

SAR Test Report

Applicant : RANGER COMMUNICATIONS (M) SDN. BHD.
Product Type : Private land mobile radio
Trade Name : SmarTrunk
Model Number : ST-2112D
Date of Received : Feb. 04, 2015
Test Period : Aug. 11 ~ Aug. 15, 2016
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Issue by

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Revision History

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Contents

1. Summary of Maximum Reported SAR Value.....	4
2. Description of Equipment under Test (EUT)	5
3. Reference Testing Standards.....	6
4. Measurement System	7
4.1 SAR Definition	7
4.2 SAR Measurement Setup.....	8
4.3 DASY E-Field Probe System	9
4.4 Data Acquisition Electronic (DAE) System.....	11
4.5 Robot	11
4.6 Measurement Server	11
4.7 Device Holder	12
4.8 Oval Flat Phantom.....	12
4.9 Data Storage and Evaluation.....	13
4.10 Test Instruments.....	15
5. Tissue Simulating Liquids.....	16
5.1 Ingredients	17
5.2 Recipes.....	17
5.3 Liquid Parameters	18
5.4 Liquid Depth.....	18
6. System Verification.....	19
6.1 Symmetric Dipoles for System Verification.....	19
6.2 Verification Summary.....	20
6.3 Validation Summary	20
6.4 Measurement Uncertainty	21
7. Measurement Procedure	25
7.1 Spatial Peak SAR Evaluation	25
7.2 Area & Zoom Scan Procedures	26
7.3 Volume Scan Procedures	26
7.4 SAR Averaged Methods	26
7.5 Power Drift Monitoring.....	26
8. Conducted Power.....	27
9. Evaluation of SAR Test.....	28
9.1 Evaluation of SAR Test Reduction	28
9.2 Antenna Location	28
9.3 Stand-alone SAR Evaluate.....	29
10. Test Results	30
10.1 Applicable Limit Regulations	30
10.2 Brain SAR Results.....	31
10.3 Muscle SAR Results.....	32
10.4 SAR Variability Results	33
Appendix A - System Performance Check	34
Appendix B - SAR Measurement Data	36
Appendix C - Calibration	40

1. ***Summary of Maximum Reported SAR Value***

Standalone SAR			
Equipment Class	Band	Max. Brain Reported SAR1-g(W/Kg)_50% Duty Cycle	Max. Muscle Reported SAR1-g(W/Kg)_50% Duty Cycle
FRF	UHF	1.22	2.12

Note: The SAR limit (Head & Body: SAR1g 8.0 W/kg) for occupational / controlled exposure is specified in ANSI/IEEE C95.1-1992.

2. Description of Equipment under Test (EUT)

Applicant	RANGER COMMUNICATIONS (M) SDN. BHD. NO.8716, BATU BERENDAM FTZ III, 75350 BATU BERENDAM, MELAKA, MALAYSIA		
Manufacture	RANGER COMMUNICATIONS (M) SDN. BHD. NO.8716, BATU BERENDAM FTZ III, 75350 BATU BERENDAM, MELAKA, MALAYSIA		
Product Type	Private land mobile radio		
Trade Name	SmarTrunk		
Model Number	ST-2112D		
FCC ID	M38-ST-2112D		
RF Function information	Operate Band	Operate Frequency (MHz)	RF Conducted Power (Avg.)
	UHF	450 - 512	30.06dBm
Device Category	Portable Device		
RF Exposure Environment	Occupational / Controlled		
Antenna Type	Monopole Antenna		
Battery Option	Standard		
	SmarTrunk, ST-B12 7.4V, 1820mA (Li-Pol battery)		
Application Type	Certification		
Test Environment	Ambient Temperature : 22 ± 2 ° C		
	Relative Humidity : 40 - 70 %		

This wireless portable device has been shown to be capable of compliance for localized specific absorption rate (SAR) for Occupational / Controlled exposure limits specified in Standard C95.1-1999 and had been tested in accordance with the measurement procedures specified in IEEE Std. 1528-2013.

3. **Reference Testing Standards**

Standard	Description	Version
ANSI/IEEE C95.1	American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 300 KHz to 100 GHz, New York.	1992
IEEE 1528	IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head From Wireless Communications Devices: Measurement Techniques.	2013
FCC 47 CFR Part 2.1093	Radiofrequency radiation exposure evaluation: portable devices.	---
FCC KDB 865664 D01	SAR measurement 100 MHz to 6 GHz - describes SAR measurement procedures for devices operating between 100 MHz to 6 GHz	v01r04
FCC KDB 865664 D02	RF Exposure Reporting - provides general reporting requirements as well as certain specific information required to support MPE and SAR compliance.	v01r02
FCC KDB 643646 D01	SAR Test reduction considerations for occupational PTT radios	v01r03
FCC KDB 447498 D01	General RF Exposure Guidance - provides guidance pertaining to RF exposure requirements for mobile and portable device equipment authorizations.	v06

4. Measurement System

4.1 SAR Definition

Specific Absorption Rate (SAR) 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). It is also defined as the rate of RF energy absorption per unit mass at a point in an absorbing body (see Figure 2).

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

Figure 2. SAR Mathematical Equation

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

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

Where :

σ = conductivity of the tissue (S/m)

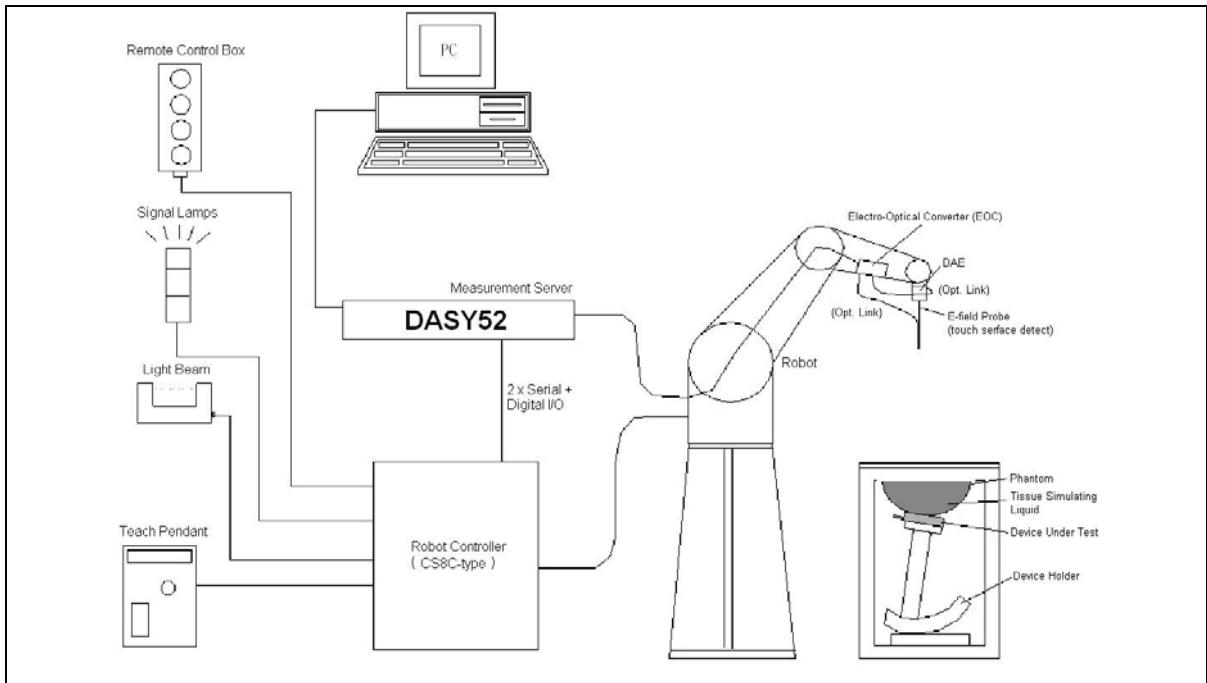
ρ = mass density of the tissue (kg/m³)

E = RMS electric field strength (V/m)

* Note :

The primary factors that control rate of energy absorption were found to be the wavelength of the incident field in relations to the dimensions and geometry of the irradiated organism, the orientation of the organism in relation to the polarity of field vectors, the presence of reflecting surfaces, and whether conductive contact is made by the organism with a ground plane [2]

4.2 SAR Measurement Setup



The DASY52 system for performing compliance tests consists of the following items:

1. A standard high precision 6-axis robot (Stäubli TX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
2. 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.
3. A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
4. The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
5. A probe alignment unit which improves the (absolute) accuracy of the probe positioning.
6. A computer operating Windows 2000 or Windows XP.
7. DASY52 software.
8. Remote controls with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
9. The SAM twin phantom enabling testing left-hand and right-hand usage.
10. The device holder for handheld mobile phones.
11. Tissue simulating liquid mixed according to the given recipes.
12. Validation dipole kits allowing validating the proper functioning of the system.

4.3 DASY E-Field Probe System

The SAR measurements were conducted with the dosimetric probe (manufactured by SPEAG), designed in the classical triangular configuration [3] and optimized for dosimetric evaluation. The probe is constructed using the thick film technique; with printed resistive lines on ceramic substrates. The probe is equipped with an optical multi-fiber line ending at the front of the probe tip. It is connected to the EOC box on the robot arm and provides an automatic detection of the phantom surface. Half of the fibers are connected to a pulsed infrared transmitter, the other half to a synchronized receiver. As the probe approaches the surface, the reflection from the surface produces a coupling from the transmitting to the receiving fibers. This reflection increases first during the approach, reaches maximum and then decreases. If the probe is flatly touching the surface, the coupling is zero. The distance of the coupling maximum to the surface is independent of the surface reflectivity and largely independent of the surface to probe angle. The DASY software reads the reflection during a software approach and looks for the maximum using a 2nd order fitting. The approach is stopped when reaching the maximum.

■ E-Field Probe Specification

Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Calibration	ISO/IEC 17025 calibration service available
Frequency	10 MHz to > 6 GHz Linearity: ± 0.2 dB (30 MHz to 6 GHz)
Directivity	± 0.3 dB in brain tissue (rotation around probe axis) ± 0.5 dB in brain tissue (rotation normal probe axis)
Dimensions	Overall length: 337 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Typical distance from probe tip to dipole centers: 1 mm



Figure 3. E-field Probe



Figure 4. Probe setup on robot

■ E-Field Probe Calibration process

Dosimetric Assessment Procedure

Each E-Probe/Probe Amplifier combination has unique calibration parameters. A TEM cell calibration procedure is conducted to determine the proper amplifier settings to enter in the probe parameters. The amplifier settings are determined for a given frequency by subjecting the probe to a known E-field density (1 mW/cm²) using an RF Signal generator, TEM cell, and RF Power Meter.

Free Space Assessment

The free space E-field from amplified probe outputs is determined in a test chamber. This calibration can be performed in a TEM cell if the frequency is below 1 GHz and in a waveguide or other methodologies above 1 GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity and at the proper orientation with the field. The probe is rotated 360 degrees until the three channels show the maximum reading. The power density readings equates to 1 mW/cm².

Temperature Assessment

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

$$\text{SAR} = C \frac{\Delta T}{\Delta t}$$

Where :

Δt = Exposure time (30 seconds),

C = Heat capacity of tissue (head or body),

ΔT = Temperature increase due to RF exposure.

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

Where :

σ = Simulated tissue conductivity,

ρ = Tissue density (kg/m³).

4.4 Data Acquisition Electronic (DAE) System

Model : DAE3, DAE4
Construction : Signal amplifier, multiplexer, A/D converter and control logic. Serial optical link for communication with DASY4/5 embedded system (fully remote controlled). Two step probe touch detector for mechanical surface detection and emergency robot stop.
Measurement Range : -100 to +300 mV (16 bit resolution and two range settings: 4mV, 400mV)
Input Offset Voltage : < 5µV (with auto zero)
Input Bias Current : < 50 fA
Dimensions : 60 x 60 x 68 mm

4.5 Robot

Positioner : Stäubli Unimation Corp. Robot Model: TX90XL
Repeatability : ±0.02 mm
No. of Axis : 6

4.6 Measurement Server

Processor : PC/104 with a 400MHz intel ULV Celeron
I/O-board : Link to DAE4 (or DAE3)
16-bit A/D converter for surface detection system
Digital I/O interface
Serial link to robot
Direct emergency stop output for robot

4.7 Device Holder

The DASY device holder is constructed of low-loss POM material having the following dielectric parameters: relative permittivity $\epsilon=3$ and loss tangent $\delta=0.02$. The amount of dielectric material has been reduced in the closest vicinity of the device, since measurements have suggested that the influence of the clamp on the test results could thus be lowered.

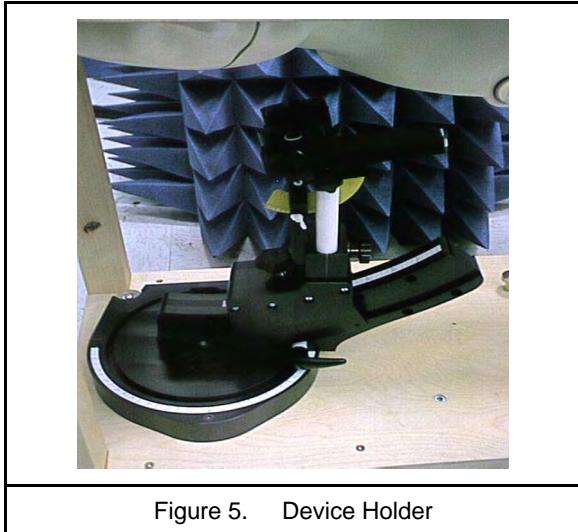


Figure 5. Device Holder

4.8 Oval Flat Phantom

The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (Oval Flat) phantom defined in IEEE 1528-2013, CENELEC 50361 and IEC 62209. It enables the dosimetric evaluation of wireless portable device usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points with the robot.

Shell Thickness	2 \pm 0.2 mm
Filling Volume	Approx. 30 liters
Dimensions	190x600x400 mm (HxLxW)

Table 1. Specification of ELI 4.0

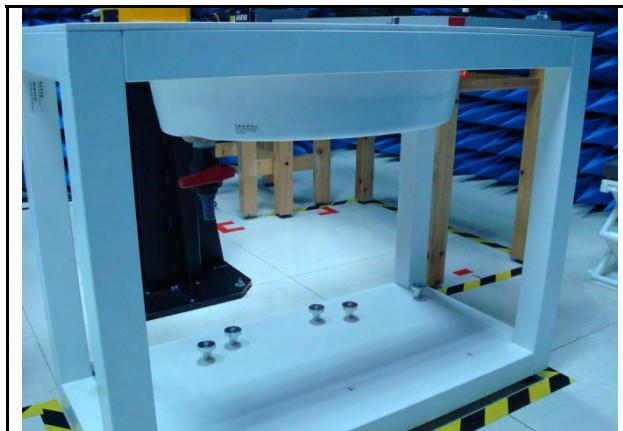


Figure 6. Oval Flat Phantom

4.9 Data Storage and Evaluation

■ Data Storage

The DASY software stores the assessed data from the data acquisition electronics as raw data (in microvolt readings from the probe sensors), together with all the necessary software parameters for the data evaluation (probe calibration data, liquid parameters and device frequency and modulation data) in measurement files with the extension DA4 or DA52. The post processing software evaluates the desired unit and format for output each time the data is visualized or exported. This allows verification of the complete software setup even after the measurement and allows correction of erroneous parameter settings. For example, if a measurement has been performed with an incorrect crest factor parameter in the device setup, the parameter can be corrected afterwards and the data can be reevaluated.

■ Data Evaluation

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

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

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

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

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

With 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)
 $dcpi$ = diode compression point (DASY parameter)

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

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

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

with 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 E-field 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.

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

with 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 set to 1, to account for actual head tissue density rather than the density of the tissue simulating liquid.

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

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

with 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

4.10 Test Instruments

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	450MHz System Validation Kit	D450V2	1021	Apr. 21, 2016	Apr. 21, 2017
SPEAG	Dosimetric E-Field Probe	EX3DV4	3847	Apr. 14, 2016	Apr. 14, 2017
SPEAG	Data Acquisition Electronics	DAE4	779	Mar. 02, 2016	Mar. 02, 2017
SPEAG	Device Holder	N/A	N/A	NCR	
SPEAG	Measurement Server	SE UMS 011 AA	1025	NCR	
SPEAG	Phantom (ELI V4.0)	QDOVA001BB	1036	NCR	
SPEAG	Robot	Staubli TX90XL	F07/564ZA1/A/01	NCR	
SPEAG	Software	DASY52 V52.8 (8)	N/A	NCR	
SPEAG	Software	SEMCAD X V14.6.10 (7331)	N/A	NCR	
Agilent	Dielectric Probe Kit	85070C	US99360094	NCR	
Agilent	ENA Series Network Analyzer	E5071B	MY42404655	Apr. 13, 2016	Apr. 13, 2018
Agilent	MXG Vector Signal Generator	N5182B	MY53050382	May 20, 2016	May 20, 2017
Agilent	Power Sensor	8481H	3318A20779	Jun. 06, 2016	Jun. 06, 2017
Agilent	Power Meter	EDM Series E4418B	GB40206143	Jun. 06, 2016	Jun. 06, 2017
Anritsu	Power Meter	ML2495A	1135009	Aug. 24, 2015	Aug. 24, 2016
Agilent	Dual Directional Coupler	778D	50334	NCR	
Mini-Circuits	Power Amplifier	ZHL-42W-SMA	D111103#5	NCR	
Mini-Circuits	Power Amplifier	ZVE-8G-SMA	D042005 671800514	NCR	
Aisi	Attenuator	IEAT 3dB	N/A	NCR	

5. **Tissue Simulating Liquids**

The mixture is calibrated to obtain proper dielectric constant (permittivity) and conductivity of the tissue.

The dielectric parameters of the liquids were verified prior to the SAR evaluation using an 85070C Dielectric Probe Kit and an E5071B Network Analyzer.

IEEE SCC-34/SC-2 in 1528 recommended Tissue Dielectric Parameters

The head tissue dielectric parameters recommended by the IEEE SCC-34/SC-2 in 1528 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 human head. Other head and body tissue parameters that have not been specified in 1528 are derived from the tissue dielectric parameters computed from the 4-Cole-Cole equation and extrapolated according to the head parameter specified in 1528.

Target Frequency (MHz)	Head		Body	
	ϵ_r	σ (S/m)	ϵ_r	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	55.2	0.97
900	41.5	0.97	55.0	1.05
915	41.5	0.98	55.0	1.06
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

(ϵ_r = relative permittivity, σ = conductivity and ρ = 1000 kg/m³)

Table 2. Tissue dielectric parameters for head and body phantoms

5.1 Ingredients

The following ingredients are used:

- Water: deionized water (pure H₂O), resistivity ≥ 16 M Ω -as basis for the liquid
- Sugar: refined white sugar (typically 99.7 % sucrose, available as crystal sugar in food shops)
-to reduce relative permittivity
- Salt: pure NaCl -to increase conductivity
- Cellulose: Hydroxyethyl-cellulose, medium viscosity (75-125 mPa.s, 2% in water, 20 °C), CAS # 54290 -to increase viscosity and to keep sugar in solution.
- Preservative: Preventol D-7 Bayer AG, D-51368 Leverkusen, CAS # 55965-84-9 -to prevent the spread of bacteria and molds
- DGBE: Diethylenglycol-monobutyl ether (DGBE), Fluka Chemie GmbH, CAS # 112-34-5 -to reduce relative permittivity

5.2 Recipes

The following tables give the recipes for tissue simulating liquids to be used in different frequency bands.

Note: The goal dielectric parameters (at 22 °C) must be achieved within a tolerance of ±5% for ε and ±5% for σ.

Liquid type	HSL 450 - A	
Ingredient	Weight (g)	Weight (%)
Water	522.94	38.91
Sugar	765.09	56.93
Cellulose	3.39	0.25
Salt	50.94	3.79
Preventol	1.63	0.12
Total amount	1'344.00	100.00
Goal dielectric parameters		
Frequency [MHz]	450	
Relative Permittivity	43.5	
Conductivity [S/m]	0.87	

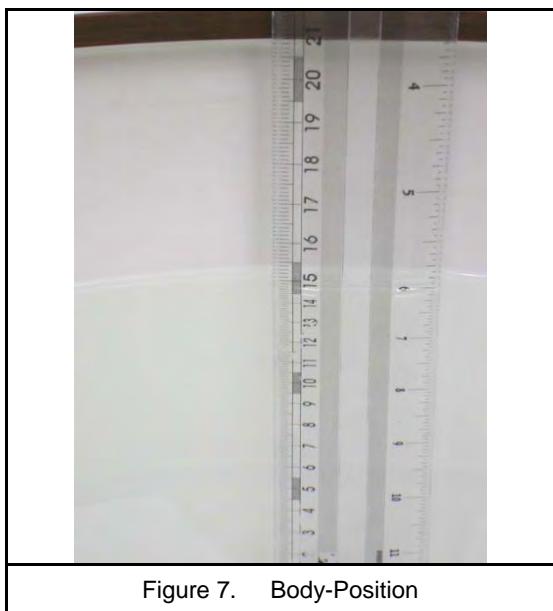
Liquid type	MSL 450 - B	
Ingredient	Weight (g)	Weight (%)
Water	590.62	46.21
Sugar	654.00	51.17
Cellulose	2.36	0.18
Salt	29.96	2.34
Preventol	1.06	0.08
Total amount	1'278.00	100.00
Goal dielectric parameters		
Frequency [MHz]	450	
Relative Permittivity	56.7	
Conductivity [S/m]	0.94	

5.3 Liquid Parameters

Liquid Verify								
Ambient Temperature : 22 \pm 2 °C ; Relative Humidity : 40 -70%								
Liquid Type	Frequency	Temp (°C)	Parameters	Target Value	Measured Value	Deviation (%)	Limit (%)	Measured Date
450MHz (Head)	450MHz	22.0	ϵ_r	43.50	43.14	-0.92%	\pm 5%	Aug. 15, 2016
			σ	0.870	0.840	-3.45%	\pm 5%	
	481MHz	22.0	ϵ_r	43.33	42.83	-1.16%	\pm 5%	
			σ	0.872	0.858	-1.15%	\pm 5%	
	520MHz	22.0	ϵ_r	43.13	41.74	-3.25%	\pm 5%	
			σ	0.875	0.893	2.30%	\pm 5%	
450MHz (Body)	450MHz	22.0	ϵ_r	56.70	56.57	-0.18%	\pm 5%	Aug. 11, 2016
			σ	0.940	0.914	-3.19%	\pm 5%	
	481MHz	22.0	ϵ_r	56.58	58.00	2.47%	\pm 5%	
			σ	0.942	0.939	0.00%	\pm 5%	
	520MHz	22.0	ϵ_r	56.43	54.66	-3.01%	\pm 5%	
			σ	0.945	0.947	0.00%	\pm 5%	

5.4 Liquid Depth

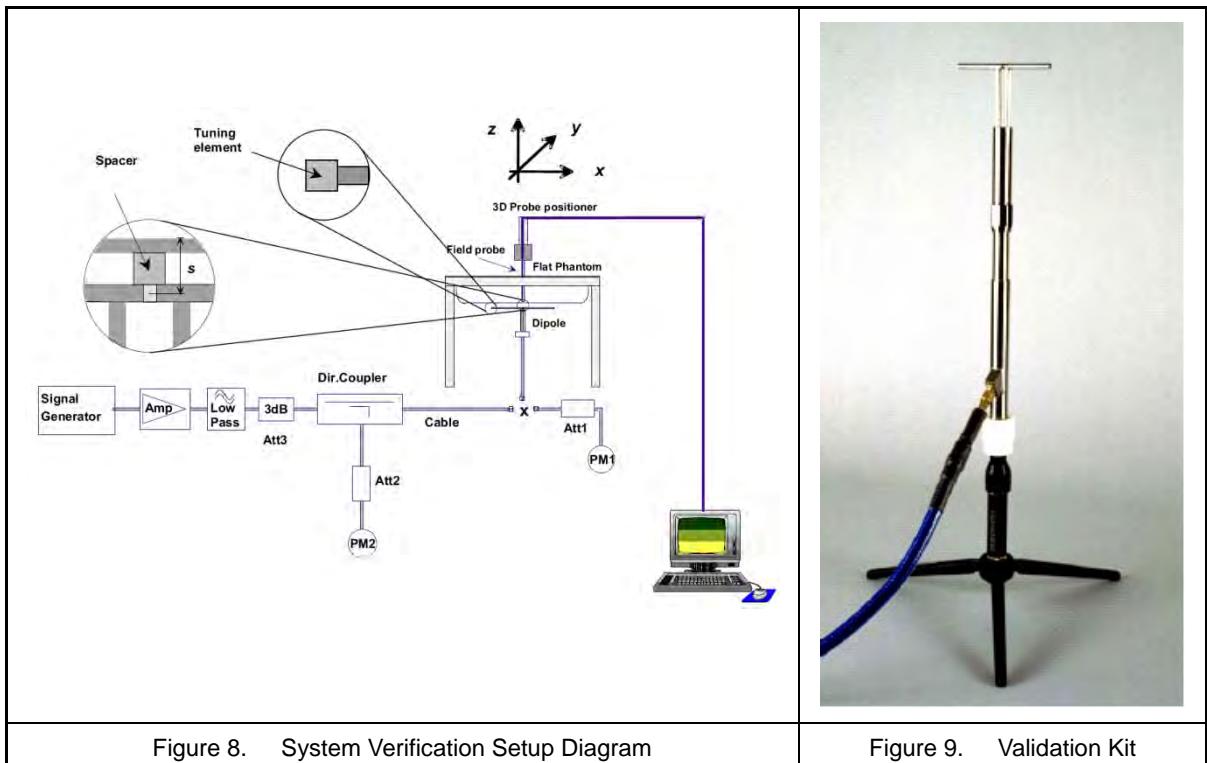
According to KDB 865664 ,the depth of tissue-equivalent liquid in a phantom must be \geq 15.0 cm with $\leq \pm 0.5$ cm variation for SAR measurements \leq 3 GHz and \geq 10.0 cm with $\leq \pm 0.5$ cm variation for measurements $>$ 3 GHz.



6. System Verification

6.1 Symmetric Dipoles for System Verification

Construction	Symmetrical dipole with $l/4$ balun enables measurement of feed point impedance with NWA matched for use near flat phantoms filled with head simulating solutions. Includes distance holder and tripod adaptor. Calibration. Calibrated SAR value for specified position and input power at the flat phantom in head simulating solutions.
Frequency	450 MHz
Return Loss	> 20 dB at specified verification position
Power Capability	> 100 W ($f < 1\text{GHz}$); > 40 W ($f > 1\text{GHz}$)
Options	Dipoles for other frequencies or solutions and other calibration conditions are available upon request
Dimensions	D450V2 : dipole length 270 mm; overall height 330 mm



6.2 Verification Summary

Prior to the assessment, the system validation kit was used to test whether the system was operating within its specifications of $\pm 7\%$. The verification was performed at 450MHz.

Mixture Type	Frequency (MHz)	Power	SAR _{1g} (W/Kg)	SAR _{10g} (W/Kg)	Drift (dB)	Difference percentage		Probe	Dipole	1W Target		Date
						1g	10g			Model / Serial No.	Model / Serial No.	
Head	450	250 mW	1.16	0.776	0	-2.7%	-2.1%	EX3DV4 SN: 3847	D450V2 SN:1021	4.77	3.17	Aug. 15, 2016
		Normalize to 1 Watt	4.64	3.1								
Body	450	250 mW	1.18	0.805	-0.01	-1.7%	1.6%	EX3DV4 SN: 3847	D450V2 SN:1021	4.8	3.17	Aug. 11, 2016
		Normalize to 1 Watt	4.72	3.22								

6.3 Validation Summary

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

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

Probe Type Model / Serial No.	Prob Cal. Point (MHz)	Head / Body	Cond.	Perm.	CW Validation			Mod. Validation			Date	
			ϵ_r	σ	Sensitivity	Probe	Probe	Mod. Type	Duty Factor	PAR		
						Linearity	Isotropy					
EX3DV4 SN: 3847	450	Head	43.14	0.84	Pass	Pass	Pass	FM	Pass	N/A	Aug. 15, 2016	
EX3DV4 SN: 3847	450	Body	56.57	0.914	Pass	Pass	Pass	FM	Pass	N/A	Aug. 11, 2016	

6.4 Measurement Uncertainty

IEC62209-1/IEEE 1528:2013

Item	Uncertainty Component	Uncertainty Value	Prob. Dist	Div.	c_i (1g)	c_i (10g)	Std. Unc. (1-g)	Std. Unc. (10-g)	v_i or V_{eff}
Measurement System									
u1	Probe Calibration ($k=1$)	$\pm 6.7\%$	Normal	1	1	1	$\pm 6.7\%$	$\pm 6.7\%$	∞
u2	Axial Isotropy	$\pm 4.7\%$	Rectangular	$\sqrt{3}$	0.7	0.7	$\pm 1.9\%$	$\pm 1.9\%$	∞
u3	Hemispherical Isotropy	$\pm 9.6\%$	Rectangular	$\sqrt{3}$	0.7	0.7	$\pm 3.9\%$	$\pm 3.9\%$	
u4	Boundary Effect	$\pm 1.0\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 0.6\%$	$\pm 0.6\%$	∞
u5	Linearity	$\pm 4.7\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 2.7\%$	$\pm 2.7\%$	∞
u6	System Detection Limit	$\pm 1.0\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 0.6\%$	$\pm 0.6\%$	∞
u7	Readout Electronics	$\pm 0.3\%$	Normal	1	1	1	$\pm 0.3\%$	$\pm 0.3\%$	∞
u8	Response Time	$\pm 0.8\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 0.5\%$	$\pm 0.5\%$	∞
u9	Integration Time	$\pm 1.9\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 1.1\%$	$\pm 1.1\%$	∞
u10	RF Ambient Conditions	$\pm 3.0\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 1.7\%$	$\pm 1.7\%$	∞
u11	RF Ambient Reflections	$\pm 3.0\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 1.7\%$	$\pm 1.7\%$	∞
u12	Probe Positioner Mechanical Tolerance	$\pm 0.4\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 0.2\%$	$\pm 0.2\%$	∞
u13	Probe Positioning with respect to Phantom Shell	$\pm 2.9\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 1.7\%$	$\pm 1.7\%$	∞
u14	Extrapolation, interpolation and integration Algorithms for Max. SAR Evaluation	$\pm 1.0\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 0.6\%$	$\pm 0.6\%$	∞
Test sample Related									
u15	Test sample Positioning	$\pm 3.6\%$	Normal	1	1	1	$\pm 3.6\%$	$\pm 3.6\%$	∞
u16	Device Holder Uncertainty	$\pm 2.7\%$	Normal	1	1	1	$\pm 2.7\%$	$\pm 2.7\%$	∞
u17	Output Power Variation - SAR drift measurement	$\pm 5.0\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 2.9\%$	$\pm 2.9\%$	∞
Phantom and Tissue Parameters									
u18	Phantom Uncertainty (shape and thickness tolerances)	$\pm 4.0\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 2.3\%$	$\pm 2.3\%$	∞
u19	Liquid Conductivity - deviation from target values	$\pm 5.0\%$	Rectangular	$\sqrt{3}$	0.64	0.43	$\pm 1.8\%$	$\pm 1.2\%$	∞
u20	Liquid Conductivity - measurement uncertainty	$\pm 2.5\%$	Normal	1	0.64	0.43	$\pm 1.6\%$	$\pm 1.08\%$	∞
u21	Liquid Permittivity - deviation from target values	$\pm 5.0\%$	Rectangular	$\sqrt{3}$	0.6	0.49	$\pm 1.7\%$	$\pm 1.4\%$	∞
u22	Liquid Permittivity - measurement uncertainty	$\pm 2.5\%$	Normal	1	0.6	0.49	$\pm 1.5\%$	$\pm 1.23\%$	∞
Combined standard uncertainty				RSS			$\pm 10.58\%$	$\pm 10.15\%$	∞
Expanded uncertainty (95% CONFIDENCE LEVEL)				$k=2$			$\pm 21.15\%$	$\pm 20.31\%$	

Table 3. Uncertainty Budget for frequency range 300MHz to 3GHz

IEC62209-2

Item	Uncertainty Component	Uncertainty Value	Prob. Dist	Div.	c_i (1g)	c_i (10g)	Std. Unc. (1-g)	Std. Unc. (10-g)	V_i or V_{eff}
Measurement System									
u1	Probe Calibration ($k=1$)	$\pm 6.7\%$	Normal	1	1	1	$\pm 6.7\%$	$\pm 6.7\%$	∞
u2	Axial Isotropy	$\pm 4.7\%$	Rectangular	$\sqrt{3}$	0.7	0.7	$\pm 1.9\%$	$\pm 1.9\%$	∞
u3	Hemispherical Isotropy	$\pm 9.6\%$	Rectangular	$\sqrt{3}$	0.7	0.7	$\pm 3.9\%$	$\pm 3.9\%$	
u4	Boundary Effect	$\pm 2.0\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 1.2\%$	$\pm 1.2\%$	∞
u5	Linearity	$\pm 4.7\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 2.7\%$	$\pm 2.7\%$	∞
u6	System Detection Limit	$\pm 1.0\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 0.6\%$	$\pm 0.6\%$	∞
u7	Readout Electronics	$\pm 0.3\%$	Normal	1	1	1	$\pm 0.3\%$	$\pm 0.3\%$	∞
u8	Response Time	$\pm 0.8\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 0.5\%$	$\pm 0.5\%$	∞
u9	Integration Time	$\pm 1.9\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 1.1\%$	$\pm 1.1\%$	∞
u10	RF Ambient Conditions	$\pm 3.0\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 1.7\%$	$\pm 1.7\%$	∞
u11	RF Ambient Reflections	$\pm 3.0\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 1.7\%$	$\pm 1.7\%$	∞
u12	Probe Positioner Mechanical Tolerance	$\pm 0.8\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 0.5\%$	$\pm 0.5\%$	∞
u13	Probe Positioning with respect to Phantom Shell	$\pm 6.7\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 3.9\%$	$\pm 3.9\%$	∞
u14	Extrapolation, interpolation and integration Algorithms for Max. SAR Evaluation	$\pm 1.0\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 0.6\%$	$\pm 0.6\%$	∞
Test sample Related									
u15	Test sample Positioning	$\pm 3.6\%$	Normal	1	1	1	$\pm 3.6\%$	$\pm 3.6\%$	∞
u16	Device Holder Uncertainty	$\pm 2.7\%$	Normal	1	1	1	$\pm 2.7\%$	$\pm 2.7\%$	∞
u17	Output Power Variation - SAR drift measurement	$\pm 5.0\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 2.9\%$	$\pm 2.9\%$	∞
Phantom and Tissue Parameters									
u18	Phantom Uncertainty (shape and thickness tolerances)	$\pm 4.0\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 2.3\%$	$\pm 2.3\%$	∞
u19	SAR correction	$\pm 1.9\%$	Rectangular	$\sqrt{3}$	1	0.84	$\pm 1.11\%$	$\pm 0.9\%$	∞
u20	Liquid Conductivity – deviation from target values	$\pm 5.0\%$	Rectangular	$\sqrt{3}$	0.64	0.43	$\pm 1.8\%$	$\pm 1.2\%$	∞
u21	Liquid Conductivity – measurement uncertainty	$\pm 2.5\%$	Normal	1	0.64	0.43	$\pm 1.6\%$	$\pm 1.08\%$	∞
u22	Liquid Permittivity - deviation from target values	$\pm 5.0\%$	Rectangular	$\sqrt{3}$	0.64	0.43	$\pm 1.8\%$	$\pm 1.2\%$	∞
u23	Liquid Permittivity - measurement uncertainty	$\pm 2.5\%$	Normal	1	0.64	0.43	$\pm 1.6\%$	$\pm 1.08\%$	∞
u24	Temp.Unc.- Conductivity	$\pm 3.4\%$	Rectangular	$\sqrt{3}$	0.78	0.71	$\pm 1.5\%$	$\pm 1.4\%$	∞
u25	Temp.Unc.- Permittivity	$\pm 0.4\%$	Normal	$\sqrt{3}$	0.23	0.26	$\pm 0.1\%$	$\pm 0.1\%$	∞
Combined standard uncertainty				RSS			$\pm 12.08\%$	$\pm 11.44\%$	∞
Expanded uncertainty (95% CONFIDENCE LEVEL)				$k=2$			$\pm 24.16\%$	$\pm 22.88\%$	

Table 4. Uncertainty Budget for frequency range 300MHz to 3GHz

Uncertainty of a System Performance Check with DASY System_IEC62209-2

Item	Uncertainty Component	Uncertainty Value	Prob. Dist	Div.	c_i (1g)	c_i (10g)	Std. Unc. (1-g)	Std. Unc. (10-g)	v_i or V_{eff}
Measurement System									
u1	Probe calibration (k=1)	±6.7%	Normal	1	1	1	±6.7%	±6.7%	∞
u2	Isotropy	±4.7%	Rectangular	$\sqrt{3}$	1	1	±0.52%	±0.52%	∞
u3	Linearity	±9.6%	Rectangular	$\sqrt{3}$	1	1	±0.52%	±0.52%	∞
u4	Modulation response	±1.0%	Rectangular	$\sqrt{3}$	1	1	±1.56%	±1.56%	∞
u5	Detection limits	±4.7%	Rectangular	$\sqrt{3}$	1	1	±0.58%	±0.58%	∞
u6	Boundary effect	±1.0%	Rectangular	$\sqrt{3}$	1	1	±0.58%	±0.58%	∞
u7	Readout electronics	±0.3%	Normal	1	1	1	±0.3%	±0.3%	∞
u8	Response time	±0.8%	Rectangular	$\sqrt{3}$	1	1	±0.46%	±0.46%	∞
u9	Integration time	±1.9%	Rectangular	$\sqrt{3}$	1	1	±1.5%	±1.5%	∞
u10	RF ambient conditions- noise	±3.0%	Rectangular	$\sqrt{3}$	1	1	±1.73%	±1.73%	∞
u11	RF ambient conditions- reflections	±3.0%	Rectangular	$\sqrt{3}$	1	1	±1.73%	±1.73%	∞
u12	Probe positioner mech. restrictions	±0.4%	Rectangular	$\sqrt{3}$	1	1	±0.23%	±0.23%	∞
u13	Probe positioning with respect to phantom shell	±2.9%	Rectangular	$\sqrt{3}$	1	1	±1.67%	±1.67%	∞
u14	Post-processing	±1.0%	Rectangular	$\sqrt{3}$	1	1	±0.58%	±0.58%	∞
Field source									
u15	Deviation of the experimental source from numerical source	±3.6%	Normal	1	1	1	±2%	±2%	∞
u16	Source to liquid distance	±2.7%	Rectangular	$\sqrt{3}$	1	1	±0.58%	±0.58%	∞
u17	Drift of output power (measured SAR drift)	±5.0%	Rectangular	$\sqrt{3}$	1	1	±2.89%	±2.89%	∞
Phantom and set-up									
u18	Phantom uncertainty (shape and thickness tolerances)	±4.0%	Rectangular	$\sqrt{3}$	1	1	±2.31%	±2.31%	∞
u19	Algorithm for correcting SAR for deviations in permittivity and conductivity	±5.0%	Normal	1	1	0.84	±2%	±1.68%	∞
u20	Liquid conductivity (meas.)	±2.5%	Normal	1	0.78	0.21	±1.95%	±0.53%	M
u21	Liquid permittivity (meas.)	±5.0%	Normal	1	0.23	0.26	±0.58%	±0.65%	M
u22	Liquid conductivity – temperature uncertainty	±2.5%	Rectangular	$\sqrt{3}$	0.78	0.71	±1.13%	±1.02%	∞
u23	Liquid permittivity – temperature uncertainty	±2.5%	Rectangular	$\sqrt{3}$	0.23	0.26	±0.33%	±0.38%	∞
Combined standard uncertainty				RSS			±8.88%	±8.61%	∞
Expanded uncertainty (95% CONFIDENCE LEVEL)				k=2			±17.77%	±17.22%	

Table 5. Uncertainty Budget for frequency range 300MHz to 3GHz

Uncertainty of a System Performance Check with DASY System_IEEE 1528-2013

Item	Uncertainty Component	Uncertainty Value	Prob. Dist	Div.	c_i (1g)	c_i (10g)	Std. Unc. (1-g)	Std. Unc. (10-g)	v_i or V_{eff}
Measurement System									
u1	Probe calibration ($k=1$)	$\pm 6.7\%$	Normal	1	1	1	$\pm 6.7\%$	$\pm 6.7\%$	∞
u2	Axial isotropy	$\pm 0.9\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 0.52\%$	$\pm 0.52\%$	∞
u3	Hemispherical isotropy	$\pm 9.6\%$	Rectangular	$\sqrt{3}$	0	0	$\pm 0\%$	$\pm 0\%$	∞
u4	Boundary effect	$\pm 2.7\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 1.56\%$	$\pm 1.56\%$	∞
u5	Linearity	$\pm 1\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 0.58\%$	$\pm 0.58\%$	∞
u6	System detection limits	$\pm 1\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 0.58\%$	$\pm 0.58\%$	∞
u7	Modulation response	$\pm 2.7\%$	Rectangular	$\sqrt{3}$	0	0	$\pm 0\%$	$\pm 0\%$	∞
u8	Readout electronics	$\pm 0.3\%$	Normal	1	1	1	$\pm 0.3\%$	$\pm 0.3\%$	∞
u9	Response time	$\pm 0.8\%$	Rectangular	$\sqrt{3}$	0	0	$\pm 0\%$	$\pm 0\%$	∞
u10	Integration time	$\pm 2.6\%$	Rectangular	$\sqrt{3}$	0	0	$\pm 0\%$	$\pm 0\%$	∞
u11	RF ambient conditions—noise	$\pm 3\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 1.73\%$	$\pm 1.73\%$	∞
u12	RF ambient conditions—reflections	$\pm 3\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 1.73\%$	$\pm 1.73\%$	∞
u13	Probe positioner mechanical tolerance	$\pm 0.4\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 0.23\%$	$\pm 0.23\%$	∞
u14	Probe positioning with respect to phantom shell	$\pm 2.9\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 1.67\%$	$\pm 1.67\%$	∞
u15	Extrapolation, interpolation and integration algorithms for max. SAR evaluation	$\pm 1\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 0.58\%$	$\pm 0.58\%$	∞
System validation source (dipole)									
u16	Deviation of experimental dipole from numerical dipole	$\pm 2\%$	Normal	1	1	1	$\pm 2\%$	$\pm 2\%$	∞
u17	Input power and SAR drift measurement	$\pm 1\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 0.58\%$	$\pm 0.58\%$	∞
u18	Dipole axis to liquid distance	$\pm 5\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 2.89\%$	$\pm 2.89\%$	∞
Phantom and set-up									
u19	Phantom shell uncertainty—thickness and permittivity	$\pm 4\%$	Rectangular	$\sqrt{3}$	1	1	$\pm 2.31\%$	$\pm 2.31\%$	∞
u20	Uncertainty in SAR correction for deviations in permittivity and conductivity	$\pm 2\%$	Normal	1	1	0.84	$\pm 2\%$	$\pm 1.68\%$	∞
u21	Liquid conductivity measurement	$\pm 2.5\%$	Normal	1	0.78	0.71	$\pm 1.95\%$	$\pm 1.78\%$	M
u22	Liquid permittivity measurement	$\pm 2.5\%$	Normal	1	0.23	0.26	$\pm 0.58\%$	$\pm 0.65\%$	M
u23	Liquid conductivity—temperature uncertainty	$\pm 2.5\%$	Rectangular	$\sqrt{3}$	0.78	0.71	$\pm 1.13\%$	$\pm 1.02\%$	∞
u24	Liquid permittivity—temperature uncertainty	$\pm 2.5\%$	Rectangular	$\sqrt{3}$	0.23	0.26	$\pm 0.33\%$	$\pm 0.38\%$	∞
Combined standard uncertainty				RSS			$\pm 8.73\%$	$\pm 8.62\%$	∞
Expanded uncertainty (95% CONFIDENCE LEVEL)				k=2			$\pm 17.46\%$	$\pm 17.23\%$	

Table 6. Uncertainty Budget for frequency range 300MHz to 3GHz

7. **Measurement Procedure**

The measurement procedures are as follows:

1. Measure output power through RF cable and power meter
2. Set scan area, grid size and other setting on the DASY software
3. Find out the largest SAR result on these testing positions of each band

According to the test standard, the recommended procedure for assessing the peak spatial-average SAR value consists of the following steps:

1. Power reference measurement
2. Area scan
3. Zoom scan
4. Power drift measurement

7.1 **Spatial Peak SAR Evaluation**

The procedure for spatial peak SAR evaluation has been implemented according to the test standard. It can be conducted for 1g and 10g, as well as for user-specific masses. The DASY software includes all numerical procedures necessary to evaluate the spatial peak SAR value.

The base for the evaluation is a "cube" measurement. The measured volume must include the 1g and 10g cubes with the highest averaged SAR values. For that purpose, the center of the measured volume is aligned to the interpolated peak SAR value of a previously performed area scan.

The entire evaluation of the spatial peak values is performed within the post-processing engine (SEMCAD). The system always gives the maximum values for the 1g and 10g cubes. The algorithm to find the cube with highest averaged SAR is divided into the following stages

1. Extraction of the measured data (grid and values) from the Zoom Scan
2. Calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters)
3. Generation of a high-resolution mesh within the measured volume
4. Interpolation of all measured values from the measurement grid to the high-resolution grid
5. Extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface
6. Calculation of the averaged SAR within masses of 1g and 10g

7.2 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 measures points and step size follow as below. The Zoom Scan is performed around the highest E-field value to determine the averaged SAR-distribution over 10 g.

Grid Type	Frequency	Step size (mm)			X*Y*Z (Point)	Cube size			Step size		
		X	Y	Z		X	Y	Z	X	Y	Z
uniform grid	$\leq 3\text{GHz}$	≤ 8	≤ 8	≤ 5	$5*5*7$	32	32	30	8	8	5
		≤ 5	≤ 5	≤ 5	$7*7*7$	30	30	30	5	5	5
	3 - 6GHz	≤ 5	≤ 5	≤ 4	$7*7*8$	30	30	28	5	5	4
		≤ 4	≤ 4	≤ 3	$8*8*10$	28	28	27	4	4	3
		≤ 4	≤ 4	≤ 2	$8*8*12$	28	28	22	4	4	2

(Our measure settings are refer KDB Publication 865664 D01v01r04)

7.3 Volume Scan Procedures

The volume scan is used for assess overlapping SAR distributions for antennas transmitting in different frequency bands. It is equivalent to an oversized zoom scan used in standalone measurements. The measurement volume will be used to enclose all the simultaneous transmitting antennas. For antennas transmitting simultaneously in different frequency bands, the volume scan is measured separately in each frequency band. In order to sum correctly to compute the 1g aggregate SAR, the DUT remain in the same test position for all measurements and all volume scan use the same spatial resolution and grid spacing. When all volume scan were completed, the software, SEMCAD postprocessor can combine and subsequently superpose these measurement data to calculating the multiband SAR.

7.4 SAR Averaged Methods

In DASY, the interpolation and extrapolation are both based on the modified Quadratic Shepard's method. The interpolation scheme combines a least-square fitted function method and a weighted average method which are the two basic types of computational interpolation and approximation. 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. The uncertainty increases with the extrapolation distance. To keep the uncertainty within 1% for the 1 g and 10 g cubes, the extrapolation distance should not be larger than 5 mm.

7.5 Power Drift Monitoring

All SAR testing is under the DUT install full charged battery and transmit maximum output power. In DASY measurement software, the power reference measurement and power drift measurement procedures are used for monitoring the power drift of DUT during SAR test. Both these procedures measure the field at a specified reference position before and after the SAR testing. The software will calculate the field difference in dB. If the power drift more than 5%, the SAR will be retested.

8. **Conducted Power**

Note : 1.The conducted power turn-up tolerance, please reference manufacturer specification.

2.Start by testing a PTT radio with a standard battery (default battery) that is supplied with the radio to measure the SAR of each antenna on the highest output power channel (481MHz) , according to the test channels required by the number-of-test-channels formula in KDB Publication 447498 D01 (frequency range : 450~512MHz, Nc = 6) and in the frequency range covered by each antenna within the operating frequency bands of the radio.

■ Measurement result

Usage	Operates with a built-in test mode by client					
EUT Battery	Fully-charged with Li-Pol battery					
Frequency Band	Frequency (MHz)	SAR Test Time-Avg. (dBm)	Duty Cycle	Time-Avg.Tune-up Power (dBm)		
				Min.	Nominal	Max.
UHF	450.0	36.03	1	34.1	35.1	36.1
	465.5	36.02	1	34.1	35.1	36.1
	481.0	36.06	1	34.1	35.1	36.1
	496.5	36.03	1	34.1	35.1	36.1
	512.0	36.05	1	34.1	35.1	36.1

9. Evaluation of SAR Test

9.1 Evaluation of SAR Test Reduction

■ General:

1. The test data reported are the worst-case SAR value with the position set in a typical configuration.
Test procedures used were according to IEEE1528-2013..
2. All modes of operation were investigated, and worst-case results are reported.
3. Tissue parameters and temperatures are listed on the SAR plots.
4. Batteries are fully charged for all readings.

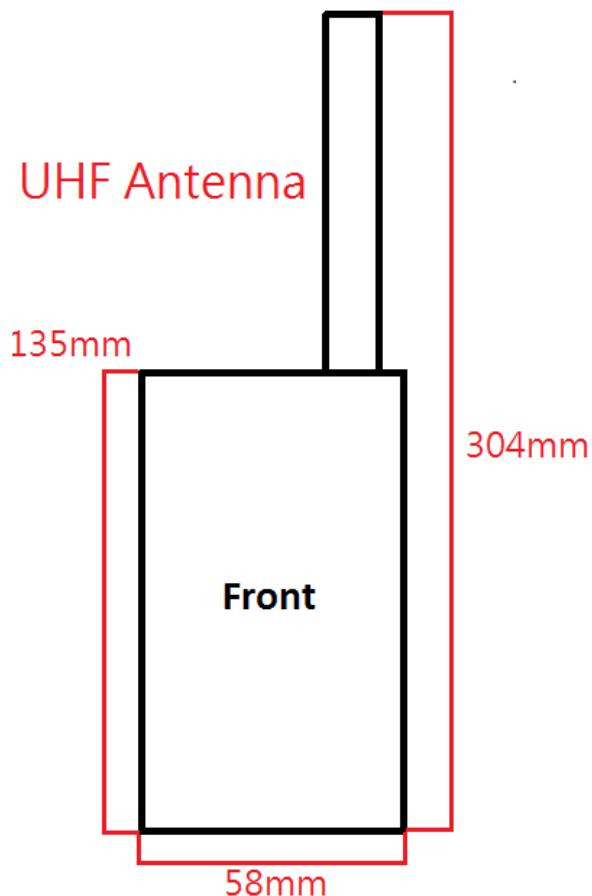
■ According to FCC KDB KDB 447498:

1. The test data reported are the worst-case SAR value with the position set in a typical configuration.
Test procedures used were according to IEEE1528-2013.

■ According to FCC KDB 865664:

1. The original highest measured Reported SAR 1g is ≥ 4.0 W/kg, repeat that measurement once.
2. Perform a second repeated measurement the ratio of largest to smallest SAR for the original and first repeated measurements is < 1.2 , the original or repeated measurement is ≥ 7.25 W/kg ($\sim 10\%$ from the 1-g SAR limit).
3. Perform a third repeated measurement only if the original, first or second repeated measurement is ≥ 7.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20 .

9.2 Antenna Location



9.3 Stand-alone SAR Evaluate

Transmitter and antenna implementation as below:

Band	UHF Antenna
UHF	V

Stand-alone transmission configurations as below:

Band	Front	Back
UHF	V	V

10. Test Results

■ Test Condition of EUT:

1. According to the TCB guidance :
 - (1) We can use the unconventional means of connecting the device to a DC power supply during test.
 - (2) We can reduce the size of the grid, and do the scanning and testing for the location of the maximum energy SAR point only.
 - (3) We can use segmentation emission way to perform the test.
2. Start by testing a PTT radio with a standard battery (default battery) that is supplied with the radio to measure the SAR of each antenna on formula in KDB Publication 447498 D01 (frequency range : 450~512MHz, $N_c = 6$) and in the frequency range covered by each antenna.
3. When the SAR ≤ 3.5 W/kg, testing of all other required channels is not necessary for that antenna.
4. 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.
5. When the SAR > 4.0 W/kg and ≤ 6.0 W/kg, head SAR should be measured for that antenna on the required immediately adjacent channels; testing of the other required channels still needs consideration.
6. When the SAR > 6.0 W/kg, test all required channels for that antenna.

10.1 Applicable Limit Regulations

According ANSI/IEEE C95.1 - IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

Safety Limits for Partial Body Exposure		
Human Exposure	Population Uncontrolled Exposure (W/kg) or (mW/g)	Occupational Controlled Exposure (W/kg) or (mW/g)
Spatial Peak SAR* (head)	1.60	8.00
Spatial Peak SAR** (Whole Body)	0.08	0.40
Spatial Peak SAR*** (Partial-Body)	1.60	8.00
Spatial Peak SAR**** (Hands / Feet / Ankle / Wrist)	4.00	20.00

NOTE :

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

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

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

10.2 Brain SAR Results

Test Position	Band	Ch.	Frequency (MHz)	Spacing (mm)	Power supply	ASSY	SAR _{1g} (W/Kg)	Power Drift	Avg Power	Max tune-up	Reported SAR _{1g} (W/Kg)
Front	UHF	3	481	25	8.2V_2A	N/A	2.41	-0.01	36.06	36.1	2.43

◆ SAR values are scaled for the power drift

Band	Ch.	Power supply	ASSY.	SAR _{1g} [W/Kg]		power drift (dB)	+ power drift 10^(dB/10)	SAR _{1g} [W/Kg] (include +power drift)		Remark			
				Duty Cycle				Duty Cycle					
				100%	50%			100%	50%				
UHF	3	8.2V_2A	N/A	2.43	1.22	-0.010000	1.002	2.44	1.22	---			

SAR is basically proportional to average transmit power and duty cycle

(i.e. SAR = P x T where P is the average transmit power and T is the transmit duty cycle).

SAR(unknown) = SAR(know) x (PxTx/P(known) T(known))

Where Px is the unknown power (i.e. the power at the highest drift)

Tx is the transmit duty cycle used at that unknown power.

If transmitter duty cycle is the same then it should be a relationship of Px/Pknown)

10.3 Muscle SAR Results

Test Position	Band	Ch.	Frequency (MHz)	Spacing (mm)	Power supply	ASSY	SAR _{1g} (W/Kg)	Power Drift	Avg Power	Max tune-up	Reported SAR _{1g} (W/Kg)
Back	UHF	3	481	10	8.2V_2A	N/A	3.95	-0.05	36.06	36.1	3.99
Back	UHF	3	481	0	8.2V_2A	Belt clip	4.17	-0.03	36.06	36.1	4.21

◆ SAR values are scaled for the power drift

Band	Ch.	Power supply	ASSY.	SAR _{1g} [W/Kg]		power drift (dB)	+ power drift 10^(dB/10)	SAR _{1g} [W/Kg] (include +power drift)		Remark			
				Duty Cycle				Duty Cycle					
				100%	50%			100%	50%				
UHF	3	8.2V_2A	N/A	3.99	1.99	-0.050000	1.012	4.03	2.02	---			
	3	8.2V_2A	Belt clip	4.21	2.10	-0.030000	1.007	4.24	2.12	---			

SAR is basically proportional to average transmit power and duty cycle

(i.e. SAR = P x T where P is the average transmit power and T is the transmit duty cycle).

SAR(unknown) = SAR(know) x (PxTx/P(known) T(known))

Where Px is the unknown power (i.e. the power at the highest drift)

Tx is the transmit duty cycle used at that unknown power.

If transmitter duty cycle is the same then it should be a relationship of Px/Pknown)

10.4 SAR Variability Results

■ Test Condition of Variability:

1. The original highest measured Reported SAR 1g is ≥ 4.0 W/kg, repeat that measurement once.
2. Perform a second repeated measurement the ratio of largest to smallest SAR for the original and first repeated measurements is < 1.2 , the original or repeated measurement is ≥ 7.25 W/kg ($\sim 10\%$ from the 1-g SAR limit).
3. Perform a third repeated measurement only if the original, first or second repeated measurement is ≥ 7.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20 .

Test Position	Band	Ch.	Power supply	ASSY	Frequency (MHz)	Side to Phantom	Original SAR _{1g} (W/Kg)	First SAR _{1g} (W/Kg)	First Ratio	Second SAR _{1g} (W/Kg)	Second Ratio	Third SAR _{1g} (W/Kg)	Third Ratio
Back	UHF	3	8.2V_2A	Belt clip	481	Back	4.17	4.13	1.01 < 1.2	---	---	---	---

Appendix A - System Performance Check

Test Laboratory: A Test Lab Techno Corp.

Date/Time: 2016/8/15 AM 09:03:11

System Performance Check at 450MHz_20160815_Head

DUT: Dipole 450MHz; Type: D450V2; Serial: D450V2 SN:1021

Communication System: UID 0, CW; Frequency: 450 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 450$ MHz; $\sigma = 0.84$ S/m; $\epsilon_r = 43.143$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY5.2 Configuration:

- Area Scan setting - Find Secondary Maximum Within: 2.0dB and with a peak SAR value greater than 0.5 W/Kg
- Probe: EX3DV4 - SN3847; ConvF(10.69, 10.69, 10.69); Calibrated: 2016/4/14;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn779; Calibrated: 2016/3/2
- Phantom: ELI v4.0; Type: QDOVA001BB; Serial: TP:1036
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

System Performance Check at 450MHz/Area Scan (61x201x1):

Interpolated grid: dx=1.500 mm, dy=1.500 mm

Maximum value of SAR (interpolated) = 1.47 W/kg

System Performance Check at 450MHz/Zoom Scan (7x7x7)/Cube 0:

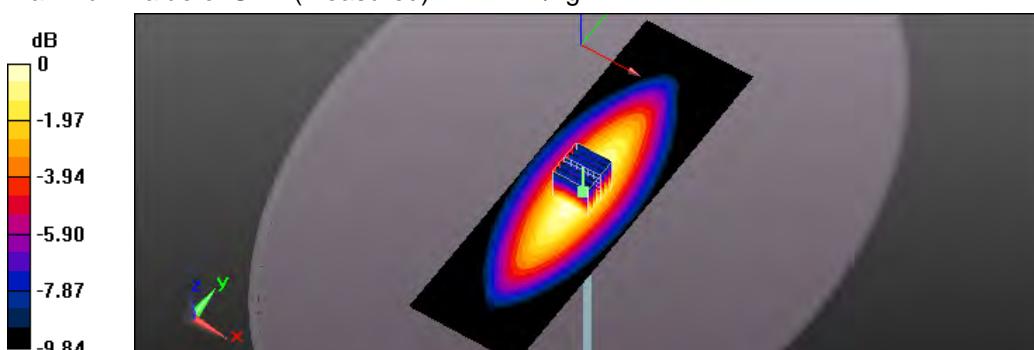
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 42.45 V/m; Power Drift = 0.00 dB

Peak SAR (extrapolated) = 1.76 W/kg

SAR(1 g) = 1.16 W/kg; SAR(10 g) = 0.776 W/kg

Maximum value of SAR (measured) = 1.47 W/kg



Test Laboratory: A Test Lab Techno Corp.

Date/Time: 2016/8/11 PM 03:04:53

System Performance Check at 450MHz_20160811_Body

DUT: Dipole 450MHz; Type: D450V2; Serial: D450V2 SN:1021

Communication System: UID 0, CW (0); Frequency: 450 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 450$ MHz; $\sigma = 0.914$ S/m; $\epsilon_r = 56.568$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY5.2 Configuration:

- Area Scan setting - Find Secondary Maximum Within: 2.0dB and with a peak SAR value greater than 0.5 W/Kg
- Probe: EX3DV4 - SN3847; ConvF(11.13, 11.13, 11.13); Calibrated: 2016/4/14;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn779; Calibrated: 2016/3/2
- Phantom: ELI v4.0; Type: QDOVA001BB; Serial: TP:1036
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

System Performance Check at 450MHz/Area Scan (61x201x1):

Interpolated grid: $dx=1.500$ mm, $dy=1.500$ mm

Maximum value of SAR (interpolated) = 1.49 W/kg

System Performance Check at 450MHz/Zoom Scan (7x7x7)/Cube 0:

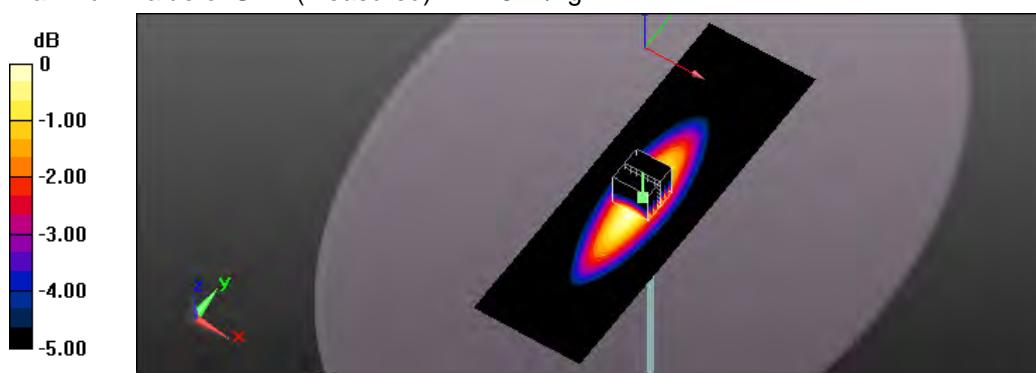
Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

Reference Value = 40.55 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 1.77 W/kg

SAR(1 g) = 1.18 W/kg; SAR(10 g) = 0.805 W/kg

Maximum value of SAR (measured) = 1.48 W/kg



Appendix B - SAR Measurement Data

Test Laboratory: A Test Lab Techno Corp.

Date/Time: 2016/8/15 AM 10:45:55

1_UHF CH3_Front_25mm_Brain_Power supply_8.2V_2A

DUT: ST-2112D; Type: Private land mobile radio

Communication System: UID 0, UHF (0); Frequency: 481 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 481$ MHz; $\sigma = 0.858$ S/m; $\epsilon_r = 42.833$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY5.2 Configuration:

- Area Scan setting - Find Secondary Maximum Within: 2.0dB and with a peak SAR value greater than 0.5 W/Kg
- Probe: EX3DV4 - SN3847; ConvF(10.69, 10.69, 10.69); Calibrated: 2016/4/14;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn779; Calibrated: 2016/3/2
- Phantom: ELI v4.0; Type: QDOVA001BB; Serial: TP:1036
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Flat/Area Scan (71x91x1):

Interpolated grid: $dx=1.500$ mm, $dy=1.500$ mm

Maximum value of SAR (interpolated) = 2.86 W/kg

Flat/Zoom Scan (5x5x7)/Cube 0:

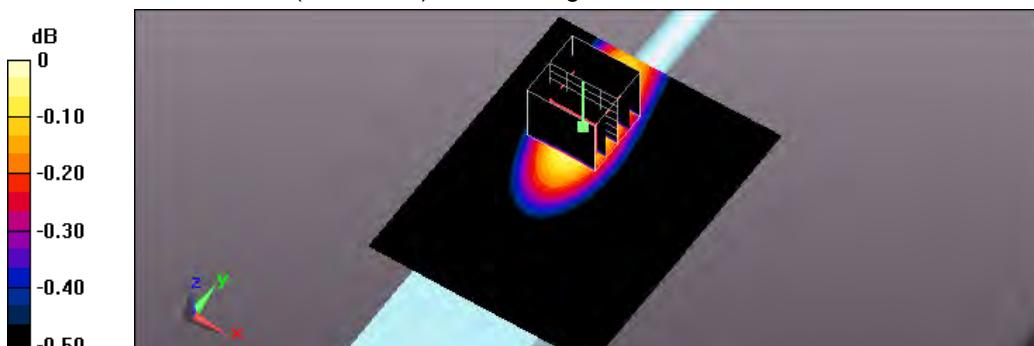
Measurement grid: $dx=8$ mm, $dy=8$ mm, $dz=5$ mm

Reference Value = 57.90 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 3.25 W/kg

SAR(1 g) = 2.41 W/kg; SAR(10 g) = 1.8 W/kg

Maximum value of SAR (measured) = 2.86 W/kg



Test Laboratory: A Test Lab Techno Corp.

Date/Time: 2016/8/11 PM 03:41:09

2_UHF CH3_Back_10mm_Muscle_Power supply_ 8.2V_2A

DUT: ST-2112D; Type: Private land mobile radio

Communication System: UID 0, UHF (0); Frequency: 481 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 481$ MHz; $\sigma = 0.939$ S/m; $\epsilon_r = 58.004$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY5.2 Configuration:

- Area Scan setting - Find Secondary Maximum Within: 2.0dB and with a peak SAR value greater than 0.5 W/Kg
- Probe: EX3DV4 - SN3847; ConvF(11.13, 11.13, 11.13); Calibrated: 2016/4/14;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn779; Calibrated: 2016/3/2
- Phantom: ELI v4.0; Type: QDOVA001BB; Serial: TP:1036
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Flat/Area Scan (71x91x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm

Maximum value of SAR (interpolated) = 4.82 W/kg

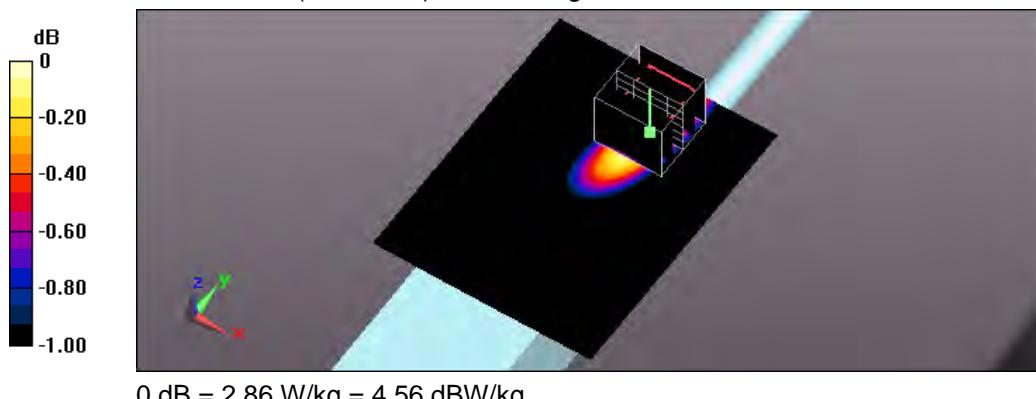
Flat/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 65.23 V/m; Power Drift = -0.05 dB

Peak SAR (extrapolated) = 5.60 W/kg

SAR(1 g) = 3.95 W/kg; SAR(10 g) = 2.85 W/kg

Maximum value of SAR (measured) = 4.81 W/kg



Test Laboratory: A Test Lab Techno Corp.

Date/Time: 2016/8/11 PM 04:01:39

3_Flat_UHF CH3_Back_0mm_Muscle_Belt-clip_Power supply_ 8.2V_2A

DUT: ST-2112D; Type: Private land mobile radio

Communication System: UID 0, UHF (0); Frequency: 481 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 481$ MHz; $\sigma = 0.939$ S/m; $\epsilon_r = 58.004$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY5.2 Configuration:

- Area Scan setting - Find Secondary Maximum Within: 2.0dB and with a peak SAR value greater than 0.5 W/Kg
- Probe: EX3DV4 - SN3847; ConvF(11.13, 11.13, 11.13); Calibrated: 2016/4/14;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn779; Calibrated: 2016/3/2
- Phantom: ELI v4.0; Type: QDOVA001BB; Serial: TP:1036
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Flat/Area Scan (71x91x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm

Maximum value of SAR (interpolated) = 5.03 W/kg

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

Reference Value = 67.73 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 5.92 W/kg

SAR(1 g) = 4.17 W/kg; SAR(10 g) = 2.99 W/kg

Maximum value of SAR (measured) = 5.06 W/kg

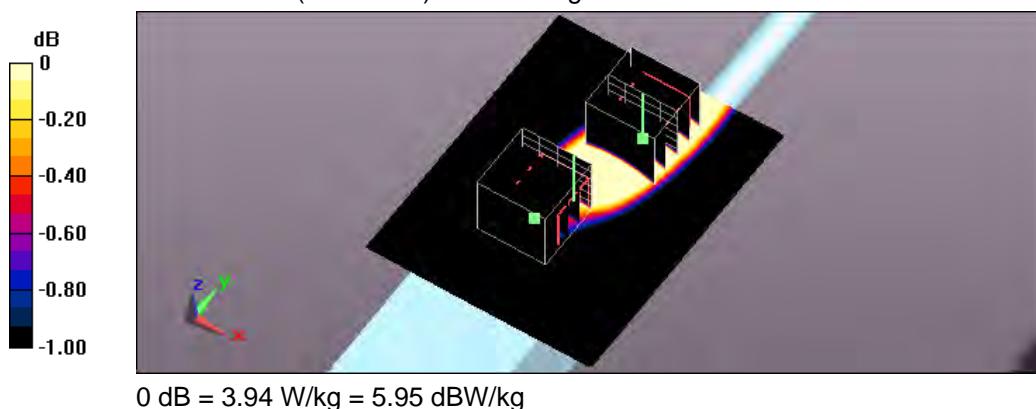
Flat/Zoom Scan (5x5x7)/Cube 1: Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 67.73 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 4.43 W/kg

SAR(1 g) = 3.21 W/kg; SAR(10 g) = 2.35 W/kg

Maximum value of SAR (measured) = 3.94 W/kg



Test Laboratory: A Test Lab Techno Corp.

Date/Time: 2016/8/11 PM 04:56:17

4_Flat_UHF CH3_Back_0mm_Muscle_Belt-clip_Power supply_8.2V_2A_original #3_measurement once

DUT: ST-2112D; Type: Private land mobile radio

Communication System: UID 0, UHF (0); Frequency: 481 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 481$ MHz; $\sigma = 0.939$ S/m; $\epsilon_r = 58.004$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY5.2 Configuration:

- Area Scan setting - Find Secondary Maximum Within: 2.0dB and with a peak SAR value greater than 0.5 W/Kg
- Probe: EX3DV4 - SN3847; ConvF(11.13, 11.13, 11.13); Calibrated: 2016/4/14;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn779; Calibrated: 2016/3/2
- Phantom: ELI v4.0; Type: QDOVA001BB; Serial: TP:1036
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Flat/Area Scan (71x91x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm

Maximum value of SAR (interpolated) = 5.01 W/kg

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

Reference Value = 67.72 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 5.91 W/kg

SAR(1 g) = 4.13 W/kg; SAR(10 g) = 2.94 W/kg

Maximum value of SAR (measured) = 5.04 W/kg

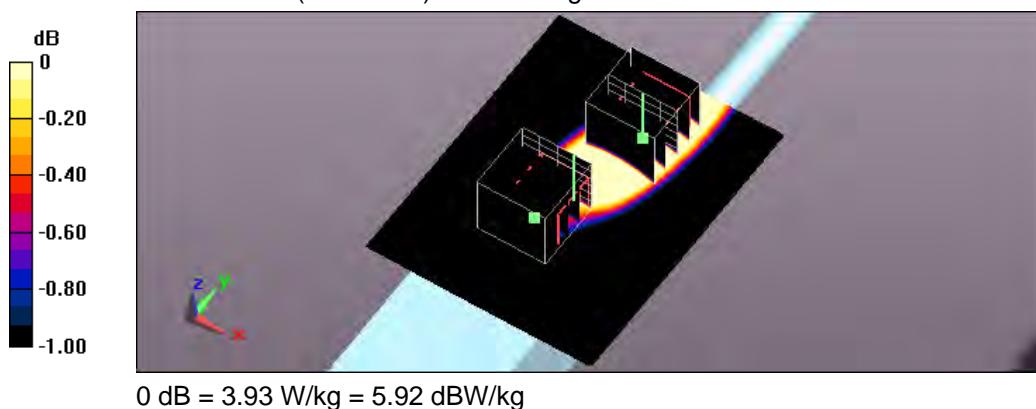
Flat/Zoom Scan (5x5x7)/Cube 1: Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 67.72 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 4.41 W/kg

SAR(1 g) = 3.17 W/kg; SAR(10 g) = 2.31 W/kg

Maximum value of SAR (measured) = 3.93 W/kg



Appendix C - Calibration

All of the instruments Calibration information are listed below.

- Dipole _ D450V2 SN:1021 Calibration No.D450V2-1021_Apr16
- Probe _ EX3DV4 SN:3847 Calibration No.EX3-3847_Apr16
- DAE _ DAE4 SN:779 Calibration No.Z16-97019

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



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C Service suisse d'étalementage
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The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **ATL (Auden)**

Certificate No: **D450V2-1021_Apr16**

CALIBRATION CERTIFICATE

Object **D450V2 - SN: 1021**

Calibration procedure(s) **QA CAL-15.v8**
Calibration procedure for dipole validation kits below 700 MHz

Calibration date: **April 21, 2016**

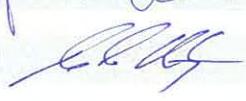
This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	06-Apr-16 (No. 217-02288/02289)	Apr-17
Power sensor NRP-Z91	SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17
Power sensor NRP-Z91	SN: 103245	06-Apr-16 (No. 217-02289)	Apr-17
Reference 20 dB Attenuator	SN: 5058 (20k)	05-Apr-16 (No. 217-02292)	Apr-17
Type-N mismatch combination	SN: 5047.2 / 06327	05-Apr-16 (No. 217-02295)	Apr-17
Reference Probe ET3DV6	SN: 1507	31-Dec-15 (No. ET3-1507_Dec15)	Dec-16
DAE4	SN: 654	08-Jul-15 (No. DAE4-654_Jul15)	Jul-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (No. 217-02285/02284)	In house check: Jun-16
Power sensor E4412A	SN: MY41498087	06-Apr-16 (No. 217-02285)	In house check: Jun-16
Power sensor E4412A	SN: 000110210	06-Apr-16 (No. 217-02284)	In house check: Jun-16
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Apr-13)	In house check: Jun-16
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

Calibrated by: Name **Jeton Kastrati** Function **Laboratory Technician** Signature 

Approved by: Name **Katja Pokovic** Function **Technical Manager** Signature 

Issued: April 21, 2016

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

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



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Accreditation No.: **SCS 0108**

Glossary:

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

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

- e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Flat Phantom V4.4	Shell thickness: 6 ± 0.2 mm
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	450 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	43.5	0.87 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	44.3 ± 6 %	0.90 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	1.22 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	4.77 W/kg ± 18.1 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	0.809 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	3.17 W/kg ± 17.6 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	56.7	0.94 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	58.9 ± 6 %	0.96 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	1.21 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	4.80 W/kg ± 18.1 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	0.798 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	3.17 W/kg ± 17.6 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)**Antenna Parameters with Head TSL**

Impedance, transformed to feed point	55.8 Ω - 5.6 $j\Omega$
Return Loss	- 22.4 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	52.4 Ω - 9.4 $j\Omega$
Return Loss	- 20.5 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.351 ns
----------------------------------	----------

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

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

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

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	February 04, 2004

DASY5 Validation Report for Head TSL

Date: 21.04.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 450 MHz; Type: D450V2; Serial: D450V2 - SN: 1021

Communication System: UID 0 - CW; Frequency: 450 MHz

Medium parameters used: $f = 450$ MHz; $\sigma = 0.9$ S/m; $\epsilon_r = 44.3$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ET3DV6 - SN1507; ConvF(6.58, 6.58, 6.58); Calibrated: 31.12.2015;
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn654; Calibrated: 08.07.2015
- Phantom: Flat Phantom 4.4 ; Type: Flat Phantom 4.4; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

Dipole Calibration for Head Tissue/d=15mm, Pin=250mW/Zoom Scan (7x7x7)/Cube 0:

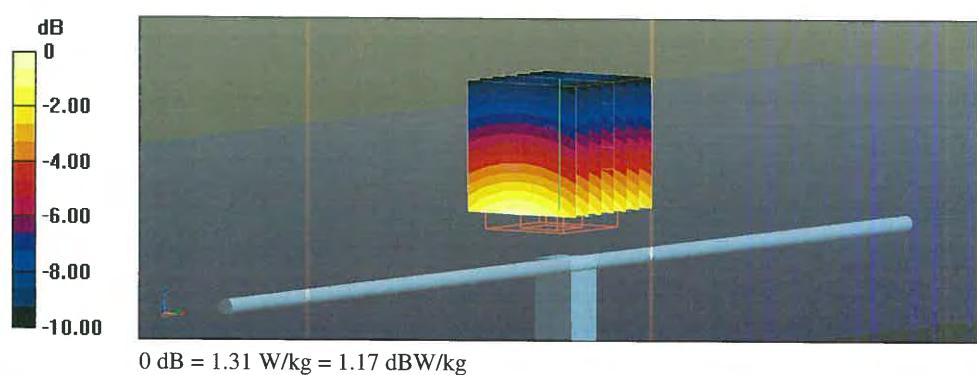
Measurement grid: dx=5mm, dy=5mm, dz=5mm

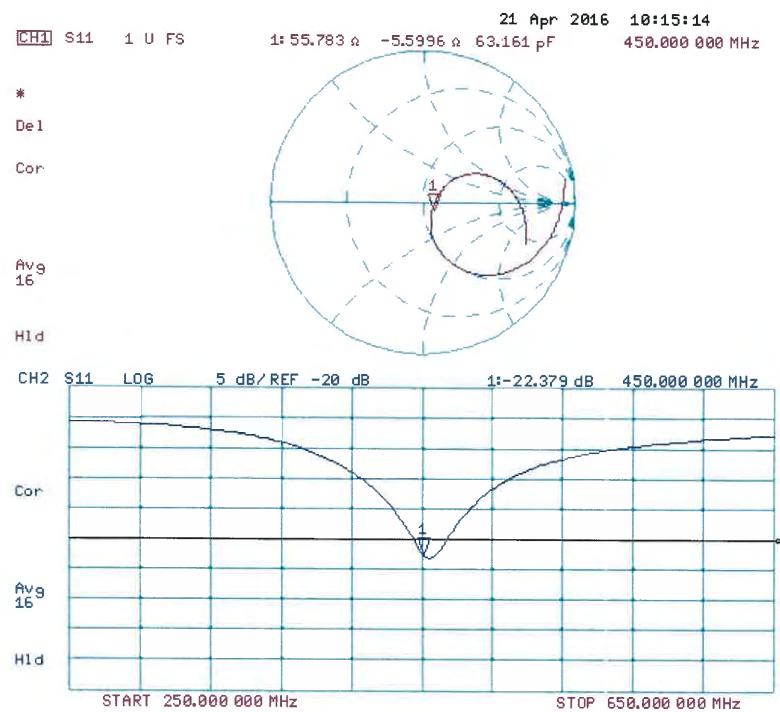
Reference Value = 39.78 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 1.75 W/kg

SAR(1 g) = 1.22 W/kg; SAR(10 g) = 0.809 W/kg

Maximum value of SAR (measured) = 1.31 W/kg



Impedance Measurement Plot for Head TSL

DASY5 Validation Report for Body TSL

Date: 21.04.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 450 MHz; Type: D450V2; Serial: D450V2 - SN:1021

Communication System: UID 0 - CW; Frequency: 450 MHz

Medium parameters used: $f = 450$ MHz; $\sigma = 0.96$ S/m; $\epsilon_r = 58.9$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ET3DV6 - SN1507; ConvF(6.99, 6.99, 6.99); Calibrated: 31.12.2015;
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn654; Calibrated: 08.07.2015
- Phantom: Flat Phantom 4.4 ; Type: Flat Phantom 4.4; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

Dipole Calibration for Body Tissue/d=15mm, Pin=250mW/Zoom Scan (7x7x7)/Cube 0:

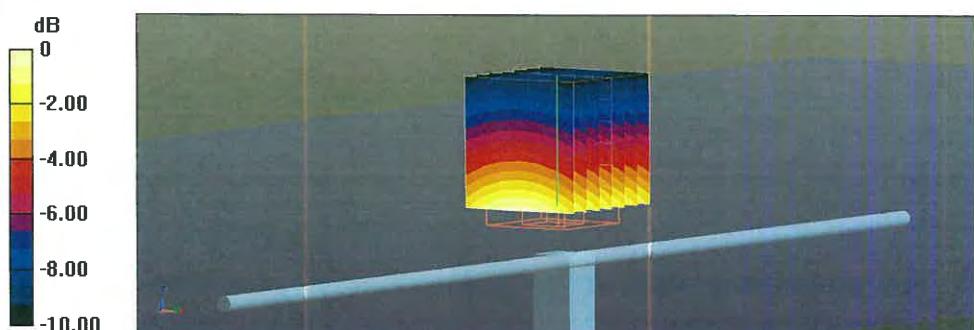
Measurement grid: dx=5mm, dy=5mm, dz=5mm

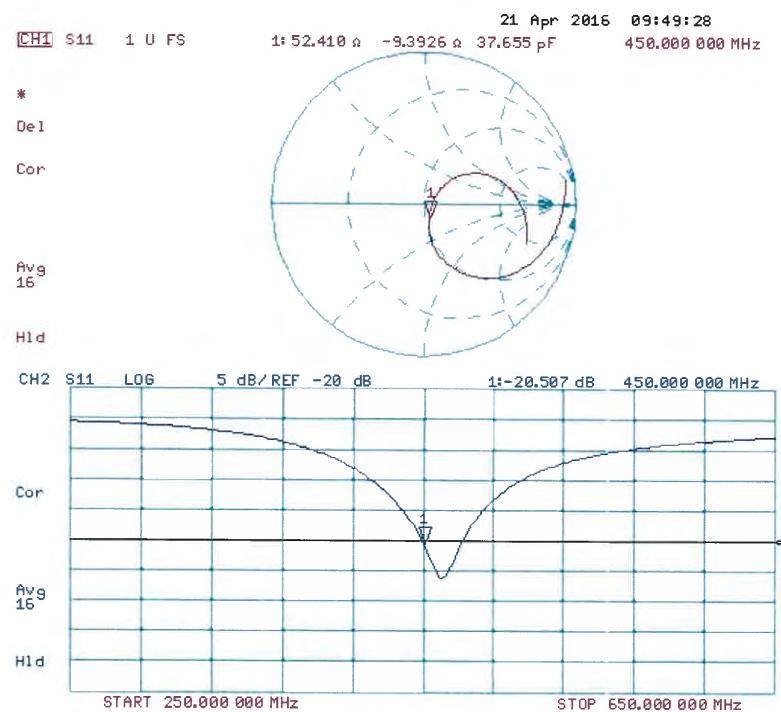
Reference Value = 37.54 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 1.91 W/kg

SAR(1 g) = 1.21 W/kg; SAR(10 g) = 0.798 W/kg

Maximum value of SAR (measured) = 1.30 W/kg



Impedance Measurement Plot for Body TSL

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



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Accreditation No.: **SCS 0108**

Client **ATL (Auden)**

Certificate No: **EX3-3847_Apr16**

CALIBRATION CERTIFICATE

Object

EX3DV4 - SN:3847

Calibration procedure(s)

QA CAL-01.v9, QA CAL-12.v9, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

Calibration date:

April 14, 2016

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	06-Apr-16 (No. 217-02288/02289)	Apr-17
Power sensor NRP-Z91	SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17
Power sensor NRP-Z91	SN: 103245	06-Apr-16 (No. 217-02289)	Apr-17
Reference 20 dB Attenuator	SN: S5277 (20x)	05-Apr-16 (No. 217-02293)	Apr-17
Reference Probe ES3DV2	SN: 3013	31-Dec-15 (No. ES3-3013_Dec15)	Dec-16
DAE4	SN: 660	23-Dec-15 (No. DAE4-660_Dec15)	Dec-16
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (No. 217-02285/02284)	In house check: Jun-16
Power sensor E4412A	SN: MY41498087	06-Apr-16 (No. 217-02285)	In house check: Jun-16
Power sensor E4412A	SN: 000110210	06-Apr-16 (No. 217-02284)	In house check: Jun-16
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Apr-13)	In house check: Jun-16
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

Calibrated by:	Name Claudio Leubler	Function Laboratory Technician	Signature 
Approved by:	Katja Pokovic	Technical Manager	

Issued: April 18, 2016

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Accreditation No.: **SCS 0108**

Glossary:

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

Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- $NORMx,y,z$: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). $NORMx,y,z$ are only intermediate values, i.e., the uncertainties of $NORMx,y,z$ does not affect the E^2 -field uncertainty inside TSL (see below ConvF).
- $NORM(f)x,y,z = NORMx,y,z * frequency_response$ (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- $DCPx,y,z$: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- PAR : PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- $Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z$: A, B, C, D are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- ConvF and Boundary Effect Parameters*: Assessed in flat phantom using E-field (or Temperature Transfer Standard for $f \leq 800$ MHz) and inside waveguide using analytical field distributions based on power measurements for $f > 800$ MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to $NORMx,y,z * ConvF$ whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle*: The angle is assessed using the information gained by determining the $NORMx$ (no uncertainty required).



Report Number: 1503FS12-02

EX3DV4 – SN:3847

April 14, 2016

Probe EX3DV4

SN:3847

Manufactured: October 25, 2011
Calibrated: April 14, 2016

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

EX3DV4- SN:3847

April 14, 2016

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3847

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.47	0.35	0.40	$\pm 10.1\%$
DCP (mV) ^B	99.2	104.1	95.7	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc ^E (k=2)
0	CW	X	0.0	0.0	1.0	0.00	129.8	$\pm 3.8\%$
		Y	0.0	0.0	1.0		130.1	
		Z	0.0	0.0	1.0		141.3	

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

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

^B Numerical linearization parameter: uncertainty not required.

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

EX3DV4- SN:3847

April 14, 2016

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3847

Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) ^C	Relative Permittivity ^F	Conductivity (S/m) ^F	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unc (k=2)
450	43.5	0.87	10.69	10.69	10.69	0.15	1.20	± 13.3 %

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

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

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

EX3DV4- SN:3847

April 14, 2016

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3847

Calibration Parameter Determined in Body Tissue Simulating Media

f (MHz) ^C	Relative Permittivity ^F	Conductivity (S/m) ^F	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unc (k=2)
450	56.7	0.94	11.13	11.13	11.13	0.09	1.20	± 13.3 %

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

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

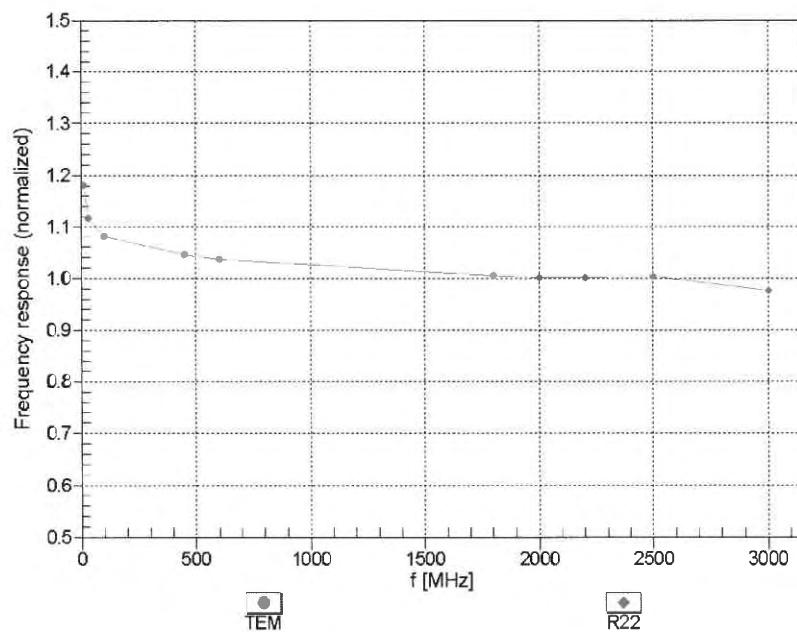
^G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from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

EX3DV4- SN:3847

April 14, 2016

Frequency Response of E-Field

(TEM-Cell:ifi110 EXX, Waveguide: R22)



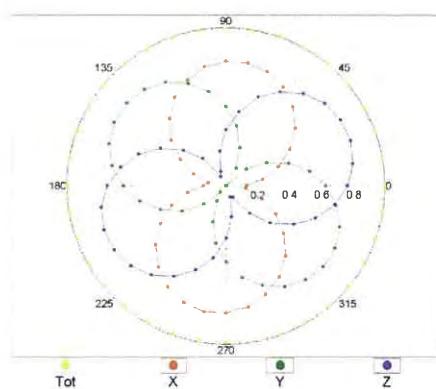
Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ (k=2)

EX3DV4– SN:3847

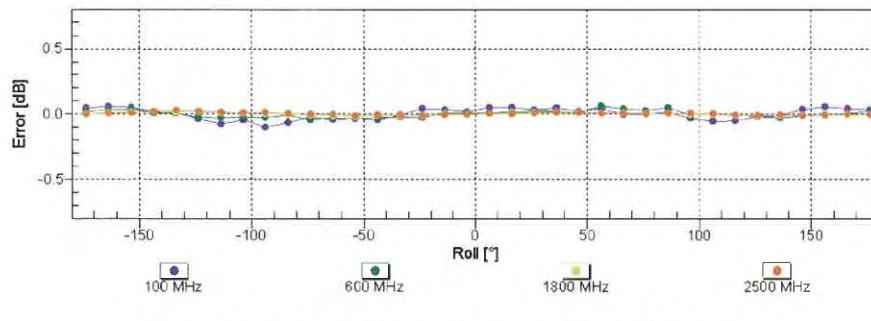
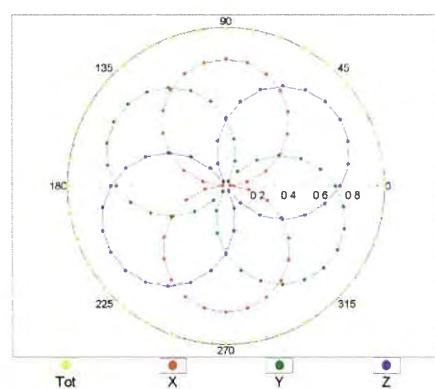
April 14, 2016

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

f=600 MHz,TEM



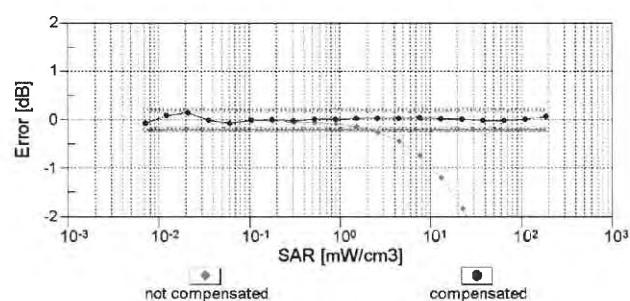
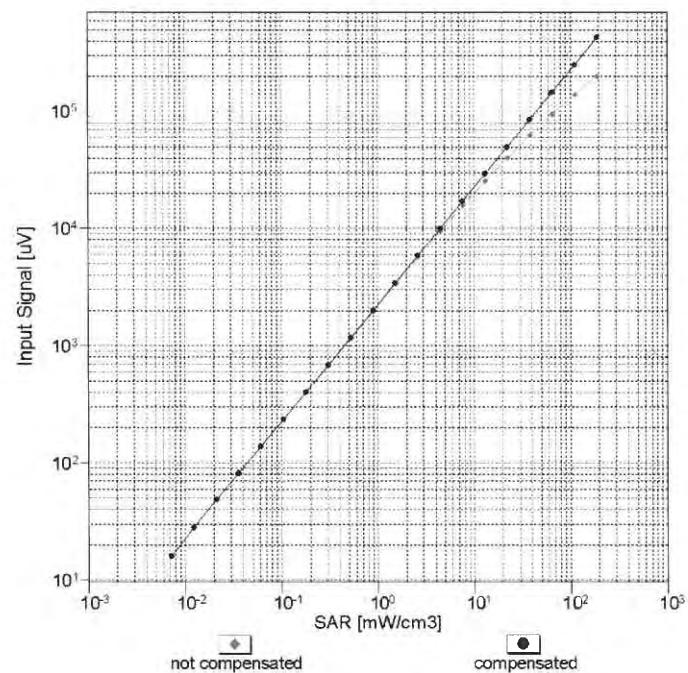
f=1800 MHz,R22


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

EX3DV4- SN:3847

April 14, 2016

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

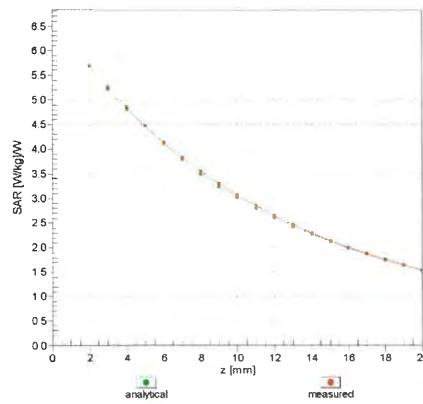
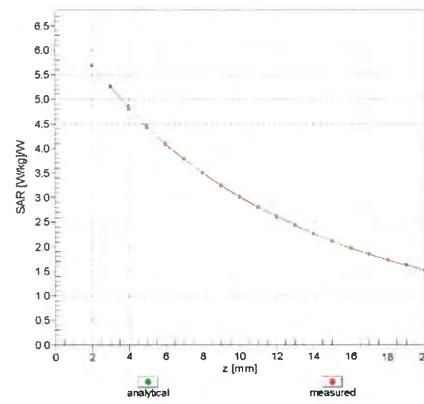


Uncertainty of Linearity Assessment: ± 0.6% (k=2)

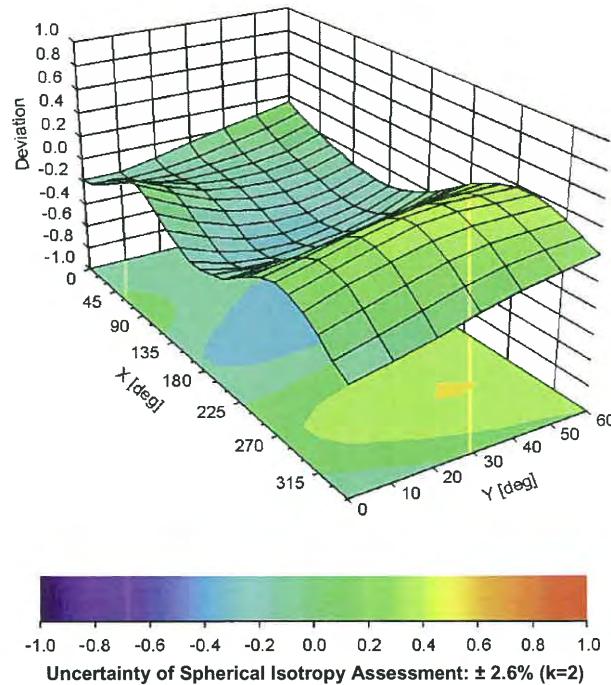
EX3DV4- SN:3847

April 14, 2016

Conversion Factor Assessment

 $f = 450 \text{ MHz, WGLS Flat Phantom 4.4}$

 $f = 450 \text{ MHz, WGLS Flat Phantom 4.4}$


Deviation from Isotropy in Liquid

Error (ϕ, θ) , $f = 900 \text{ MHz}$


EX3DV4- SN:3847

April 14, 2016

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3847

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	16.2
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm



In Collaboration with



CALIBRATION LABORATORY

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CALIBRATION
CNAS L0570

Client : ATL

Certificate No: Z16-97019

CALIBRATION CERTIFICATE

Object DAE4 - SN: 779

Calibration Procedure(s) FD-Z11-2-002-01
Calibration Procedure for the Data Acquisition Electronics
(DAEx)

Calibration date: March 2, 2016

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Process Calibrator 753	1971018	06-July-15 (CTTL, No:J15X04257)	July-16

Calibrated by:	Name	Function	Signature
	Yu Zongying	SAR Test Engineer	
Reviewed by:	Qi Dianyuan	SAR Project Leader	
Approved by:	Lu Bingsong	Deputy Director of the laboratory	

Issued: March 3, 2016

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Glossary:

DAE data acquisition electronics
Connector angle information used in DASY system to align probe sensor X to the robot coordinate system.

Methods Applied and Interpretation of Parameters:

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle:* The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The report provide only calibration results for DAE, it does not contain other performance test results.



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DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = $6.1\mu V$, full range = $-100...+300 mV$

Low Range: 1LSB = $61nV$, full range = $-1.....+3mV$

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Calibration Factors	X	Y	Z
High Range	$404.044 \pm 0.15\% (k=2)$	$403.722 \pm 0.15\% (k=2)$	$403.947 \pm 0.15\% (k=2)$
Low Range	$3.97041 \pm 0.7\% (k=2)$	$3.98123 \pm 0.7\% (k=2)$	$3.99689 \pm 0.7\% (k=2)$

Connector Angle

Connector Angle to be used in DASY system	$158 \pm 1^\circ$
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