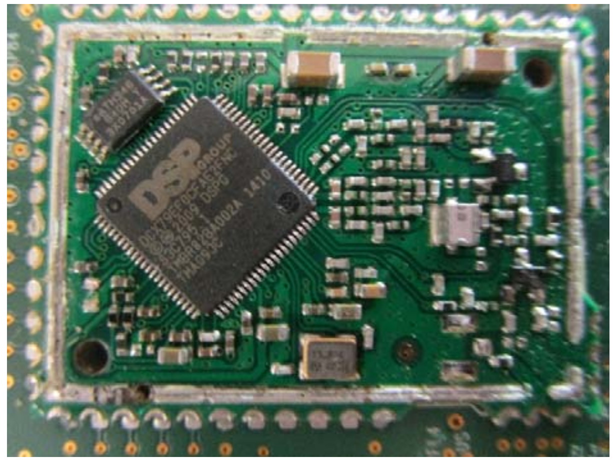
PCB A – Top View

PCB A – Bottom View

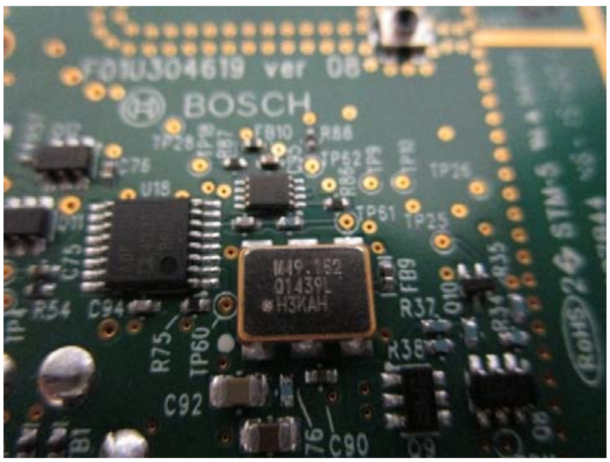
PCB B– Top View



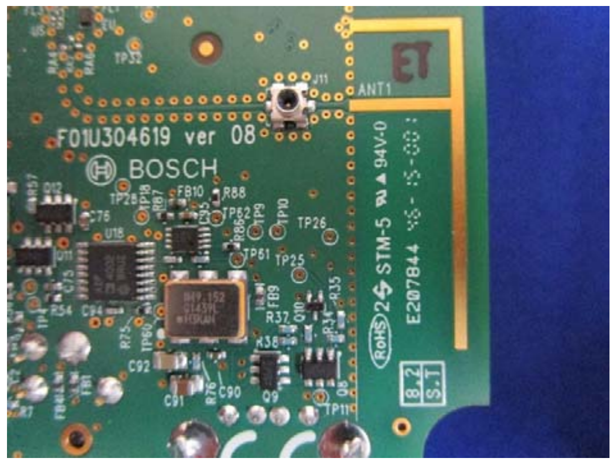
PCB B – Bottom View



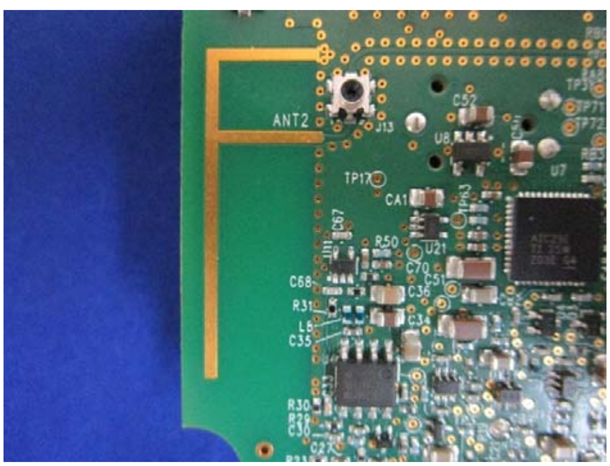
RF Module Cover Off View



Oscillator View

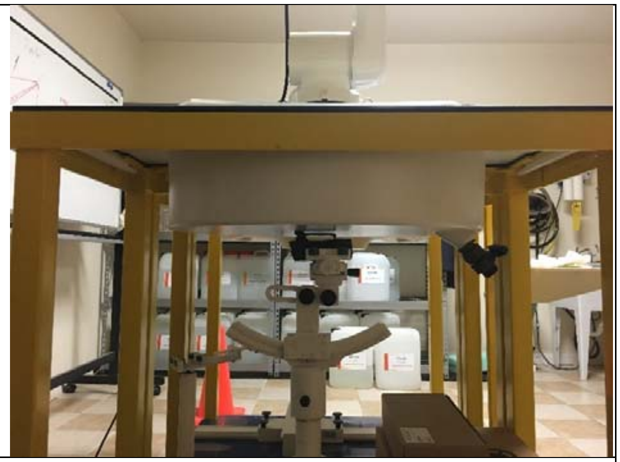


Antenna View 1



Antenna View 2

6.5 EUT Test Setup Photos

	
Back Side Touch	**Setup System View**

7 Supporting Equipment/Software and cabling Description

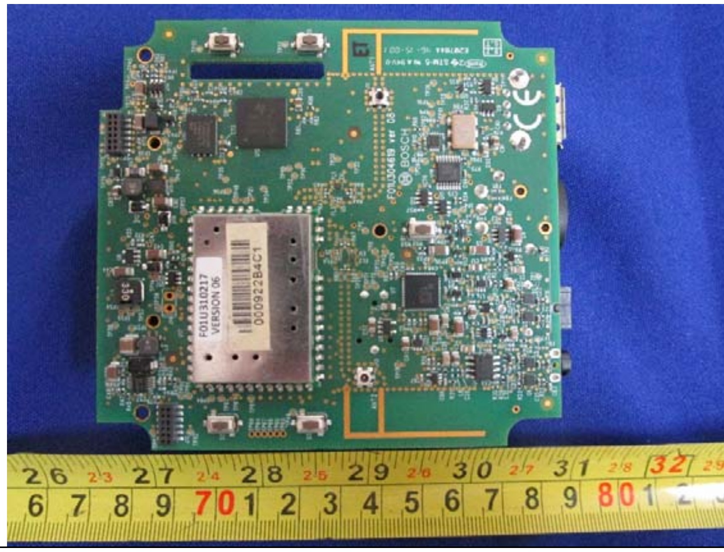
7.1 Supporting Equipment

Item	Supporting Equipment Description	Model	Serial Number	Manufacturer	Note
1	Digital Radio Communication Tester	CMD60	CCIS0149	R&S	N/A

7.2 Test Software Description

Test Item	Software	Description
1	N/A	N/A

8 Setup and Test Configuration Consideration

Radio & Antenna Location	
	
	
Remark:	SAR is not required because the distance from the antenna to the edge is > 25 mm as per KDB 941225 D09 Hotspot Mode SAR. So Top side and bottom side are not required.

9 Test Summary

Test Item	Test standard		Test Method/Procedure		Pass / Fail
SAR	FCC	OET Bulletin 65 Supplement C	IEEE	Std 1528-2013, FCC KDBs	☒ Pass ☐ N/A

10 SAR Introduction

10.1 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 co33ntrol over his or her exposure. In general, occupational/controlled exposure limits are higher than the limits for general population/uncontrolled.

10.2 SAR Definition

Specific Absorption Rate is defined as 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).

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

SAR is expressed in units of watts per kilogram (W/kg). SAR can be related to the electric field at a point by

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

Where:

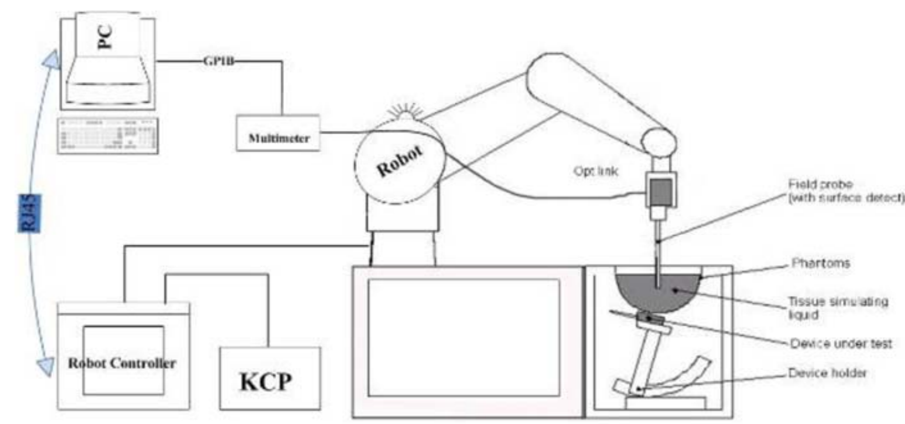
σ = conductivity of the tissue (S/m)
ρ = mass density of the tissue (kg/m3)
E = RMS electric field strength (V/m)

11 SAR Measurement Setup

11.1 Dosimetric Assessment System

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.

11.2 Measurement System Diagram



The OPENSAR system for performing compliance tests consist of the following items:

- A standard high precision 6-axis robot (KUKA) with controller and software.
- KUKA Control Panel (KCP).
- A dosimetric probe, i.e., an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.
- A computer operating Windows XP.
- OPENSAR software.
- Remote control with teaches pendant and additional circuitry for robot safety such as warning lamps, etc.
- The SAM phantom enabling testing left-hand right-hand and body usage.
- The Position device for handheld EUT.
- Tissue simulating liquid mixed according to the given recipes.
- System validation dipoles to validate the proper functioning of the system.

11.3 EPGO259 Probe

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 ±10%.

It is connected to the KRC box on the robot arm and provides an automatic detection of the phantom surface. The 3D file of the phantom is include in OpenSAR software. The Video Positioning System allow the system to take the automatic reference and to move the probe safely and accurately on the phantom.

Parameter	Description
Frequency Range	100 MHz to 6 GHz
Linearity	0.25 dB (100 MHz to 6 GHz)
Directivity	0.25 dB in brain tissue (rotation around probe axis) 0.5 dB in brain tissue (rotation normal probe axis)
Dynamic	0.001W/kg to > 100W/kg
Range Linearity	0.25 dB
Surface	0.2 mm repeatability in air and liquids
Dimensions Overall length	330 mm
Tip length	16 mm
Body diameter	8 mm
Tip diameter	2.6 mm
Distance from probe tip to dipole centers	<1.5 mm

11.4 E-Field Probe Calibration

Each probe is calibrated according to a dosimetric assessment procedure described in SAR standard with accuracy better than +/-10%. The spherical isotropy was evaluated with the procedure described in SAR standard and found to be better than +/-0.25dB. The sensitivity parameters (NormX, NormY, NormZ), the diode compression parameter (DCP) and the conversion factor (ConvF) of the probe are tested.
The free space E-field from probe outputs is determined in a test chamber. This is performed in a TEM cell for frequencies bellow 0.8 GHz, and in a waveguide above 0.8 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. E-field correlation calibration is performed in a flat phantom filled with the appropriate simulated brain tissue.

11.5 SAM Phantom

The SAM Phantom SAM29 is constructed of a fiberglass shell Integrated in a wooden table. The shape of the shell is in compliance with the specification set in IEEE P1528 and CENELEC EN62209-1.
The phantom enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region.
A cover prevents the evaporation of the liquid.
Reference markings on the Phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points in the robot.

Shell Thickness: 0.2 mm
Filling Volume: Approx. 25 liters
Dimensions (H x L x W): 810 x 1000 x 500 mm

Liquid is filled to at least 15mm from the bottom of Phantom.

11.6 Device Holder

In combination with the Generic Twin Phantom V3.0, the Mounting Device enables the rotation of the mounted transmitter in spherical coordinates whereby the rotation points is the ear opening. The devices can be easily, accurately, and repeatedly positioned according to the FCC and CENELEC specifications. The device holder can be locked at different phantom locations (left head, right head, flat phantom).

Note: A simulating human hand is not used due to the complex anatomical and geometrical structure of the hand that may produce infinite number of configurations [10]. To produce the worst-case condition. (the hand absorbs antenna output power), the hand is omitted during the tests.

11.7 Data Evaluation

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

Probe Parameters	- Sensitivity	$Norm_i$
	- Conversion factor	ConvFi
	- Diode compression point	Dcpi
Device Parameter	- Frequency	f
	- Crest factor	cf
Media Parameters	- Conductivity	σ
	- Density	ρ

These parameters must be set correctly in the software. They can either be found in the component documents or are imported into the software from the configuration files issued for the OPENSAR components.

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

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

Where V_i = Compensated signal of channel i (i = x, y, z)
U_i = Input signal of channel i (i = x, y, z)
cf = Crest factor of exciting field (DASY parameter)
dcp_i = Diode compression point (DASY parameter)

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

E-field probes: $$E_i = \sqrt{\frac{V_i}{Norm_i \cdot ConvF}}$$

H-field probes: $$H_i = \sqrt{Vi} \cdot \frac{a_{i0} + a_{i1} f + a_{i2} f^2}{f}$$

Where V_i = Compensated signal of channel i (i = x, y, z)
$Norm_i$ = Sensor sensitivity of channel i (i = x, y, z) $\mu V/(V/m)2$ for E0field Probes
ConvF = Sensitivity enhancement in solution
a_{ij} = Sensor sensitivity factors for H-field probes
f = Carrier frequency (GHz)
E_i = Electric field strength of channel i in V/m
H_i = Magnetic field strength of channel i in A/m

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

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

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

$$SAR = E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1000}$$

where SAR = local specific absorption rate in mW/g
E_{tot} = total field strength in V/m
σ = conductivity in [mho/m] or [siemens/m]
ρ = equivalent tissue density in g/cm3

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

The power flow density is calculated assuming the excitation field as a free space field.

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

where P_{pwe} = Equivalent power density of a plane wave in mW/cm2
E_{tot} = total electric field strength in V/m
H_{tot} = total magnetic field strength in A/m

11.8 SAR Evaluation – Peak Spatial - Average

The procedure for assessing the peak spatial-average SAR value consists of the following steps

- **Power Reference Measurement**
  The reference and drift jobs are useful jobs for monitoring the power drift of the device under test in the batch process. Both jobs measure the field at a specified reference position, at a selectable distance from the phantom surface. The reference position can be either the selected section's grid reference point or a user point in this section. The reference job projects the selected point onto the phantom surface, orients the probe perpendicularly to the surface, and approaches the surface using the selected detection method.

- **Area Scan**
  The area scan is used as a fast scan in two dimensions to find the area of high field values, before doing a finer measurement around the hot spot. The sophisticated interpolation routines implemented in OPENSAR software can find the maximum locations even in relatively coarse grids. The scan area is defined by an editable grid. This grid is anchored at the grid reference point of the selected section in the phantom. When the area scan's property sheet is brought-up, grid was at to 15 mm by 15 mm and can be edited by a user.

- **Zoom Scan**
  Zoom scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1 g and 10 g of simulated tissue. The default zoom scan measures 5 x 5 x 7 points within a cube whose base faces are centered on the maximum found in a preceding area scan job within the same procedure. If the preceding Area Scan job indicates more than one maximum, the number of Zoom Scans has to be enlarged accordingly (The default number inserted is 1).

- **Power Drift measurement**
  The drift job measures the field at the same location as the most recent reference job within the same procedure, and with the same settings. The drift measurement gives the field difference in dB from the reading conducted within the last reference measurement. Several drift measurements are possible for one reference measurement. This allows a user to monitor the power drift of the device under test within a batch process. In the properties of the Drift job, the user can specify a limit for the drift and have OPENSAR software stop the measurements if this limit is exceeded.

11.9 SAR Evaluation – Peak SAR

The procedure for spatial peak SAR evaluation has been implemented according to the IEEE1529 standard. It can be conducted for 1 g and 10 g. The OPENSAR system allows evaluations that combine measured data and robot positions, such as:

- Maximum search
- Extrapolation
- Boundary correction
- Peak search for averaged SAR

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

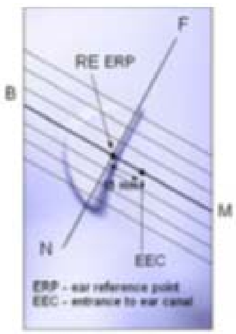
11.10 Extrapolation

Extrapolation routines are used to obtain SAR values between the lowest measurement points and the inner phantom surface. The extrapolation distance is determined by the surface detection distance and the probe sensor offset. Several measurements at different distances are necessary for the extrapolation.
They are used in the Cube Scan to obtain SAR values between the lowest measurement points and the inner phantom surface. The routine uses the fourth order least square polynomial method for extrapolation. For a grid using 5x5x7 measurement points with 5mm resolution amounting to 343 measurement points, the uncertainty of the extrapolation routines is less than 1% for 1 g and 10 g cubes.

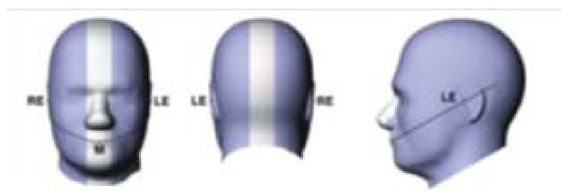
11.11 Device Reference Points

Ear Reference Point

Figure 6.2 shows the front, back and side views of the SAM Phantom. The point “M” is the reference point for the center of the mouth, “LE” is the left ear reference point (ERP), and “RE” is the right ERP. The ERPs are 15mm posterior to the entrance to the ear canal (EEC) along the B-M line (Back-Mouth), as shown in Figure 6.1. The plane passing through the two ear canals and M is defined as the Reference Plane. The line N-F (Neck-Front) is perpendicular to the reference plane and passing through the RE (or LE) is called the Reference Pivoting Line (see Figure 6.1). Line B-M is perpendicular to the N-F line. Both N-F and B-M lines are marked on the external phantom shell to facilitate handset positioning [5].

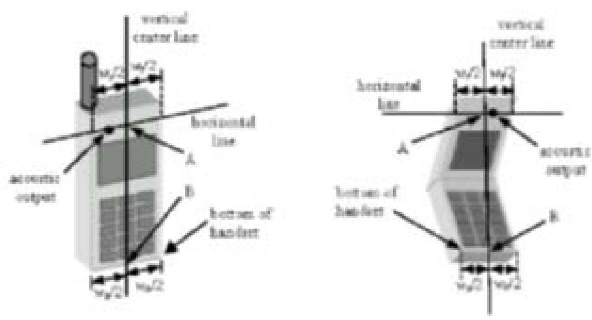


Close-up
side view of ERP's



Front, back and side view of SAM

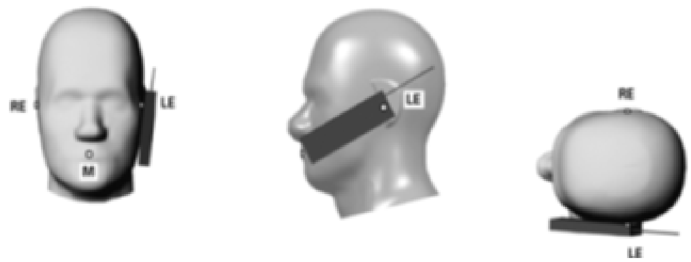
Two imaginary lines on the device need to be established: the vertical centerline and the horizontal line. The test device is placed in a normal operating position with the “test device reference point” located along the “vertical centerline” on the front of the device aligned to the “ear reference point” (See Fig. 6.3). The “test device reference point” is than located at the same level as the center of the ear reference point. The test device is positioned so that the “vertical centerline” is bisecting the front surface of the device at it’s top and bottom edges, positioning the “ear reference point” on the outer surface of both the left and right head phantoms on the ear reference point.



Handset Vertical Center & Horizontal Line Reference Points

11.12 Test Configuration – Positioning for Cheek / Touch

1. Position the device close to the surface of the phantom such that point A is on the (virtual) extension of the line passing through points RE and LE on the phantom (see Figure below), such that the plane defined by the vertical center line and the horizontal line of the device is approximately parallel to the sagittal plane of the phantom

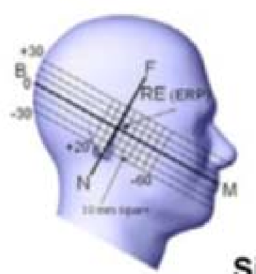


Front, Side and Top View of Cheek/Touch Position

2. Translate the device towards the phantom along the line passing through RE and LE until the device touches the ear.

3. While maintaining the device in this plane, rotate it around the LE-RE line until the vertical centerline is in the plane normal to MB-NF including the line MB (called the reference plane).
4. Rotate the device around the vertical centerline until the device (horizontal line) is symmetrical with respect to the line NF.

5. While maintaining the vertical centerline in the reference plane, keeping point A on the line passing through RE and LE and maintaining the device contact with the ear, rotate the device about the line NF until any point on the device is in contact with a phantom point below the ear (cheek). See Figure below.



Side view w/ relevant markings

11.13 Test Configuration – Positioning for Ear / 15° Tilt

With the test device aligned in the Cheek/Touch Position":

1. While maintaining the orientation of the device, retracted the device parallel to the reference plane far enough to enable a rotation of the device by 15 degrees.
2. Rotate the device around the horizontal line by 15 degrees.
3. While maintaining the orientation of the device, move the device parallel to the reference plane until any part of the device touches the head. (In this position, point A is located on the line RE-LE). The tilted position is obtained when the contact is on the pinna. If the contact is at any location other than the pinna, the angle of the device shall be reduced. The tilted position is obtained when any part of the device is in contact with the ear as well as a second part of the device is in contact with the head (see Figure below).

Front, Side and Top View of Ear/15° Tilt Position

11.14 Test Position – Body Worn Configurations

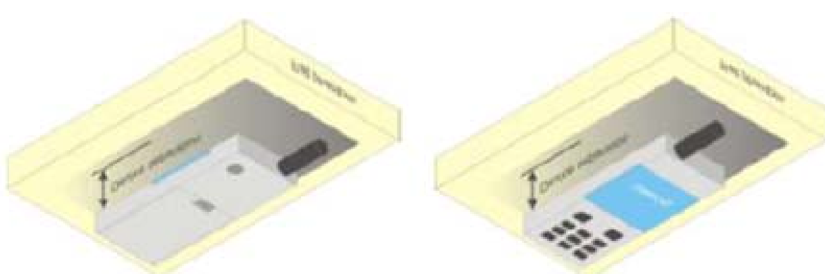
Body-worn operating configurations are tested with the accessories attached to the device and positioned against a flat phantom in a normal use configuration. A device with a headset output is tested with a headset connected to the device. Body dielectric parameters are used.

Accessories for Body-worn operation configurations are divided into two categories: those that do not contain metallic components and those that do contain metallic components. When multiple accessories that do not contain metallic components are supplied with the device, the device is tested with only the accessory that dictates the closest spacing to the body. Then, when multiple accessories that contain metallic components are supplied with the device, the device is tested with each accessory that contains a unique metallic component. If multiple accessories share an identical metallic component (i.e. the same metallic belt-clip used with different holsters with no other metallic components) only the accessory that dictates the closest spacing to the body is tested.

Body-worn accessories may not always be supplied or available as options for some devices intended to be authorized for body-worn use. In this case, a test configuration where a separation distance between the back of the device and the flat phantom is used. All test position spacing are documented.

Transmitters that are designed to operate in front of a person's face, as in push-to-talk configurations, are tested for SAR compliance with the front of the device positioned to face the flat phantom. For devices that are carried next to the body such as a shoulder, waist or chest-worn transmitters, SAR compliance is tested with the accessory(ies), including headsets and microphones, attached to the device and positioned against a flat phantom in a normal use configuration.

In all cases SAR measurements are performed to investigate the worst-case positioning. Worst-case positioning is then documented and used to perform Body SAR testing.



12 Measurement Uncertainty

The component of uncertainly may generally be categorized according to the methods used to evaluate them. The evaluation of uncertainly by the statistical analysis of a series of observations is termed a Type An evaluation of uncertainty. The evaluation of uncertainty by means other than the statistical analysis of a series of observation is termed a Type B evaluation of uncertainty. Each component of uncertainty, however evaluated, is represented by an estimated standard deviation, termed standard uncertainty, which is determined by the positive square root of the estimated variance

A Type A evaluation of standard uncertainty may be based on any valid statistical method for treating data. This includes calculating the standard deviation of the mean of a series of independent observations; using the method of least squares to fit a curve to the data in order to estimate the parameter of the curve and their standard deviations; or carrying out an analysis of variance in order to identify and quantify random effects in certain kinds of measurement.

A type B evaluation of standard uncertainty is typically based on scientific judgment using all of the relevant information available. These may include previous measurement data, experience and specification, data provided in calibration reports and uncertainties assigned to reference data taken from handbooks. Broadly speaking, the uncertainty is either obtained from an outdoor source or obtained from an assumed distribution, such as the normal distribution, rectangular or triangular distributions indicated in Table below:

Uncertainty Distribution	Normal	Rectangle	Triangular	U Shape
Multi-plying Factor(a)	1/k(b)	1 / √3	1 / √6	1 / √2

(a) Standard uncertainty is determined as the product of the multiplying factor and the estimated range of variations in the measured quantity
(b) K is the coverage factor

Standard Uncertainty for Assumed Distribution

The combined standard uncertainty of the measurement result represents the estimated standard deviation of the result. It is obtained by combining the individual standard uncertainties of both Type A and Type -sum-by taking the positive square root of the estimated variances.

Expanded uncertainty is a measure of uncertainty that defines an interval about the measurement result within which the measured value is confidently believed to lie. It is obtained by multiplying the combined standard uncertainty by a coverage factor. Typically, the coverage factor ranges from 2 to 3. Using a coverage factor allows the true value of a measured quantity to be specified with a defined probability within the specified uncertainty range. For purpose of this document, a coverage factor two is used, which corresponds to confidence interval of about 95 %.

The COMOSAR Uncertainty Budget is show in below table:

Uncertainty Budget of COMOSAR for frequency range 300 MHz to 6 GHz

Uncertainty Component	Tolerances %	Probability Distribution	Divisor	Ci (1g)	Ci (10g)	Uncertainty 1g(%)	Uncertainty 10g(%)
Measurement System Related							
Probe Calibration	6	N	1	1	1	6	6
Axial Isotropy	3	R	√3	√ (1-Cp)	√ (1-Cp)	1.22474	1.22474
Hemispherical Isotropy	4	R	√3	√ Cp	√ Cp	1.63299	1.63299
Boundary Effect	1	R	√3	1	1	0.57735	0.57735
Linearity	5	R	√3	1	1	2.88675	2.88675
System Detection Limits	1	R	√3	1	1	0.57735	0.57735
Readout Electronics	0.5	N	1	1	1	0.5	0.5
Response Time	0.2	R	√3	1	1	0.11547	0.11547
Integration Time	2	R	√3	1	1	1.1547	1.1547
RF Ambient Conditions	3	R	√3	1	1	1.73205	1.73205
Probe Positioner Mechanical Tolerances	2	R	√3	1	1	1.1547	1.1547
Probe Positioning with respect to Phantom Shell	1	R	√3	1	1	0.57735	0.57735
Extrapolation, Interpolation and integration Algorithms for Max. SAR Evaluation.	1.5	R	√3	1	1	0.86603	0.86603
Test Sample Related							
Test Sample Positioning	1.5	N	1	1	1	1.5	1.5
Device Holder Uncertainty	5	N	1	1	1	5	5
Output Power Variation – SAR Drift measurement	3	R	√3	1	1	1.73205	1.73205
Phantom and Tissue Parameters Related							
Phantom Uncertainty (Shape and thickness Tolerances)	4	R	√3	1	1	2.3094	2.394
Liquid Conductivity – deviation from target value	5	R	√3	0.64	0.43	1.84752	1.2413
Liquid Conductivity – Measurement Uncertainty	2.5	N	1	0.64	0.43	1.6	1.075
Liquid Permittivity – deviation from target value	3	R	√3	0.6	0.49	1.03923	0.8487
Liquid Permittivity – Measurement Uncertainty	2.5	N	1	0.6	0.49	1.5	1.225
Combined Standard Uncertainty						9.66051 %	9.52428 %
Expanded Standard Uncertainty (K=2 , confidence 95%)						18.9346 %	18.6676 %

13 Liquid Validation

13.1 Liquid Validation

The dielectric parameters were checked prior to assessment using the 8753ES dielectric probe kit. The dielectric parameters measured are reported in each correspondent section.

Liquid depth ≥ 15cm

13.2 IEEE SCC-34/SC-2 P1528 recommended Tissue Dielectric Parameters

The head tissue dielectric parameters recommended by the IEEE SCC-34/SC-2 in P1528 have been incorporated in the following table. These head parameters are derived from planar layer models simulating the highest expected SAR for the dielectric properties and tissue thickness variations in a human head. Other head and body tissue parameters that have not been specified in P1528 are derived from the tissue dielectric parameters computed from the 4-Cole-Cole equations and extrapolated according to the head parameters specified in P1528

Target Frequency	Head		Body	
MHz	εr	σ (S/m)	εr	σ (S/m)
150	52.3	0.76	61.9	0.80
300	45.3	0.87	58.2	0.92
450	43.5	0.87	56.7	0.94
835	41.5	0.90	53.19	0.97
900	41.5	0.97	55.0	1.05
915	41.5	0.98	55.0	1.09
1450	40.5	1.20	54.0	1.30
1610	40.3	1.29	53.8	1.40
1800-2000	40.0	1.40	53.3	1.52
2450	39.2	1.80	52.7	1.95
3000	38.5	2.40	52.0	2.73
5800	35.3	5.27	48.2	6.00

Note: ε_r = relative permittivity, σ = conductivity and ρ = 1000 kg/m^3

13.3 Liquid Validation Result:

Liquid type/Band(MHz)	Measured Date	Parameters	Measured	Target	Deviation (%)	Limit (%)
1900 Body	03/01/2017	Permittivity	51.99	53.3	-2.46	±5.00
		Conductivity	1.49	1.52	-1.97	±5.00

14 System Validation and System Verification

14.1 System Validation

The system validation procedure evaluates the system against reference SAR values and the performance of the probe, readout electronics, and software. The test setup utilizes a flat phantom and a reference dipole.

Thus, the system validation process does not include data scatter due to the use of anthropomorphic phantoms or uncertainty due to handset positioning variability. System validation should be performed annually, or when a new system is put into operation, or whenever modifications have been made to the system, such as a new software release, different readout electronics or different types of probes. The probe used in the test system to be validated should be properly calibrated.

System validation provides a means of system-level validation. The test system utilizes a flat phantom and a reference dipole. Thus, system validation verifies the system accuracy against its specifications but does not include the uncertainty due to the use of anthropomorphic phantoms, nor does it include the uncertainty due to handset positioning variability. This test is performed annually (e.g., after probe calibration), before measurements related to inter laboratory comparison and every time modifications have been made to the system, such as a new software release, different readout electronics, and for different types of probes.

System Validation procedure is at below,

a) **SAR evaluation**: A complete 1 g or 10 g averaged SAR measurement is performed. The reference dipole input power is adjusted to produce a 1 g averaged SAR value falling in the range of 0.4–10 W/kg. The 1 g or 10 g averaged SAR is measured at frequencies in reference table within the range to be used in compliance tests. The results are normalized to 1 W forward input power and compared with the reference SAR values shown in reference value. The differences from the reference values should be less than the tolerance specified for the SAR measurement system by the manufacturer or designer, i.e., within the expanded uncertainty for the system validation.

b) **Extrapolation routine**: Local SAR values are measured along a vertical axis directly above the reference dipole feed-point using the same test grid-point spacing as used for handset SAR evaluations. This measurement is repeated along another vertical axis with a 2 cm transverse offset from the reference dipole feed-point. SAR values at the phantom surface are extrapolated and compared with the numerical values given in reference table. The difference from the reference values should be less than the tolerance specified for the SAR measurement system by the manufacturer or designer, i.e., within the expanded uncertainty for system validation.

c) **Probe linearity**: The measurement in step a) is repeated using different reference dipole input power levels. The power levels are selected for each frequency to produce 1 g averaged SAR values of approximately 10 W/kg, 2 W/kg, and 0.4 W/kg. The measured SAR values are normalized to 1 W forward input power and compared with the 1 W normalized value from step a). The difference between these values should be less than the tolerance specified for the SAR measurement system by the manufacturer or designer, i.e., within the expanded uncertainty for the linearity component.

d) **Modulation response**: The measurements in step a) are repeated with pulse-modulated signals having a duty factor of 0.1 and pulse repetition rate of 10 Hz. The power is adjusted to produce a 1 g-averaged SAR of approximately 8 W/kg with the pulse modulated signal (corresponding to a peak spatial-average SAR of approximately 80 W/kg). The measured SAR values are normalized to 1 W forward input power and duty factor of 1, and compared with the 1 W normalized values from step a). The difference between these values should be less than the tolerance specified for the SAR measurement system by the manufacturer or designer, i.e., within the expanded uncertainty for system validation.

e) **System offset**: The measurements in step a) are repeated with a reference dipole input forward power that produces a 1 g or 10 g averaged SAR of approximately 0.05 W/kg. The measured SAR values are normalized to 1 W forward input power and compared with the 1 W normalized values from step a). The difference between these values should be less than the tolerance specified for the SAR measurement system by the manufacturer or designer, i.e., within the expanded uncertainty for system validation.

f) **Probe axial isotropy**: The center point of the probe's sensors is placed directly above the reference dipole center at a measurement distance of approximately 5–10 mm from the phantom inner surface. The probe (or reference dipole, if precise rotations are supported by the dipole fixture) is rotated around its axis ± 180° in steps no larger than 15°. The maximum and minimum SAR readings are recorded. The difference between these values should be less than the tolerance specified for the SAR measurement system by the manufacturer or designer, i.e., within the expanded uncertainty for the axial isotropy component.

Numerical reference SAR values (W/kg) for reference dipole and flat phantom

Frequency (MHz)	1 g SAR	10 g SAR	Local SAR at surface (above feed-point)	Local SAR at surface (y = 2 cm offset from feed-point)[a]
300	3.0	2.0	4.4	2.1
450	4.9	3.3	7.2	3.2
835	9.5	6.2	4.1	4.9
900	10.8	6.9	16.4	5.4
1450	29.0	16.0	50.2	6.5
1800	38.1	19.8	69.5	6.8
1900	39.7	20.5	72.1	6.6
2000	41.1	21.1	74.6	6.5
2450	52.4	24.0	104.2	7.7
3000	63.8	25.7	140.2	9.5

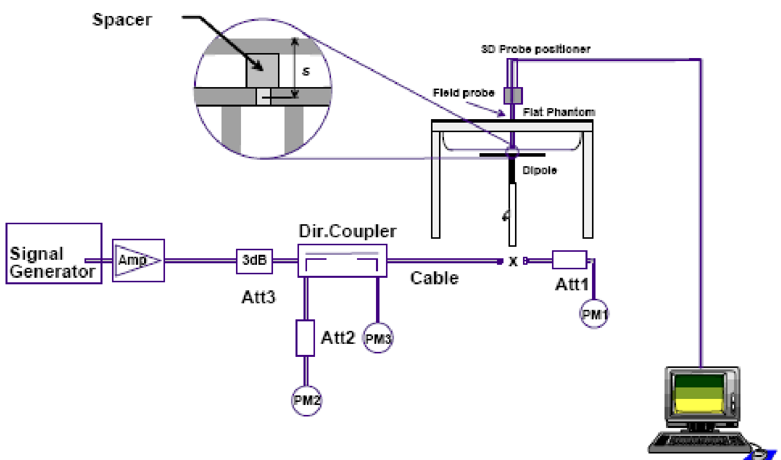
14.2 System Validation Status

Frequency (MHz)	Temp (°C)	Humidity (%)	Validation Date	Probe SN	Validation Cycle	Validation Due
835	21	44	Nov 09th, 2016	27/14 EPGO259	1 year	Nov 09th, 2017
900	21	44	Nov 09th, 2016	27/14 EPGO259	1 year	Nov 09th, 2017
1800	21	44	Nov 09th, 2016	27/14 EPGO259	1 year	Nov 09th, 2017
1900	21	44	Nov 09th, 2016	27/14 EPGO259	1 year	Nov 09th, 2017
2000	21	44	Nov 09th, 2016	27/14 EPGO259	1 year	Nov 09th, 2017
2450	21	44	Nov 09th, 2016	27/14 EPGO259	1 year	Nov 09th, 2017
5200	21	44	Nov 09th, 2016	27/14 EPGO259	1 year	Nov 09th, 2017
5400	21	44	Nov 09th, 2016	27/14 EPGO259	1 year	Nov 09th, 2017
5600	21	44	Nov 09th, 2016	27/14 EPGO259	1 year	Nov 09th, 2017
5800	21	44	Nov 09th, 2016	27/14 EPGO259	1 year	Nov 09th, 2017

14.3 System Verification

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.

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 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:



System Setup for System Evaluation

Equipment description: 1. Signal Generator. 2. Amplifier. 3. Directional Coupler. 4. Power Meter. 5. Calibrated Dipole.

14.4 System Verification Results

Test Date	Test Condition		Freq. (MHz)	Target (W/kg)	Input Power (dBm)	Measured (W/kg)	1W Normalized SAR1g (W/kg)	Delta (%)	Limit (%)
03/01/2017	Temp (°C)	21	1900	39.7	20	3.990	39.90	0.50	±10.00
	Humidity (%)	44							
	ATM (mbar)	1109							

15 Output Power Measurement Results

Requirement(s):

<table>
<tr><td>Spec</td><td>Item</td><td colspan="3">Requirement</td><td>Applicable</td></tr>
<tr><td>-</td><td>-</td><td colspan="3">Time averaged conducted output power to be measured</td><td>☒</td></tr>
<tr><td>Test Setup</td><td colspan="5">
</td></tr>
<tr><td>Test Procedure</td><td colspan="5"><u>Measurement using an Average Power Meter (PM)</u>

Measurements may be performed using a wideband gated RF power meter provided that the gate parameters are adjusted such that the power is measured only when the EUT is transmitting at its maximum power control level. Since the measurement is made only during the ON time of the transmitter, no duty cycle correction factor is required.
- Connect EUT’s RF output power to power meter
- Set EUT to be continuous transmission mode
- Measurement the average output power using power meter and record the result
Repeat above steps for different test channel and other modulation type.</td></tr>
<tr><td>Test Date</td><td colspan="2">03/01/2017</td><td>Environmental condition</td><td colspan="2">Temperature 21°C
Relative Humidity 44%
Atmospheric Pressure 1109mbar</td></tr>
<tr><td>Remark</td><td colspan="5">-</td></tr>
<tr><td>Result</td><td colspan="5">☒ Pass ☐ Fail</td></tr>
</table>

Test Data ☒ Yes ☐ N/A

Test Plot ☐ Yes ☒ N/A

Output Power measurement result

Type	CH	Freq (MHz)	Power (dBm)	Result
Power	4	1921.536	13.05	Pass
	2	1924.992	13.06	Pass
	0	1928.448	12.99	Pass

16 SAR Test Results

Requirement(s):

Spec	Item	Requirement	Applicable
IEEE 1528: 2013	1	SAR limit for devices used by the General public (Uncontrolled Environment) in localized Head and Trunk is 1.6 W/kg	☒
	2	SAR limit for Controlled Use Devices (Controlled Environment) in localized Head and Trunk is 8 W/kg	☐
Test Method	IEEE 1528: 2013 IEC 62209-2: 2010 447498 D01 General RF Exposure Guidance v05r02 KDB 865664 SAR Measurement Requirements for 3 to 6 GHz v01r03		
Test Setup	Refer to Section 6: SAR Measurement Setup		
Test Procedure	**Steps:** 1. Use client test software to set EUT transmit RF power in cont-TX mode in the highest power channel 2. Measure output power through spectrum analyzer 3. Place the DUT in the positions selected 4. Set scan area, grid size and other setting on the SATIMO software 5. Make SAR measurement for the selected highest output power channel at each testing position 6. Find out the position with highest SAR result 7. Measure additional SAR for other modes at the highest SAR position SAR measurement system will proceed the following basic steps: 1. Initial power reference measurement 2. Area Scan 3. Zoom Scan 4. Power drift measurement		
Test Date	03/01/2017 - 03/10/2017	Environmental condition	Temperature 21~24oC Relative Humidity 43~52% Atmospheric Pressure 1020~1202mbar
Remark	SAR is not required because the distance from the antenna to the edge is > 25 mm as per KDB 941225 D09 Hotspot Mode SAR. So SAR is not required for Left, Right, Top and Bottom sides.		
Result	☒ Pass ☐ Fail		

Test Data ☒ Yes ☐ N/A

Test Plot ☒ Yes ☐ N/A

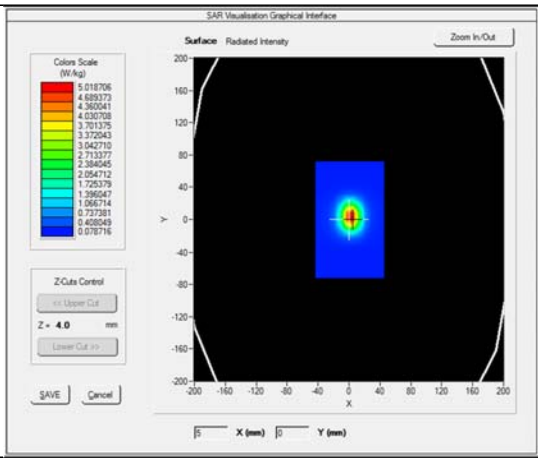
SAR Measurement for 1900MHz result to determine the worst case position configuration

Freq Band	Freq (MHz)	Position	Distance	Rated Max Power (dBm)	Measured Output Power (dBm)	Raw SAR 1g(W/kg)	Crest factor	Power Drift (%)	Scaled SAR (Tune-up & Duty Cycle) (W/kg)	1g SAR Limit (W/kg)
1900MHz	**1921.536**	**Back Touch**	**0mm**	**15**	**13.05**	**0.3506**	**0.04**	**4.33**	**0.557**	**1.6**
	1924.992	Back Touch	0mm	15	13.06	0.3302	**0.04**	-0.29	0.523	1.6
	1928.448	Back Touch	0mm	15	12.99	0.3499	**0.04**	2.23	0.563	1.6

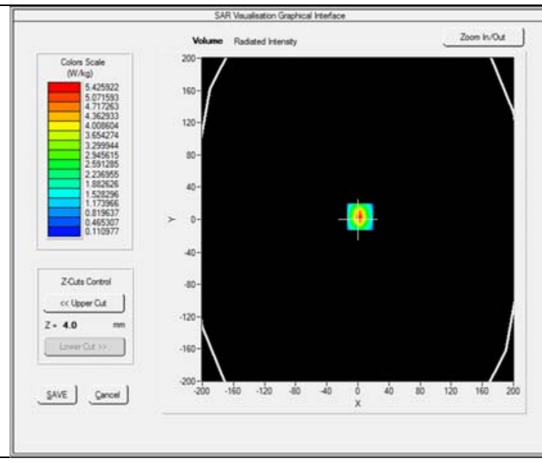
17 System Performance Plots

Test specification:	System Verification			
Environ Conditions:	Temp(oC):	21	Result:	Pass
	Humidity(%):	44		
	Atmospheric(mPa):	1109		
Mains Power:	N/A			
Test Date:	03/02/2017			
Tested by:	Arthur Tie			
Remarks:	System Validation, dipole, CW signal, duty cycle =1			

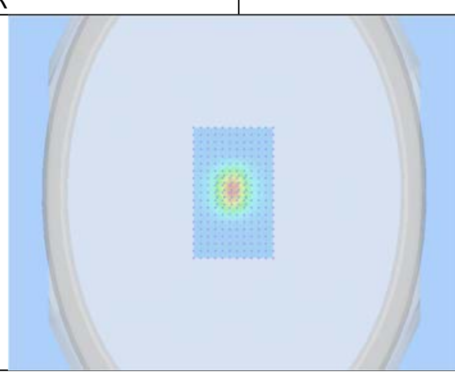
Frequency (MHz)	1900.000000
Relative permittivity (real part)	53.3
Conductivity (S/m)	1.52
Transmission Duty Factor	1.00
Probe SN	2715_EPGO259
Conversion Factor (dB)	3.02
Area Scan Resolution	8 mm
Zoom Scan Resolution	dx=5mm, dy=5mm, dz=5mm
Zoom Scan Size	30x30x34 mm
Measurement Drifts (%)	-1.09
Highest Extrapolated SAR (W/Kg)	5.77
SAR 1g (W/Kg)	3.99
Peak SAR Location	5mm(x),0mm(y),4mm(z)



SURFACE SAR



VOLUME SAR

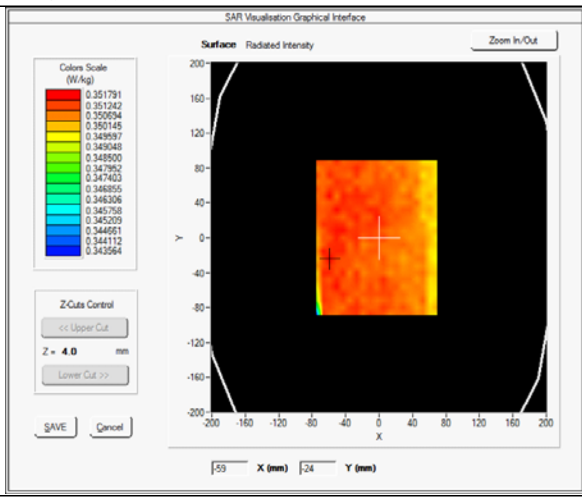


3D View

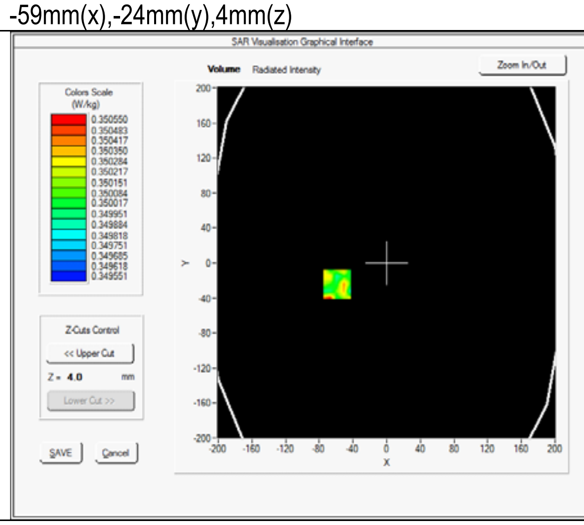
18 SAR Test Plots

Test specification:	Plane_Body_Low_1921.536_BackTouch			
Environ Conditions:	Temp(oC):	21	Result:	Pass
	Humidity(%):	44		
	Atmospheric(mPa):	1109		
Mains Power:	N/A			
Test Date:	03/02/2017			
Tested by:	Arthur Tie			
Remarks:				

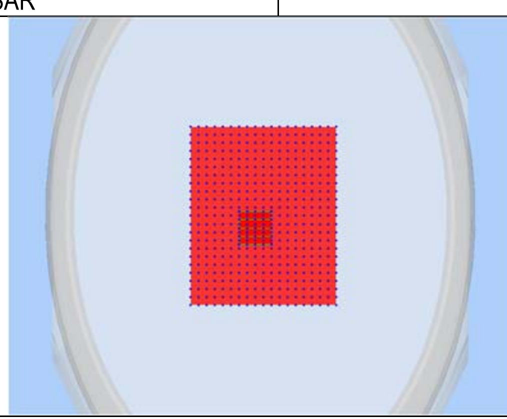
Frequency (MHz)	1921.536 (Channel 4)
Relative permittivity (real part)	53.30
Conductivity (S/m)	1.52
Transmission Duty Factor	0.04
Probe SN	2715_EPGO259
Conversion Factor (dB)	3.02
Area Scan Resolution	8 mm
Zoom Scan Resolution	dx=5mm, dy=5mm, dz=5mm
Zoom Scan Size	30x30x34 mm
Measurement Drifts (%)	4.33
Highest Extrapolated SAR (W/Kg)	0.3520
SAR 1g (W/Kg)	0.3506
Peak SAR Location	-59mm(x),-24mm(y),4mm(z)



SURFACE SAR



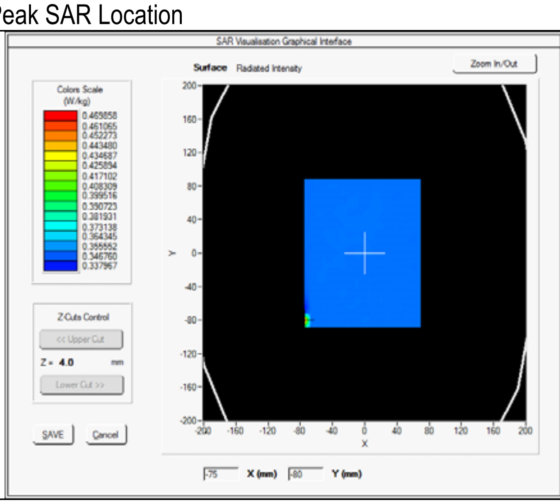
VOLUME SAR



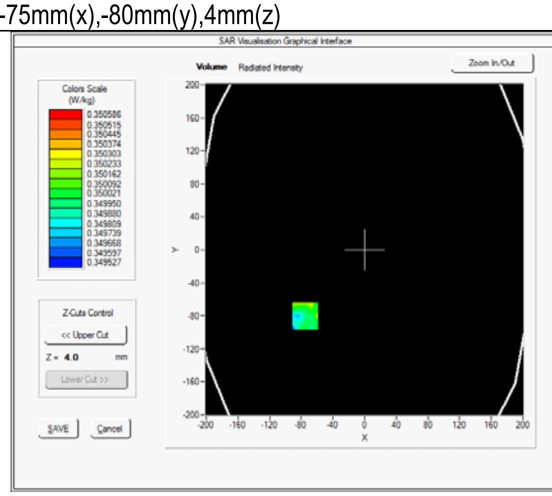
3D View Plot

Test specification:	Plane_Body_Middle_1924.992_BackTouch			
Environ Conditions:	Temp(oC):	21	Result:	Pass
	Humidity(%):	44		
	Atmospheric(mPa):	1109		
Mains Power:	N/A			
Test Date:	03/02/2017			
Tested by:	Arthur Tie			
Remarks:				

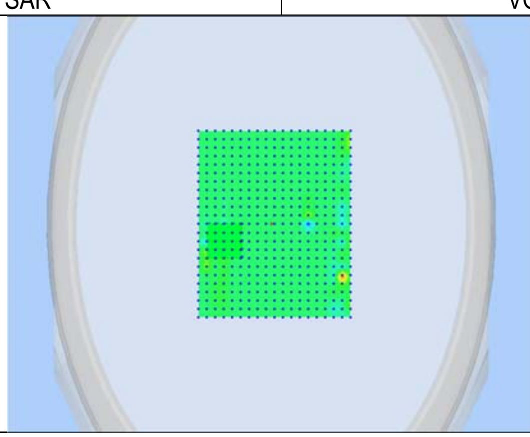
Frequency (MHz)	1924.992 (Channel 2)
Relative permittivity (real part)	53.30
Conductivity (S/m)	1.52
Transmission Duty Factor	0.04
Probe SN	2715_EPGO259
Conversion Factor (dB)	3.02
Area Scan Resolution	8 mm
Zoom Scan Resolution	dx=5mm, dy=5mm, dz=5mm
Zoom Scan Size	30x30x34 mm
Measurement Drifts (%)	-0.29
Highest Extrapolated SAR (W/Kg)	0.3510
SAR 1g (W/Kg)	0.3302
Peak SAR Location	-75mm(x),-80mm(y),4mm(z)



SURFACE SAR



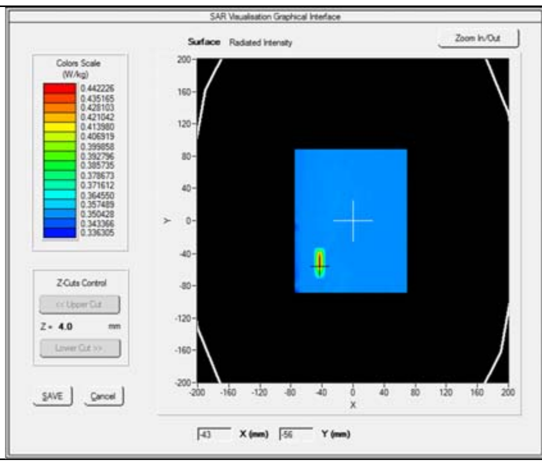
VOLUME SAR



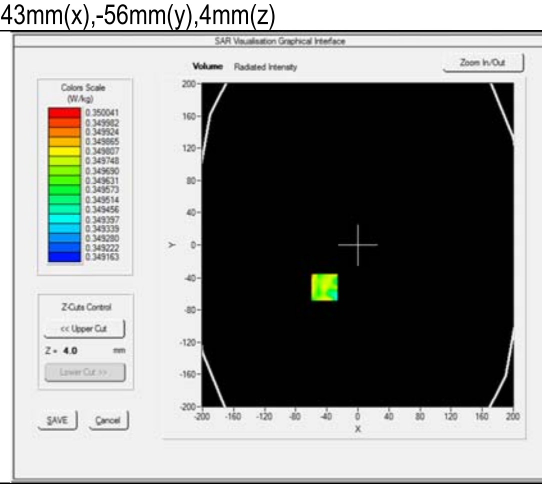
3D View Plot

Test specification:	Plane_Body_High_1928.448_BackTouch			
Environ Conditions:	Temp(oC):	21	Result:	Pass
	Humidity(%):	44		
	Atmospheric(mPa):	1109		
Mains Power:	N/A			
Test Date:	03/02/2017			
Tested by:	Arthur Tie			
Remarks:				

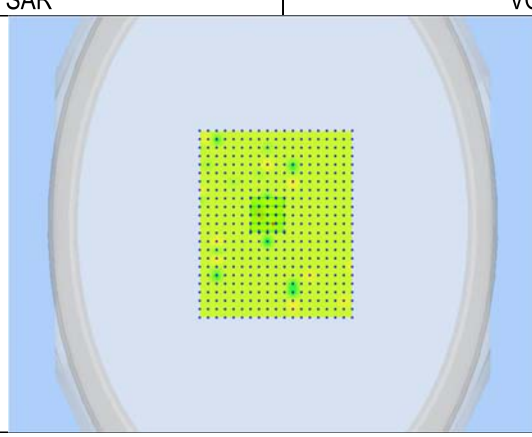
Frequency (MHz)	1928.448 (Channel 0)
Relative permittivity (real part)	53.30
Conductivity (S/m)	1.52
Transmission Duty Factor	0.04
Probe SN	2715_EPGO259
Conversion Factor (dB)	3.02
Area Scan Resolution	8 mm
Zoom Scan Resolution	dx=5mm, dy=5mm, dz=5mm
Zoom Scan Size	30x30x34 mm
Measurement Drifts (%)	2.23
Highest Extrapolated SAR (W/Kg)	0.3508
SAR 1g (W/Kg)	0.3499
Peak SAR Location	-43mm(x),-56mm(y),4mm(z)



SURFACE SAR



VOLUME SAR



3D View Plot

Annex A. TEST INSTRUMENT

Instrument	Model	Serial #	Cal Date	Cal Cycle	Cal Due	In use
SAR						
P C	PV 3.09GHz	375052-AA1	N/A	N/A	N/A	☑
MXG Vector Signal Generator	N5182A	MY47071065	04/12/2016	1 Year	04/12/2017	☑
Multi-meter	Multi-meter 2000	1259033	09/18/2016	1 Year	09/18/2017	☐
S-Parameter Network Analyzer	8753ES	US38161019	08/17/2016	1 Year	08/17/2017	☑
E-field PROBE	EPGO 259	SN 27/15 EPGO259	11/09/2016	1 Year	11/09/2017	☑
E-field PROBE	EP 204	SN 07/14 EP204	10/09/2015	1 Year	10/09/2016	☐
DIPOLE 850	DIPOLE 900MHz	SN 31/10 DIPD134	10/09/2015	1 Year	10/09/2016	☐
DIPOLE 1900	DIPOLE 2450MHz	SN 31/10 DIPF135	11/09/2016	1 Year	11/09/2017	☑
DIPOLE 2000	DIPOLE 2000MHz	SN 31/10 DIPI137	10/09/2015	1 Year	10/09/2016	☐
DIPOLE 2450	DIPOLE 2450MHz	SN 31/10 DIPJ138	10/09/2015	1 Year	10/09/2016	☐
Wave Guide 5/6 GHz	Wave Guide 5/6GHz	SN 31/10 DIPWGA13	07/08/2015	1 Year	07/08/2016	☐
COMOSAR Open Coaxial Probe	OCP36	SN 31/10 OCP36	07/08/2015	1 Year	07/08/2016	☐
Communication Antenna	ANTA30	SN 31/10 ANTA30	N/A	N/A	N/A	☐
Laptop POSITIONING DEVICE	LSH63	SN 31/10 LSH13	N/A	N/A	N/A	☑
Mobile Phone POSITIONING	MSH63	SN 31/10 MSH63	N/A	N/A	N/A	☑
DUMMY PROBE	None	SN 31/10	N/A	N/A	N/A	☐
SAM PHANTOM	SAM77	SN 31/10 SAM77	N/A	N/A	N/A	☐
Elliptic Phantom	ELLI17	SN 31-10 ELLI17	N/A	N/A	N/A	☑
PHANTOM TABLE	N/A	N/A	N/A	N/A	N/A	☑
6 AXIS ROBOT	KR5	949319	N/A	N/A	N/A	☑
Medium Power Solid State Amplifier (0.8~4.2GHz)	S41-25	M629-0408	N/A	N/A	N/A	☐

Annex B. SIEMIC Accreditation

Accreditations	Document	Scope / Remark
ISO 17025 (A2LA)		Please see the documents for the detailed scope
ISO Guide 65 (A2LA)		Please see the documents for the detailed scope
TCB Designation		A1, A2, A3, A4, B1, B2, B3, B4, C
FCC DoC Accreditation		FCC Declaration of Conformity Accreditation
FCC Site Registration		3 meter site
FCC Site Registration		10 meter site
IC Site Registration		3 meter site
IC Site Registration		10 meter site
EU NB		**Radio & Telecommunications Terminal Equipment:** EN45001 – EN ISO/IEC 17025
		Electromagnetic Compatibility: EN45001 – EN ISO/IEC 17025
Singapore iDA CB(Certification Body)		Phase I, Phase II
Vietnam MIC CAB Accreditation		Please see the document for the detailed scope
Hong Kong OFCA		**(Phase II)** OFCA Foreign Certification Body for Radio and Telecom
		(Phase I) Conformity Assessment Body for Radio and Telecom
Industry Canada CAB		**Radio:** Scope A – All Radio Standard Specification in Category I
		Telecom: CS-03 Part I, II, V, VI, VII, VIII

Japan Recognized Certification Body Designation		**Radio**: A1. Terminal equipment for purpose of calling **Telecom**: B1. Specified radio equipment specified in Article 38-2, Paragraph 1, Item 1 of the Radio Law
Korea CAB Accreditation		**EMI:** KCC Notice 2008-39, RRL Notice 2008-3: CA Procedures for EMI KN22: Test Method for EMI**EMS:** KCC Notice 2008-38, RRL Notice 2008-4: CA Procedures for EMS KN24, KN61000-4-2, -4-3, -4-4, -4-5, -4-6, -4-8, -4-11: Test Method for EMS
		Radio: RRL Notice 2008-26, RRL Notice 2008-2, RRL Notice 2008-10, RRL Notice 2007-49, RRL Notice 2007-20, RRL Notice 2007-21, RRL Notice 2007-80, RRL Notice 2004-68
		Telecom: President Notice 20964, RRL Notice 2007-30, RRL Notice 2008-7 with attachments 1, 3, 5, 6; President Notice 20964, RRL Notice 2008-7 with attachment 4
Taiwan NCC CAB Recognition		LP0002, PSTN01, ADSL01, ID0002, IS6100, CNS14336, PLMN07, PLMN01, PLMN08
Taiwan BSMI CAB Recognition		CNS 13438
Japan VCCI		R-3083: Radiation 3 meter site C-3421: Main Ports Conducted Interference Measurement T-1597: Telecommunication Ports Conducted Interference Measurement
Australia CAB Recognition		**EMC:** AS/NZS CISPR 11, AS/NZS CISPR 14.1, AS/NZS CISPR22, AS/NZS 61000.6.3, AS/NZS 61000.6.4
		Radio communications: AS/NZS 4281, AS/NZS 4268, AS/NZS 4280.1, AS/NZS 4280.2, AS/NZS 4295, AS/NZS 4582, AS/NZS 4583, AS/NZS 4769.1, AS/NZS 4769.2, AS/NZS 4770, AS/NZS 4771
		Telecommunications: AS/ACIF S002:05, AS/ACIF S003:09, AS/ACIF S004:09 AS/ACIF S009:01, AS/ACIF S016:01, AS/ACIF S031:01, AS/ACIF S038:01, AS/ACIF S040:01, AS/ACIF S041:05, AS/ACIF S043.2:09, AS/ACIF S60950.1
Australia NATA Recognition		AS/ACIF S002, AS/ACIF S003, AS/ACIF S004, AS/ACIF S009, AS/ACIF S016,AS/ACIF S031, AS/ACIF S038, AS/ACIF S040, AS/ACIF S041, AS/ACIF S043.2

Annex C. Probe Calibration Report

COMOSAR E-Field Probe Calibration Report

Ref : ACR.315.1.16.SATU.A

SIEMIC TESTING AND CERTIFICATION SERVICES
775 MONTAGUE EXPRESSWAY
MILPITAS, CA 95035, USA
MVG COMOSAR DOSIMETRIC E-FIELD PROBE
SERIAL NO.: SN 27/15 EPGO259

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

Calibration Date: 11/09/2016

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	11/10/2016	JS
Checked by :	Jérôme LUC	Product Manager	11/10/2016	JS
Approved by :	Kim RUTKOWSKI	Quality Manager	11/10/2016	Kim Rutkowski

	Customer Name
Distribution :	SIEMIC Testing and Certification Services

Issue	*Date*	*Modifications*
A	11/10/2016	Initial release

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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 27/15 EPGO259
Product Condition (new / used)	Used
Frequency Range of Probe	0.7 GHz-6GHz
Resistance of Three Dipoles at Connector	Dipole 1: R1=0.229 MΩ Dipole 2: R2=0.210 MΩ Dipole 3: R3=0.215 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.

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%

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 %

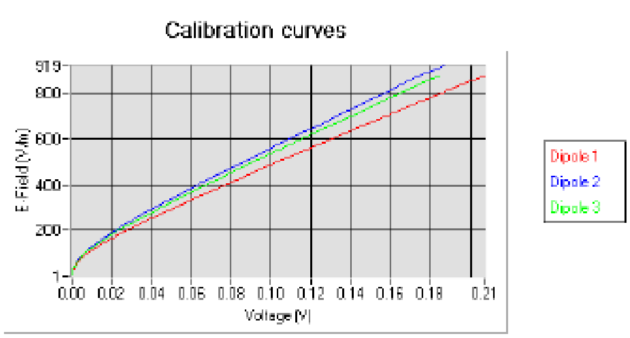
5.1 SENSITIVITY IN AIR

Normx dipole 1 ($\mu V/(V/m)^2$)	Normy dipole 2 ($\mu V/(V/m)^2$)	Normz dipole 3 ($\mu V/(V/m)^2$)
0.88	0.74	0.73

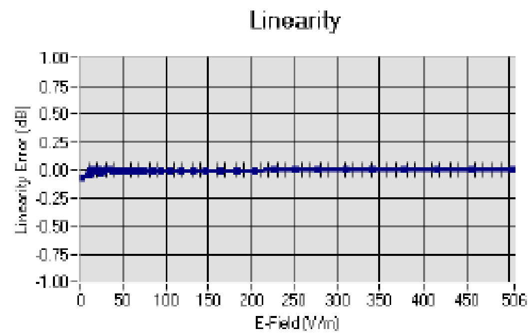
DCP dipole 1 (mV)	DCP dipole 2 (mV)	DCP dipole 3 (mV)
92	91	90

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

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



5.2 LINEARITY



Linearity:0+/-1.61% (+/-0.07dB)

5.3 SENSITIVITY IN LIQUID

Liquid	Frequency (MHz +/- 100MHz)	Permittivity	Epsilon (S/m)	ConvF
HL850	835	42.19	0.90	2.74
BL850	835	54.67	1.01	2.84
HL900	900	42.08	1.01	2.34
BL900	900	55.25	1.08	2.42
HL1800	1800	41.68	1.46	2.66
BL1800	1800	53.86	1.46	2.74
HL1900	1900	38.45	1.45	2.95
BL1900	1900	53.32	1.56	3.02
HL2450	2450	37.50	1.80	3.17
BL2450	2450	53.22	1.89	3.26
HL5200	5200	35.64	4.67	2.90
BL5200	5200	48.64	5.51	3.01
HL5400	5400	36.44	4.87	2.98
BL5400	5400	46.52	5.77	3.05
HL5600	5600	36.66	5.17	3.11
BL5600	5600	46.79	5.77	3.21
HL5800	5800	35.31	5.31	2.89
BL5800	5800	47.04	6.10	2.99

LOWER DETECTION LIMIT: 8mW/kg

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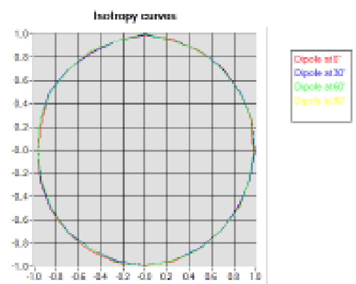
5.4 ISOTROPY

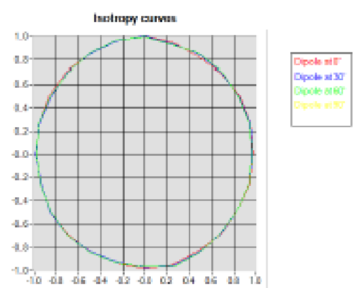
HL900 MHz

- Axial isotropy: 0.04 dB
- Hemispherical isotropy: 0.05 dB

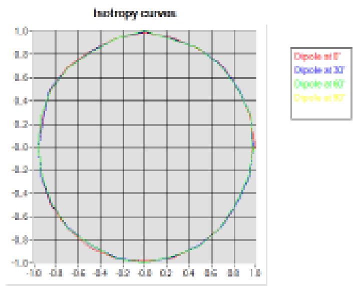


HL1800 MHz

- Axial isotropy: 0.04 dB
- Hemispherical isotropy: 0.07 dB



<u>HL5600 MHz</u>
- Axial isotropy: 0.06 dB
- Hemispherical isotropy: 0.09 dB



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	12/2013	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.
Temperature / Humidity Sensor	Control Company	150798832	10/2015	10/2017

Annex D. Dipoles Calibration Repor

SAR Reference Dipole Calibration Report

Ref : ACR.315.5.16.SATU.A

SIEMIC TESTING AND CERTIFICATION SERVICES

775 MONTAGUE EXPRESSWAY

MILPITAS, CA 95035, USA

MVG COMOSAR REFERENCE DIPOLE

FREQUENCY: 1900 MHZ

SERIAL NO.: SN 31/10 DIPG136

Calibrated at MVG US

2105 Barrett Park Dr. - Kennesaw, GA 30144

Calibration Date: 11/09/2016

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.315.5.16.SATU.A

	Name	*Function*	*Date*	*Signature*
Prepared by :	Jérôme LUC	Product Manager	11/10/2016	
Checked by :	Jérôme LUC	Product Manager	11/10/2016	
Approved by :	Kim RUTKOWSKI	Quality Manager	11/10/2016	

	Customer Name
Distribution :	SIEMIC Testing and Certification Services

Issue	*Date*	*Modifications*
A	11/10/2016	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 1900 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SID1900
Serial Number	SN 31/10 DIPG136
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*

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

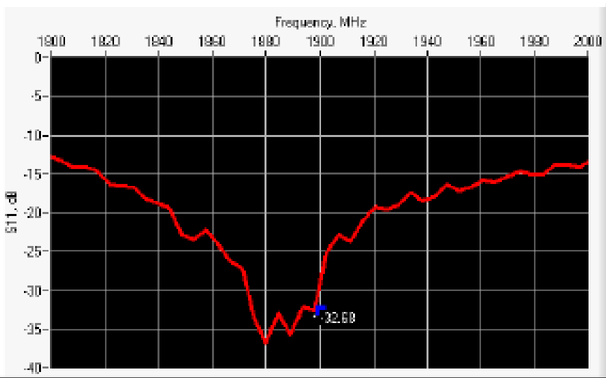
The guidelines outlined in the IEEE 1528, FCC KDBs, CENELEC EN50361 and CEI/IEC 62209 standards were followed to generate the measurement uncertainty for validation measurements.

Scan Volume	Expanded Uncertainty
1 g	20.3 %

10 g	20.1 %

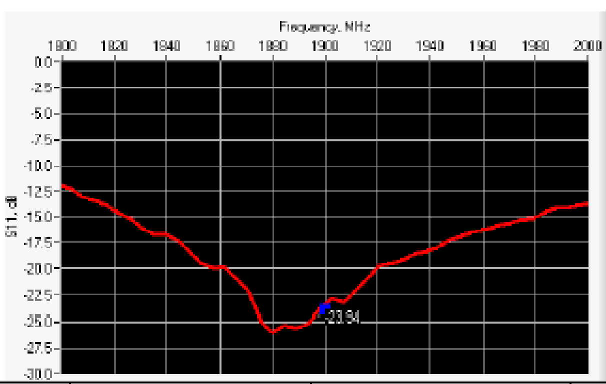
6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
1900	-32.68	-20	51.4 Ω + 1.9 jΩ

6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
1900	-23.94	-20	45.7 Ω + 4.4 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 %.	

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 %.	PASS	39.5 ±1 %.	PASS	3.6 ±1 %.	PASS
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 %.		30.4 ±1 %.		3.6 ±1 %.	
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 %	PASS	1.40 ±5 %	PASS
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 %	

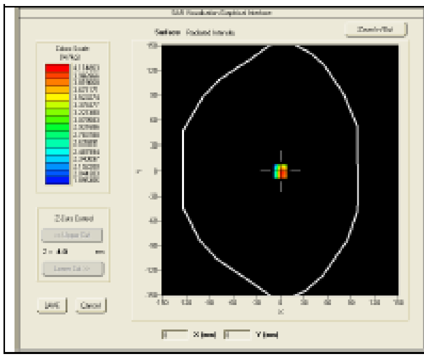
7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

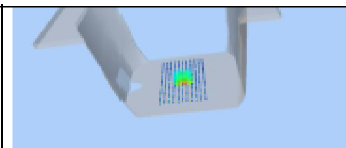
The IEEE Std. 1528 and CEI/IEC 62209 standards state that the system validation measurements should produce the SAR values shown below (for phantom thickness of 2 mm), within the uncertainty for the system validation. All SAR values are normalized to 1 W forward power. In bracket, the measured SAR is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

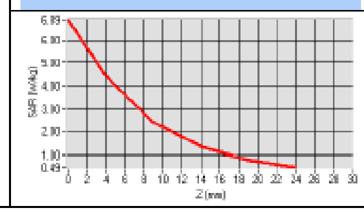
Software	OPENSAR V4
Phantom	SN 20/09 SAM71
Probe	SN 18/11 EPG122
Liquid	Head Liquid Values: eps' : 38.5 sigma : 1.45
Distance between dipole center and liquid	10.0 mm
Area scan resolution	dx=8mm/dy=8mm
Zoon Scan Resolution	dx=8mm/dy=8mm/dz=5mm
Frequency	1900 MHz
Input power	20 dBm
Liquid Temperature	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	

1900	39.7	40.24 (4.02)	20.5	20.62 (2.06)
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	
3700	67.4		24.2	







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 %	PASS	1.52 ±5 %	PASS
2000	53.3 ±5 %		1.52 ±5 %	
2100	53.2 ±5 %		1.62 ±5 %	

2300	52.9 ±5 %		1.81 ±5 %	
2450	52.7 ±5 %		1.95 ±5 %	
2600	52.5 ±5 %		2.16 ±5 %	
3000	52.0 ±5 %		2.73 ±5 %	
3500	51.3 ±5 %		3.31 ±5 %	
3700	51.0 ±5 %		3.55 ±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 %	

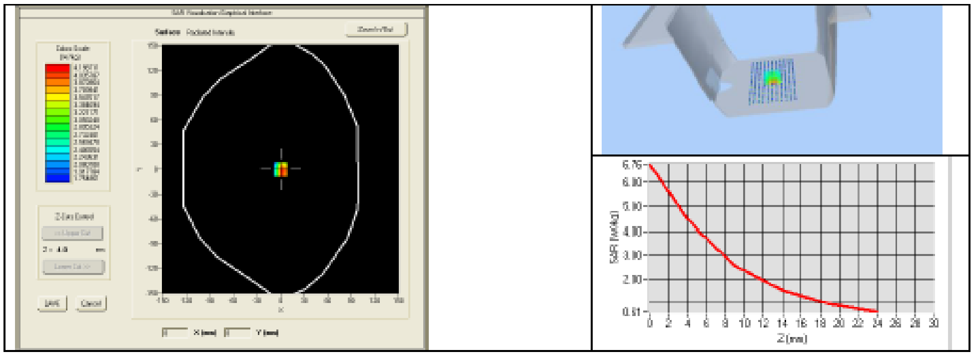
7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

Software	OPENSAR V4
Phantom	SN 20/09 SAM71
Probe	SN 18/11 EPG122
Liquid	Body Liquid Values: eps' : 53.3 sigma : 1.56
Distance between dipole center and liquid	10.0 mm
Area scan resolution	dx=8mm/dy=8mm
Zoon Scan Resolution	dx=8mm/dy=8mm/dz=5mm
Frequency	1900 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
1900	40.09 (4.01)	20.99 (2.10)

SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.315.5.16.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	02/2016	02/2019
Calipers	Carrera	CALIPER-01	12/2013	12/2016
Reference Probe	MVG	EPG122 SN 18/11	10/2016	10/2017
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	150798832	10/2015	10/2017