SAR Test Report

Model: BCM943142Y

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REVISION HISTORY

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Table of contents

1. Introduction

This measurement report shows compliance of the Broadcom Corporation Model BCM943142Y FCC ID: QDS-BRCM1079 with FCC Part 2, 1093, ET Docket 93-62 Rules for mobile and portable devices and IC Certificate: 4324A-BRCM1079 with RSS102 & Safety Code 6. The FCC have adopted the guidelines for evaluating the environmental effects of radio frequency radiation in ET Docket 93-62 on August 6, 1996 to protect the public and workers from the potential hazards of RF emissions due to FCC regulated portable devices. [1], [6]

The purpose of this report is to show compliance of this wireless module to be used in multiple host platforms with antenna-to-user separation distance of 5 mm or greater per FCC KDB 616217 D04 SAR for laptop and tablets v01 and FCC KDB 447498 D01 General RF Exposure Guidance v05r02

Per FCC KDB 447498 D01 v05r02; When the highest *reported* 1-g SAR is > 0.4 W/kg and ≤ 0.8 W/kg, modules and peripheral transmitters may be approved to operate in multiple host platforms. To qualify for multiple host platforms, the modular transmitter may be approved under one FCC ID, either in the initial filing or through Class II permissive changes. All subsequent Class II permissive changes must be within the scope of the defined host platform configurations and exposure conditions in the initial equipment approval.

Per FCC KDB 616217 D04 v01r01; The *modular approach* is applied to this module in order to use it in qualified laptop and tablet hosts. When the test separation distances and test setups for the laptop and tablet host platforms are satisfied by the antenna and host configurations and the highest *reported* SAR for a host platform is ≤ 0.8 W/kg, testing in representative hosts is optional for the *modular approach.*

The test results recorded herein are based on a single type test of Broadcom Corporation model BCM943142Y with Hitachi HMT05 (Zanzibar) antenna with 50 cm RF cable length and therefore apply only to the tested sample.

The test procedures, as described in ANSI C95.1 – 1999 Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz [2], ANSI C95.3 – 2002 Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields [3], FCC OET Bulletin 65 Supp. C – 2001 [4], IEEE Std.1528 – 2003 Recommended Practice [5], and Industry Canada Safety Code 6 Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz were employed.

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/m^3)

E = rms electric field strength (V/m)

2. SAR measurement setup

Robotic system

These measurements are performed using the DASY52 automated dosimetric assessment system. The DASY52 is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland and consists of high precision robotics system (Staubli), robot controller, Intel Core2 computer, near-field probe, probe alignment sensor, and the generic twin phantom containing the body equivalent material. The robot is a six-axis industrial robot performing precise movements to position the probe to the location (points) of maximum electromagnetic field (EMF) (see Fig. 2.1).

System hardware

A cell controller system contains the power supply, robot controller teach pendant (Joystick), and a remote control used to drive the robot motors. The PC consists of the HP Intel Core2 computer with Windows XP system and SAR Measurement Software DASY52, A/D interface card, monitor, mouse, and keyboard. The Staubli Robot is connected to the cell controller to allow software manipulation of the robot. A data acquisition electronic (DAE) circuit that performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. is connected to the Electro-optical coupler (EOC). The EOC performs the conversion from the optical into digital electric signal of the DAE and transfers data to the PC plug-in card.

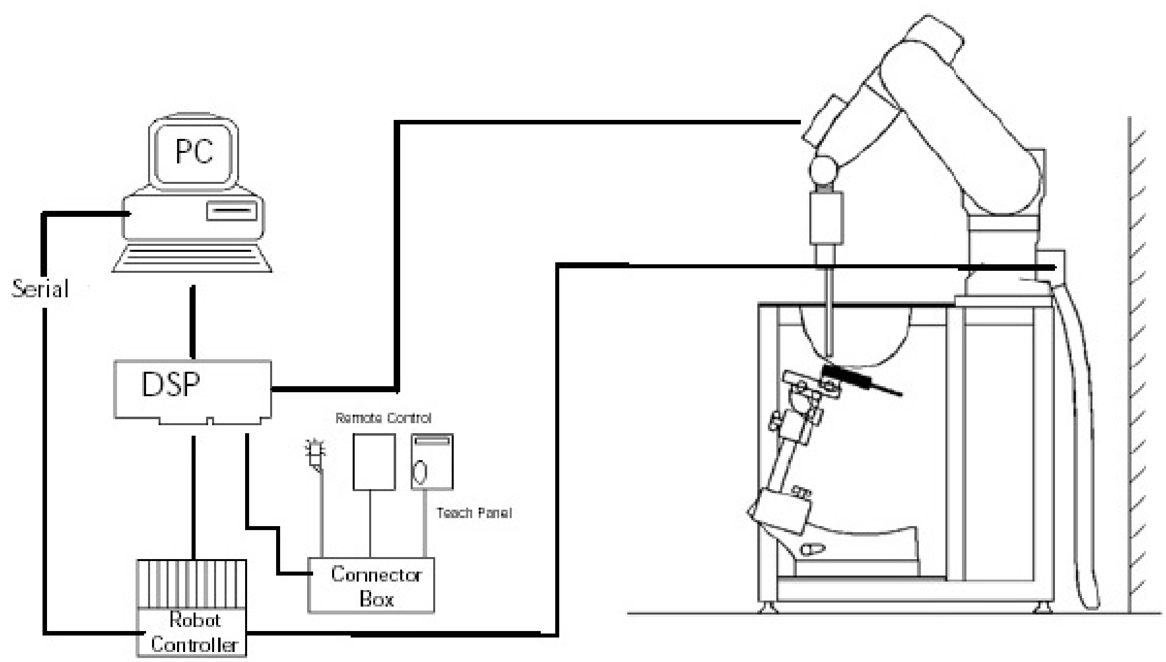


Figure 2.1 SAR measurement system setup

System electronics

The DAE4 consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the PC-card is accomplished through an optical downlink for data and status information and an optical uplink for commands and clock lines. The mechanical probe mounting device includes two different sensor systems for frontal and sidewise probe contacts. They are also used for mechanical surface detection and probe collision detection. The robot uses its own controller with a built in VME-bus computer. The system is described in detail in.

Probe measurement system

The SAR measurements were conducted with the dosimetric probe EX3DV4, designed in the classical triangular configuration (see Fig. 2.2) 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. (see Fig. 2.3) 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 DASY52 software reads the reflection during a software approach and looks for the maximum using a 2nd order fitting. The approach is stopped at reaching the maximum.

DAE system

Probe specifications

Calibration: In air from 10 MHz to 6.0 GHz
In brain and muscle simulating tissue at Frequencies of 450 MHz, 835 MHz, 1750 MHz, 1900 MHz, 2450 MHz, 2600 MHz, 3500 MHz, 5200 MHz, 5300 MHz, 5600 MHz, 5800 MHz

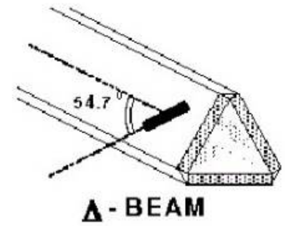


Figure 2.2 Triangular Probe Configurations

Frequency: 10 MHz to 6 GHz

Linearity: ±0.2dB (30 MHz to 6 GHz)

Dynamic: 10 mW/kg to 100 W/kg

Range: Linearity: ±0.2dB

Dimensions: Overall length: 330 mm

Tip length: 20 mm

Body diameter: 12 mm

Tip diameter: 2.5 mm

Distance from probe tip to sensor center: 1 mm

Figure 2.3 Probe Thick-Film Technique

Application: SAR Dosimetry Testing
Compliance tests of wireless device

Probe calibration process

Dosimetric assessment procedure

Each probe is calibrated according to a dosimetric assessment procedure described in with accuracy better than +/- 10%. The spherical isotropy was evaluated with the procedure described in and found to be better than +/-0.25dB. The sensitivity parameters (Norm X, Norm Y, Norm Z), the diode compression parameter (DCP) and the conversion factor (Conv F) of the probe is tested.

Free space assessment

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

Temperature assessment *

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

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

where:

Δt = exposure time (30 seconds),

C = heat capacity of tissue (brain or muscle),

ΔT = temperature increase due to RF exposure.

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

where:

σ = simulated tissue conductivity,

ρ = Tissue density (1.25 g/cm^3 for brain tissue)

SAR is proportional to $\Delta T / \Delta t$, the initial rate of tissue heating, before thermal diffusion takes place. Now it’s possible to quantify the electric field in the simulated tissue by equating the thermally derived SAR to the E- field;

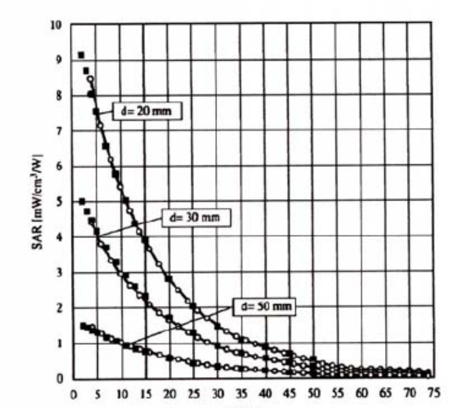


Figure 2.4 E-Field and Temperature Measurements at 900MHz

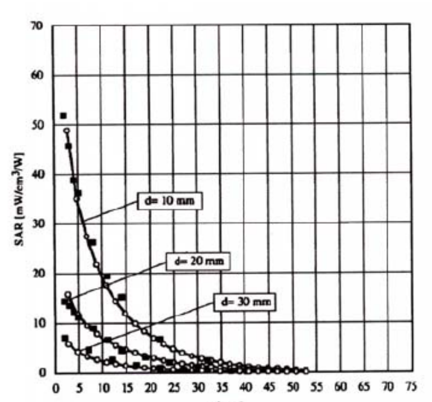


Figure 2.5 E-Field and Temperature Measurements at 1800MHz

Data extrapolation

The DASY52 software automatically executes the following procedures to calculate the field units from the microvolt readings at the probe connector. 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 like below;

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

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)
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:

$$E_i = \sqrt{\frac{V_i}{Norm_i \cdot ConvF}}$$

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 of enhancement in solution
E_i = electric field strength of channel i in V/m

The RSS value of the field components gives the total field strength (Hermetian 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 W/g
E_{tot} = total field strength in V/m
σ = conductivity in [mho/m] or [Siemens/m]
ρ = equivalent tissue density in g/cm^3

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

$$P_{pwe} = \frac{E_{tot}^2}{3770}$$

with P_{pwe} = equivalent power density of a plane wave in W/cm^2
E_{tot} = total electric field strength in V/m

SAM phantom

The SAM Twin Phantom V4.0 is constructed of a fiberglass shell integrated in a wooden table. The shape of the shell is based on data from an anatomical study designed to determine the maximum exposure in at least 90% of all users. It 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. (see Fig. 2.6)

Phantom: SAM Twin Phantom (V4.0)
Shell material: Vivac Composite
Thickness: 2.0 ± 0.2 mm

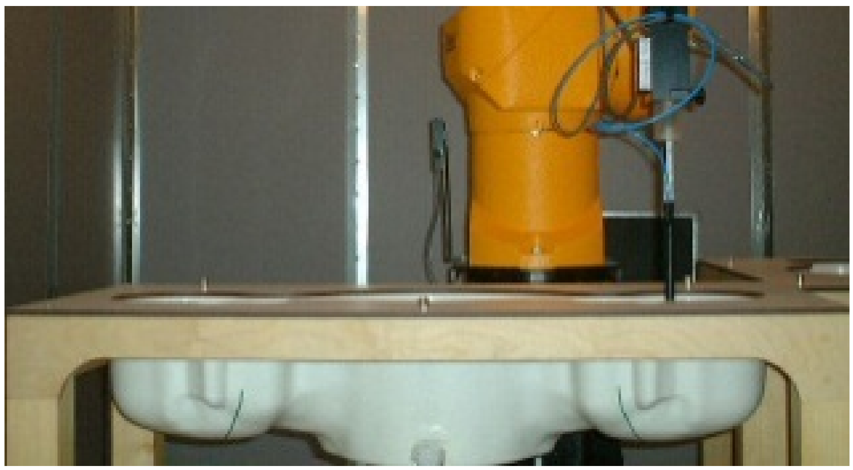


Figure 2.6 SAM twin phantom

Device holder for transmitters

In combination with the SAM Twin Phantom V4.0 the Mounting Device (see Fig. 2.7), enables the rotation of the mounted transmitter in spherical coordinates whereby the rotation point is the ear opening. The devices can be easily, accurately, and repeat ably be positioned according to the FCC, CENELEC, IEC and IEEE specifications. The device holder can be locked at different phantom locations (left head, right head, flat phantom).

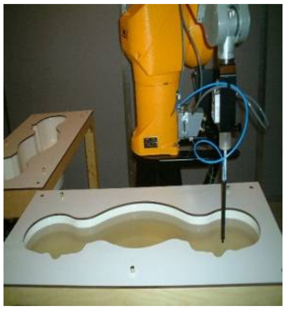
Figure 2.7 Mounting device

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. To produce the worst-case condition (the hand absorbs antenna output power), the hand is omitted during the tests.

3. Probe and dipole calibration

See Appendix D and E.

4. Simulating tissue specifications

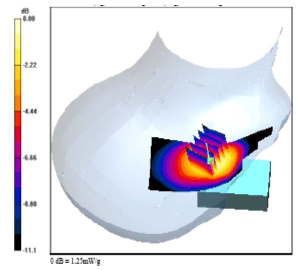


The head and body simulating mixtures consist of the material based on the table listed below.
The mixture is calibrated to obtain proper permittivity and conductivity of the desired tissue. Body tissue parameters that have not been specified in P1528 are derived from the tissue dielectric parameters computed from the 4-Cole-Cole equations

Table 4.1 Typical composition of ingredients for tissue

Ingredients		**Body simulating tissue**			
		2450 MHz	**5200 MHz**	**5500 MHz**	**5800 MHz**
Mixing Percentage					
Water		73.20	Proprietary mixture	Proprietary mixture	Proprietary mixture
Sugar		0.00			
Salt		0.00			
HEC		0.00			
Bactericide		0.00			
DGBE		26.70			
Dielectric Constant	Target	52.70	49.0	48.6	48.20
Conductivity (S/m)	Target	1.95	5.30	5.65	6.00

5. SAR measurement procedure



Sample SAR Area Scan

The evaluation was performed using the following procedure:

1. The SAR measurement was taken at a selected spatial reference point to monitor power variations during testing. This fixed location point was measured and used as a reference value.
2. The SAR distribution at the exposed side of the head was measured at a distance of 3.9mm from the Inner surface of the shell. The area covered the entire dimension of the head and the horizontal grid spacing was 15 mm
3. Based on the area scan data, the area of the maximum absorption was determined by sp line interpolation. Around this point, a volume of 32 mm x32 mm x 30 mm (fine resolution volume scan, zoom scan) was assessed by measuring 5 x 5 x 7 points. On this basis of this data set, the spatial peak SAR value was evaluated with the following procedure (see Sample SAR Area Scan):
   a. The data at the surface was extrapolated, since the center of the dipoles is 2.5 mm away from the tip of the probe and the distance between the surface and the lowest measuring point is 1.2mm. The extrapolation was based on a least square algorithm. A polynomial of the fourth order was calculated through the points in z-axes. This polynomial was then used to evaluate the points between the surface and the probe tip.
   b. The maximum interpolated value was searched with a straight-forward algorithm. Around this maximum the SAR values averaged over the spatial volumes (1g or 10g) were computed using the 3D-Spline interpolation algorithm. The 3D-spline is composed of three one-dimensional sp lines with the “Not a knot” condition (in x, y, and z directions). The volume was integrated with the trapezoidal algorithm. One thousand points (10 x 10x 10) were interpolated to calculate the average.
   c. All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.
4. The SAR reference value, at the same location as step 1, was re-measured. If the value changed by more than 5%, the evaluation is repeated.

Specific anthropomorphic mannequin (SAM) specifications

The phantom for handset SAR assessment testing is a low-loss dielectric shell, with shape and dimensions derived from the anthropometric data of the 90th percentile adult male head dimensions as tabulated by the US Army. The SAM Twin Phantom shell is bisected along the mid-sagittal plane into right and left halves (see Fig. 5.1). The perimeter side walls of each phantom halves are extended to allow filling with liquid to a depth that is sufficient to minimized reflections from the upper surface. The liquid depth is maintained at a minimum depth of 15cm to minimize reflections from the upper surface.

Figure 5.1 Sam twin phantom

6. Definition of reference points

EAR reference point

Figure 6.1 shows the front, back and side views of the SAM Twin 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 6.5. 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 6.2). 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.

Figure 6.1 Front, back and side view of SAM twin phantom

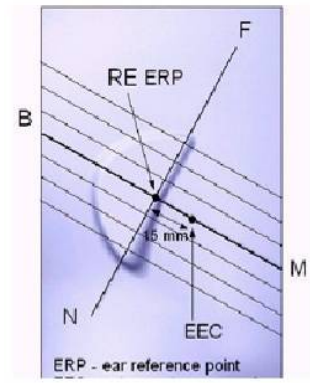


Figure 6.2 Close-up side view of ERPs

Handset reference points

Two imaginary lines on the handset were established: the vertical centerline and the horizontal line. The test device was 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" was than located at the same level as the center of the ear reference point. The test device was positioned so that the "vertical centerline" was bisecting the front surface of the handset at it's top and bottom edges, positioning the "ear reference point" on the outer surface of the both the left and right head phantoms on the ear reference point.

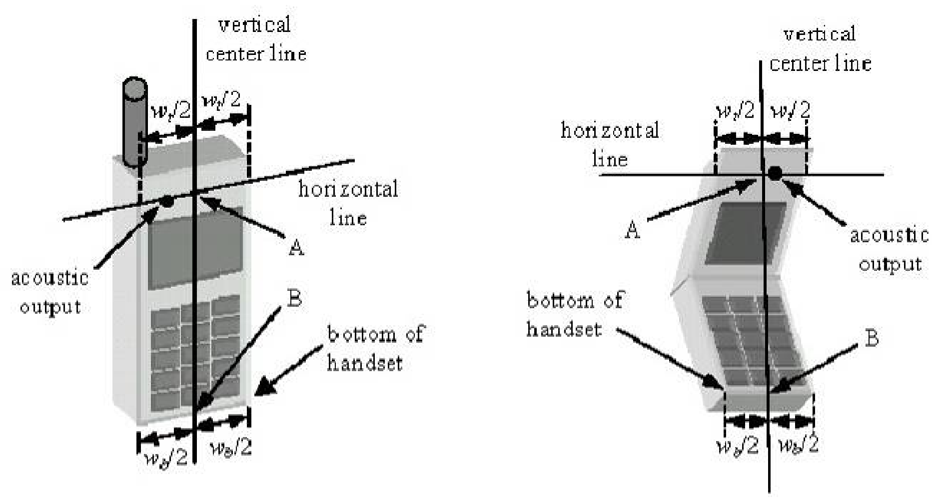


Figure 6.3 Handset vertical center & horizontal line reference points

Test configuration positions

<u>Positioning for cheek/touch</u>

1. The test device was positioned with the handset 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 6.4), such that the plane defined by the vertical center line and the horizontal line of the phone is approximately parallel to the sagittal plane of the phantom.

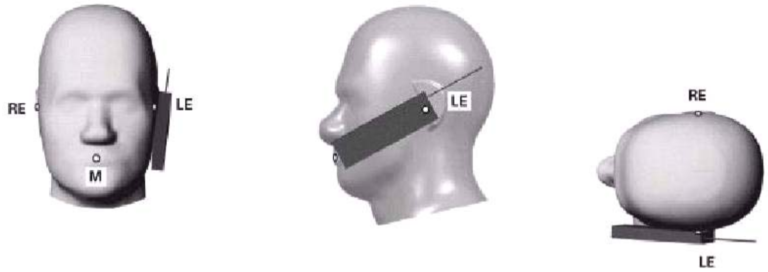


Figure 6.4 Front, side and top view of cheek/touch position

2. The handset was translated towards the phantom along the line passing through RE & LE until the handset touches the ear.
3. While maintaining the handset in this plane, the handset was rotated around the LE-RE line until the vertical centerline was in the plane normal to MB-NF including the line MB (reference plane).
4. The phone was hen rotated around the vertical centerline until the phone (horizontal line) was symmetrical was 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 phone contact with the ear, the handset was rotated about the line NF until any point on the handset made contact with a phantom point below the ear (cheek). (See Figure 6.5)

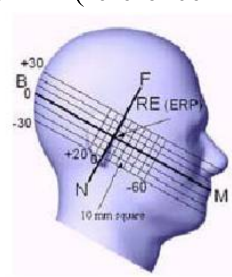


Figure 6.5 Side view w/ relevant markings

<u>Positioning for ear / 15 ° tilt</u>

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

1. While maintaining the orientation of the phone, the phone was retracted parallel to the reference plane far enough to enable a rotation of the phone by 15 degrees.
2. The phone was then rotated around the horizontal line by 15 degrees.
3. While maintaining the orientation of the phone, the phone was moved parallel to the reference plane until any part of the phone touches the head. (In this position, point A was located on the line RE-LE). The tilted position is obtained when the contact is on the pinna. If the contact was at any location other than the pinna, the angle of the phone would then be reduced. The tilted position was obtained when any part of the phone was in contact of the ear as well as a second part of the phone was in contact with the head (see Figure 6.6)

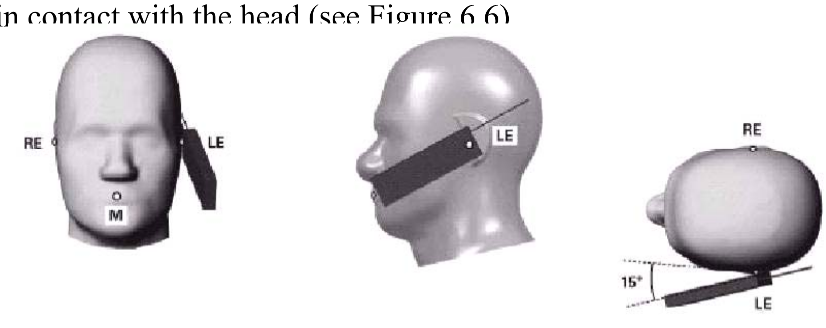


Figure 6.6 Front, side and top view of ear/15^o tilt position

Body holster /belt clip configurations

Body-worn operating configurations are tested with the belt-clips and holsters attached to the device and positioned against a flat phantom in a normal use configuration (see Figure 6.7). A device with a headset output is tested with a headset connected to the device. Body dielectric parameters are used.

Figure 6.7 Body belt clip & holster configurations

Accessories for Body-worn operation configurations are divided into two categories: those that do not contain metallic components and those that 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 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 distances between the back of the device and the flat phantom is used. All test position spacing is 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 accessories, 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.
In order for users to be aware of the body-worn operating requirements for meeting RF exposure compliance, operating instructions and cautions statements are included in the user's manual.

7. ANSI/IEEE C95.1 – 1992 RF exposure limits

Uncontrolled environment

Uncontrolled Environments are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

Controlled environment

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

Table 7.1 Human exposure limits

	Uncontrolled environment general population (W/kg) or (mW/g)	Controlled environment professional population (W/kg) or (mW/g)
Spatial Peal SAR[1] Head	1.60	8.00
Spatial Peal SAR[2] Whole Body	0.08	0.40
Spatial Peal SAR[3] Hands, Feet, Ankles, Wrist	4.00	20.00

[1] 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.
[2] The Spatial Average value of the SAR averaged over the whole body.
[3] 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.

8. Measurement uncertainty

Source of Uncertainty	Tolerance Value	Probability Distribution	Divisor	c_i^1 (1-g)	c_i^1 (10-g)	Standard Uncertainty (1-g) %	Standard Uncertainty (10-g) %	v_i
Measurement System								
Probe Calibration	5.5	normal	1	1	1	5.5	5.5	∞
Axial Isotropy	4.7	rectangular	√3	0.7	0.7	1.9	1.9	∞
Hemispherical Isotropy	9.6	rectangular	√3	0.7	0.7	3.9	3.9	∞
Boundary Effect	1	rectangular	√3	1	1	0.6	0.6	∞
Linearity	4.7	rectangular	√3	1	1	2.7	2.7	∞
Detection Limit	1	rectangular	√3	1	1	0.6	0.6	∞
Readout Electronics	0.3	normal	1	1	1	0.3	0.3	∞
Response Time	0.8	rectangular	√3	1	1	0.5	0.5	∞
Integration Time	2.6	rectangular	√3	1	1	1.5	1.5	∞
RF Ambient Condition	3	rectangular	√3	1	1	1.7	1.7	∞
Probe Positioner Mech. Restriction	0.4	rectangular	√3	1	1	0.2	0.2	∞
Probe Positioning with respect to Phantom Shell	2.9	rectangular	√3	1	1	1.7	1.7	∞
Extrapolation and Integration	1	rectangular	√3	1	1	0.6	0.6	∞
Test Sample Positioning	2.9	normal	1	1	1	2.9	2.9	145
Device Holder Uncertainty	3.6	normal	1	1	1	3.6	3.6	5
Drift of Output Power	5	rectangular	√3	1	1	2.9	2.9	∞
Phantom and Setup								
Phantom Uncertainty(shape & thickness tolerance)	4	rectangular	√3	1	1	2.3	2.3	∞
Liquid Conductivity(target)	5	rectangular	√3	0.64	0.43	1.8	1.2	∞
Liquid Conductivity(meas.)	2.5	normal	1	0.64	0.43	1.6	1.1	5
Liquid Permittivity(target)	5	rectangular	√3	0.6	0.49	1.7	1.4	∞
Liquid Permittivity(meas.)	2.5	normal	1	0.6	0.49	1.5	1.2	5
Combined Uncertainty		RSS				10.7	10.5	387
Combined Uncertainty (coverage factor=2)		Normal(k=2)				21.4	21.0	

9. System validation

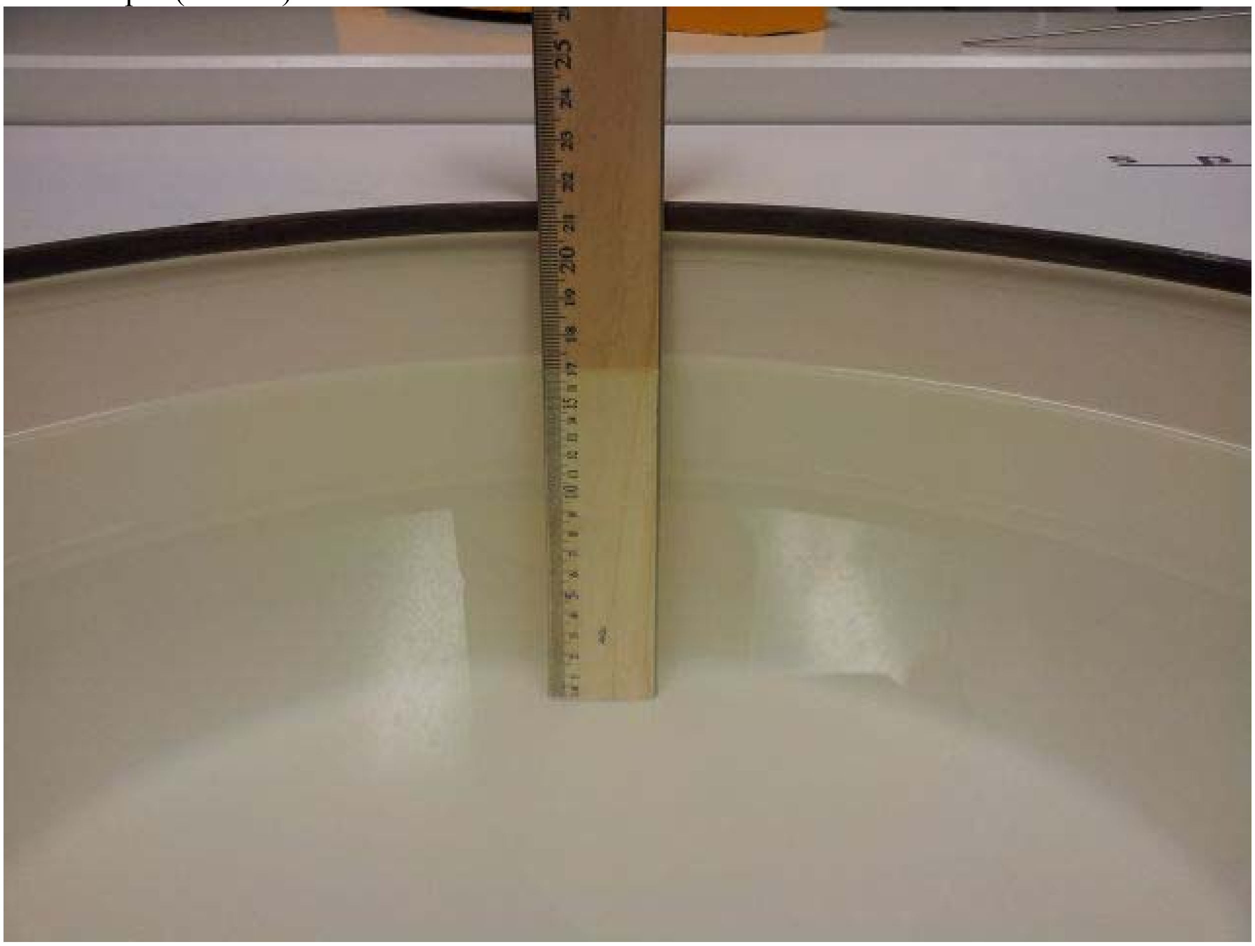
Tissue Verification

Prior to assessment, the system is verified to the ±5% of the specifications at the test frequency by using the speag DAK (Dielectric Assessment Kit) measurement kit

Table 9.1 Measured tissue parameters

Frequency (MHz)	Tissue type	Tissue temp. (˚C)	Measured dielec. cons. (ε)	Measured conductivity (σ)	Target value	Deviation (%)	Date
2452	Body	22.0	52.76		52.87	0.1	01/21/14
				1.95	1.96	0.1	

Tissue depth (>15 cm)



Test system verification

Prior to assessment, the system is verified to the ±10% of the specifications at the test frequency by using the system kit.

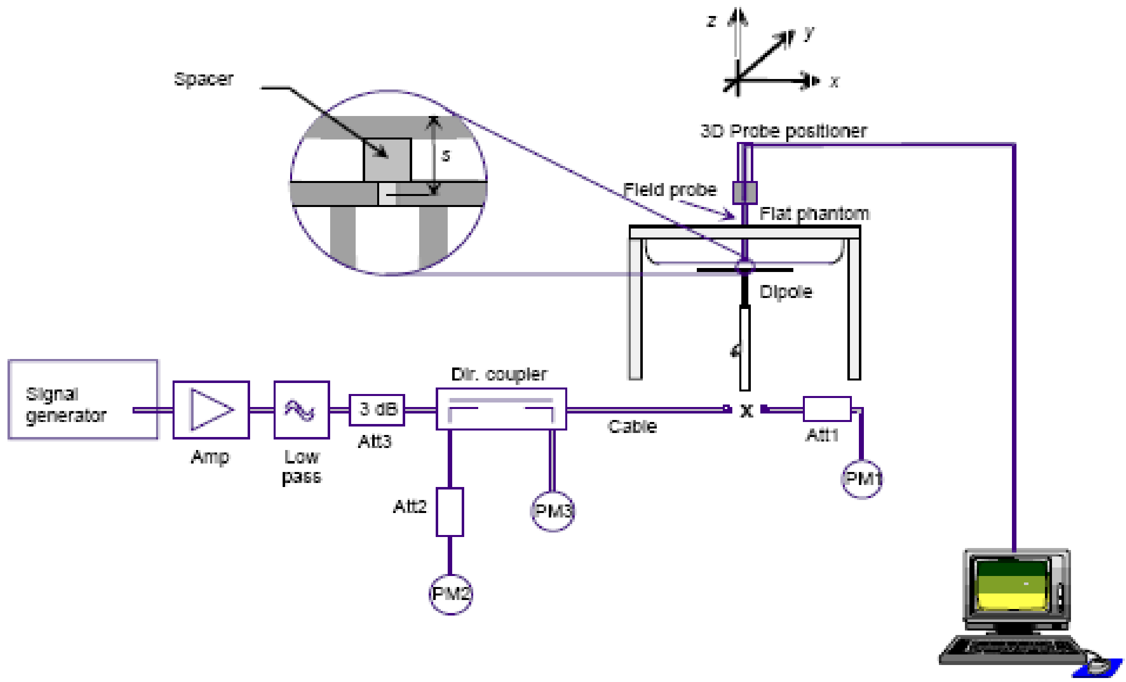
Table 9.2 System dipole validation target & measured

Test Frequency	Targeted SAR_{1g} (W/kg)	Measured SAR_{1g} (W/kg)	Tissue Used for Verification	Deviation (%)	Verification Date
2450 MHz	12.8	12.7	Body	0.8	01/21/14

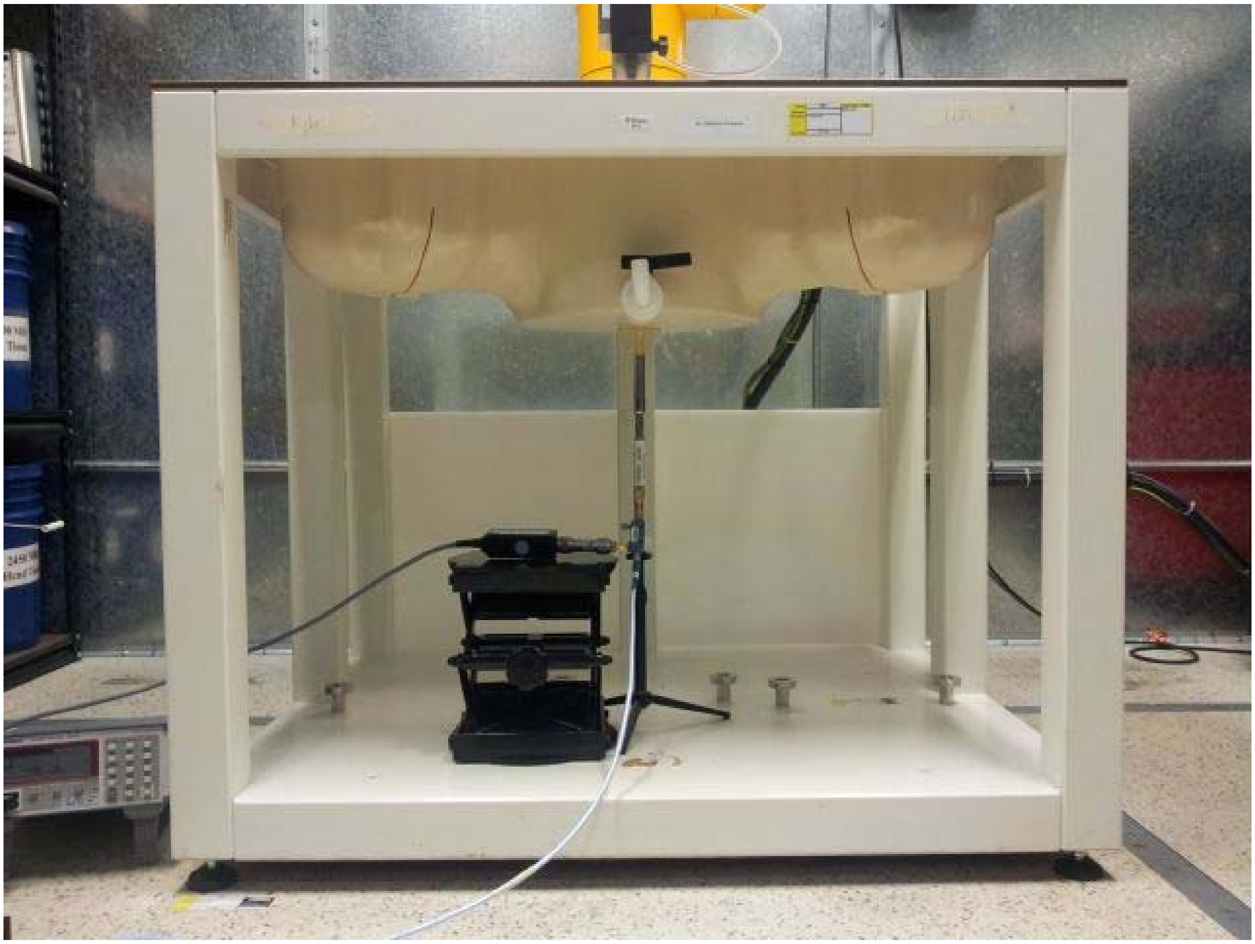
See Appendix A for detailed results and plots.

Figure 9.1 Dipole validation test setup

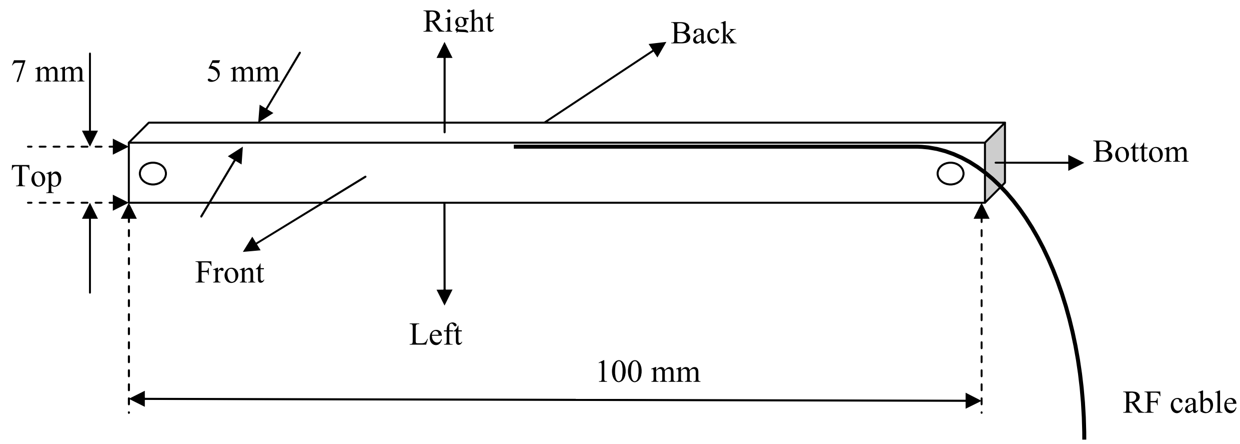
Note: KDB 450824 was applied for probe calibration frequencies greater than or equal to 50 MHz of the DUT frequencies.



Dipole validation photo



EUT SAR location diagram
(Antenna)



10. SAR test data summary (2450 MHz Body 802.11b)

Hitachi HMT05 (Zanzibar) antenna (RF cable length = 50 cm)

Gap (mm)	Position	Frequency MHz	Frequency Channel	Data rate (Mbps)	Antenna	Meas. Plot page #	End power (dBm)	SAR (W/kg)
5	Right	2437	6	1	Aux	36	13.5	0.728
5	Left	2437	6	1	Aux	37	13.5	0.649
5	Front	2437	6	1	Aux	38	13.6	0.206
5	Back	2437	6	1	Aux	39	13.5	0.101
5	Top	2437	6	1	Aux	40	13.5	0.018
5	Bottom	2437	6	1	Aux	41	13.5	0.051
					Maximum body SAR = 0.728 W/kg (mW/g) averaged over 1 gram			

1. Power Measured ☒Conducted ☐ERP ☐EIRP
2. SAR Measurement
   Phantom Configuration ☐Left Head ☒Uni-phantom ☐Right Head
3. SAR Configuration ☐Head ☒Body
   Test Signal Call Mode ☒Test Code ☐Base Station Simulator
4. Test Configuration ☐With Belt Clip ☐Without Belt Clip ☒N/A
5. Tissue Depth is at least 15.0 cm

Note 1: SAR Tested on the Highest output power channel. When the measured channel is 3 dB or more below the limit the remaining channels are not required to be tested per KDB 447498 section 1) e). SAR is not required for 802.11g/HT20/HT40 channels when the maximum average output power is less than ¼ dB higher than that measured in the 802.11b. The testing was conducted on all sides of the antenna. All testing was conducted per KDB 447498, 248227, 616217 and OET Bulletin 65. See the photo in Appendix C and diagram on page 14 for a pictorial of the setup and labeling of the test locations.

Note 2: All measurements were performed with 5 mm gap (Antenna to Flat phantom measurement distance)

Note 3: Number of test channels and SAR test reductions determined based on 447498 D01 v05r01 and KDB 248227 v01r02

Note 4: Main and Aux. chains have identical power outputs, hence SAR evaluation of Aux antenna output is sufficient to represent Main antenna output compliance.

Note 6: For 2.4 GHz, measured end power values exceeds the maximum output levels of the production units (including tolerances) declared by the applicant. Scaling measured SAR results are not required

See Appendix B for SAR Test Data Plots.

See Appendix C for SAR Test Setup Photos.

Simultaneous transmission capabilities

The module has a build in Bluetooth transmitter and it is able to transmit at Aux. chain simultaneously when WIFI transmits at Main chain.

Main and Aux. chains have identical power outputs. In normal operation, antennas will be separated each other, hence SAR evaluation of Main antenna output is considered sufficient to show Aux. antenna output compliance.

11. SAR data summary – Simultaneous Evaluation

Frequency		Modulation	Frequency		Modulation	SAR_1	SAR_2	SAR Total W/kg
MHz	Ch.		MHz	Ch.				
2437	6	DSSS	2480	79	8PSK	0.728	0.071	0.799

The value for SAR2 was calculated per KDB 447498 D01 v05 section 4.3.2.2 page 12 as follows:

[max power including tune up, mW/min test separation, mm]*[$\sqrt{f_{(GHZ)}}$/x]

where x=7.5 for 1 g SAR

[1.7/5]*[√2.48/7.5] = 0.071 W/kg

Procedures used to establish test signal

The device was placed into simulated transmit mode using the manufacturer's test codes See data pages for actual procedure used in measurement.

Device test condition

The EUT is a 802.11bgn WLAN + Bluetooth module with external antennas (Hitachi HMT05 (Zanzibar). Module dimensions are approximately 25 mm x 15 mm x 5 mm, antenna dimensions are approximately 100 mm x 7 mm x 5 mm. The antenna RF cable is approximately 50 cm long

The EUT was configured via a Laptop PC to transmit at maximum power with desired channel and modes. The module and PC were positioned with a distance longer than 10 cm from the transmit antenna. The antenna was positioned with all six sides, with 5 mm gap under the phantom.
In order to verify that the device was tested at full power, conducted output power measurements were performed before and after each SAR measurement to confirm the output power unless otherwise noted. If a conducted power deviation of more than 5% occurred, the test was repeated. The power drift of each test is measured at the start of the test and again at the end of the test. The drift percentage is calculated by the formula ((end/start)-1)*100 and rounded to three decimal places. The drift percentage is calculated into the resultant SAR value on the data sheet for each test.

12. Test equipment list

Manufacturer	Description	Model	Asset #	Cal Due
SAR				
Speag	SAR Probe	EX3DV4	3833	11-Mar-14
Schmid & Partner Engineering AG	Data acquisition Electronics	DAE 4	2661	05-Mar-14
Speag	Phantom	SM 000 T02 EA	2667	N/A
NTS	Body Equivalent Matter	N/A	N/A	N/A
SAR verification				
Speag	DAK 3.5mm Probe	SM DAK 040	2660	13-Jun-14
Speag	SAR Dipole	D2450V2	2654	07-Feb-14
Rohde & Schwarz	Signal Generator	SMB 100A	2918	19-Dec-14
SM Electronics	Directional coupler	MC2045	N/A	N/A
Macom	Attenuator (3 dB)	2082-61	N/A	N/A
Mini Circuits	RF Amplifier	ZVE-8G+	N/A	N/A
Rohde & Schwarz	Power Sensor 100 uW - 2 Watts (w/ 20 dB pad, SN B844664/018)	NRV-Z53	1555	26-Feb-14
Rohde & Schwarz	Power Meter	NRVD	1538	30-Aug-14
Rohde & Schwarz	Power Sensor	NRV-Z51	1069	19-Dec-14

13. Conclusion

The SAR measurement indicates that the EUT complies with the RF radiation exposure limits of the FCC. These measurements are taken to simulate the RF effects exposure under worst-case conditions. Precise laboratory measures were taken to assure repeatability of the tests. The tested device complies with the requirements in respect to all parameters subject to the test. The test results and statements relate only to the item(s) tested.

Please note that the absorption and distribution of electromagnetic energy in the body is a very complex phenomena that depends on the mass, shape, and size of the body; the orientation of the body with respect to the field vectors; and, the electrical properties of both the body and the environment. Other variables that may play a substantial role in possible biological effects are those that characterize the environment (e.g. ambient temperature, air velocity, relative humidity, and body insulation) and those that characterize the individual (e.g. age, gender, activity level, debilitation, or disease). Because innumerable factors may interact to determine the specific biological outcome of an exposure to electromagnetic fields, any protection guide shall consider maximal amplification of biological effects as a result of field-body interactions, environmental conditions, and physiological variables.

14. References

[1] Federal Communications Commission, ET Docket 93-62, Guidelines for Evaluating the Environmental Effects of Radio Frequency Radiation, August 1996

[2] ANSI/IEEE C95.1 – 1992, American National Standard Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300kHz to 100GHz, New York: IEEE, 1992.

[3] ANSI/IEEE C95.3 – 1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave, New York: IEEE, 1992.

[4] Federal Communications Commission, OET Bulletin 65 (Edition 97-01), Supplement C (Edition 01-01), Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields, June 2001.

[5] IEEE Standard 1528 – 2003, IEEE Recommended Practice for Determining the Peak-Spatial Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communication Devices: Measurement Techniques, October 2003.

[6] Industry Canada, RSS – 102e, Radio Frequency Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands), March 2010.

[7] Health Canada, Safety Code 6, Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3kHz to 300 GHz, 2009.

[8] KDB 450824 D02 Dipole Requirements for SAR System Validation and Verification

[9] KDB 447498 D01 General RF Exposure Guidance v05r02. Section 5.2.2.2 When the highest reported 1-g SAR is > 0.4 W/kg and ≤ 0.8 W/kg, modules and peripheral transmitters may be approved to operate in multiple host platforms

[10] KDB 248227 v01r02 SAR Measurement Procedures for 802.11 a/b/g Transmitters

[11] KDB 616217 D01 SAR Evaluation Considerations for Laptop Computers with Antennas Built-in on Display Screens

[12] KDB 616217 D02 Review and Approval Policies for SAR Evaluation of Laptop Computers with Antennas Built-in on Display Screens

[13] KDB 616217 D04 v01r01 SAR Evaluation considerations for Laptop/Notebook/Netbook and Tablet Computers

Appendix A – Tissue and system validation data and plots

Name : Body 22 deg.C, 2014/01/21, 07:48:05
Date : Body 22 deg.C, 2014/01/21, 07:48:05
Temperature(C) : 22
Probe : DAK_35
Network Analyzer : HP8753X
Notes : 2.4 GHz Body Tissue calibration Jan 21 2014

Measured data

f(MHz)	eps.R	eps.I	sigma(S/m)	loss tangent	refl.R	refl.I
2402	52.91	14.08	1.88	0.27	0.17	-0.74
2407	52.91	14.13	1.89	0.27	0.17	-0.74
2412	52.86	14.15	1.90	0.27	0.17	-0.74
2417	52.85	14.17	1.91	0.27	0.17	-0.74
2422	52.83	14.22	1.92	0.27	0.16	-0.74
2427	52.82	14.22	1.92	0.27	0.16	-0.74
2432	52.78	14.29	1.93	0.27	0.16	-0.74
2437	52.79	14.24	1.93	0.27	0.16	-0.74
2442	52.79	14.28	1.94	0.27	0.16	-0.74
2447	52.79	14.27	1.94	0.27	0.16	-0.74
2452	52.76	14.30	1.95	0.27	0.16	-0.74
2457	52.75	14.33	1.96	0.27	0.15	-0.74
2462	52.73	14.36	1.97	0.27	0.15	-0.74
2467	52.69	14.37	1.97	0.27	0.15	-0.74
2472	52.66	14.36	1.98	0.27	0.15	-0.74

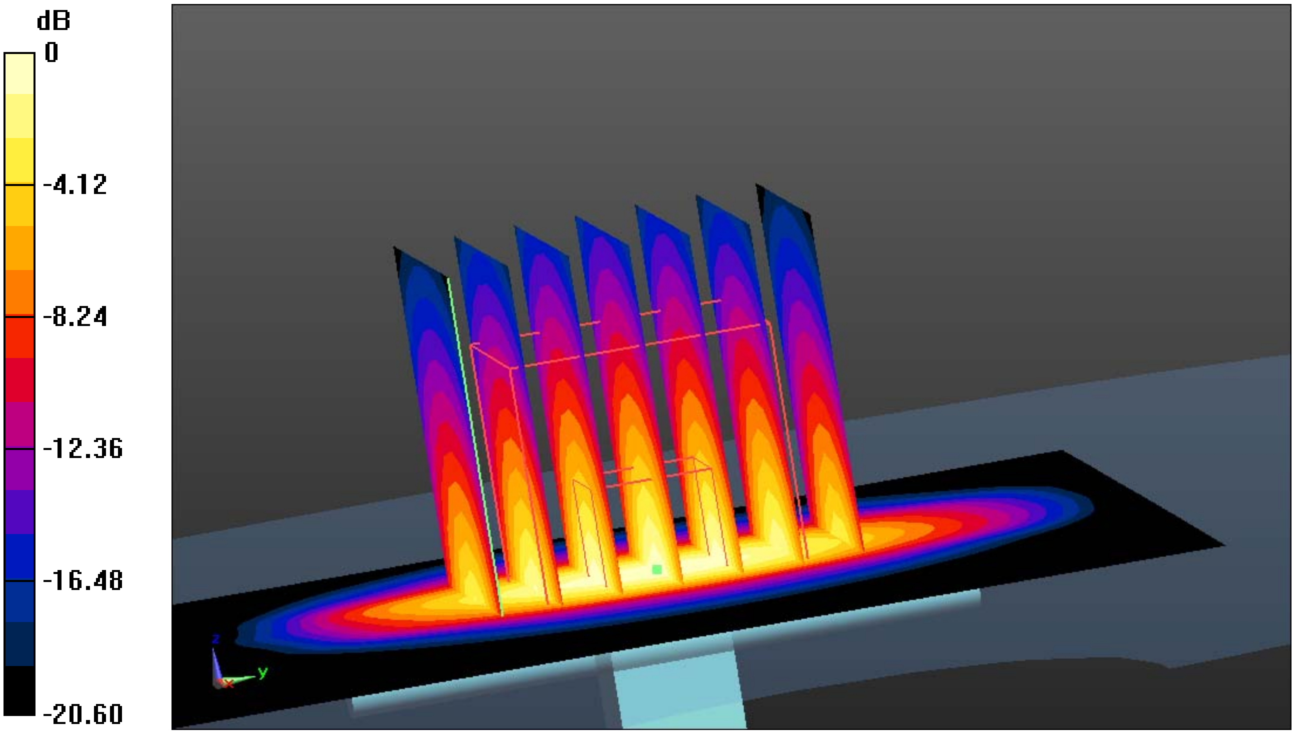
Target data : Body 22 deg.C

f(MHz)	eps.R	eps.I	sigma(S/m)	loss tangent	refl.R	refl.I
2402	52.76	14.13	1.89	0.27	0.17	-0.74
2407	52.76	14.15	1.89	0.27	0.17	-0.74
2412	52.75	14.17	1.90	0.27	0.17	-0.74
2417	52.74	14.18	1.91	0.27	0.17	-0.74
2422	52.74	14.20	1.91	0.27	0.17	-0.74
2427	52.73	14.22	1.92	0.27	0.16	-0.74
2432	52.72	14.24	1.93	0.27	0.16	-0.74
2437	52.72	14.26	1.93	0.27	0.16	-0.74
2442	52.71	14.28	1.94	0.27	0.16	-0.74
2447	52.70	14.30	1.95	0.27	0.16	-0.74
2452	52.70	14.31	1.95	0.27	0.16	-0.74
2457	52.69	14.33	1.96	0.27	0.15	-0.74
2462	52.68	14.35	1.97	0.27	0.15	-0.74
2467	52.68	14.37	1.97	0.27	0.15	-0.74
2472	52.67	14.39	1.98	0.27	0.15	-0.74

DUT: Dipole 2450 MHz D2450V2; Type: D2450V2; Serial: D2450V2 - SN:881
Procedure Name: 2450 MHz Body Validation
Communication System: UID 10000, CW; Frequency: 2450 MHz; Duty Cycle: 1:1
Medium parameters used (interpolated): f = 2450 MHz; σ = 1.948 S/m; ε_r = 52.768; ρ = 1000 kg/m^3
Phantom section: Flat Section
Test Date: 1/21/2014
DASY5 Configuration:

- Probe: EX3DV4 - SN3833; ConvF(6.69, 6.69, 6.69); Calibrated: 3/11/2013;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1321; Calibrated: 3/5/2013
- Phantom: SAM 1; Type: SAM Twin Phantom
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

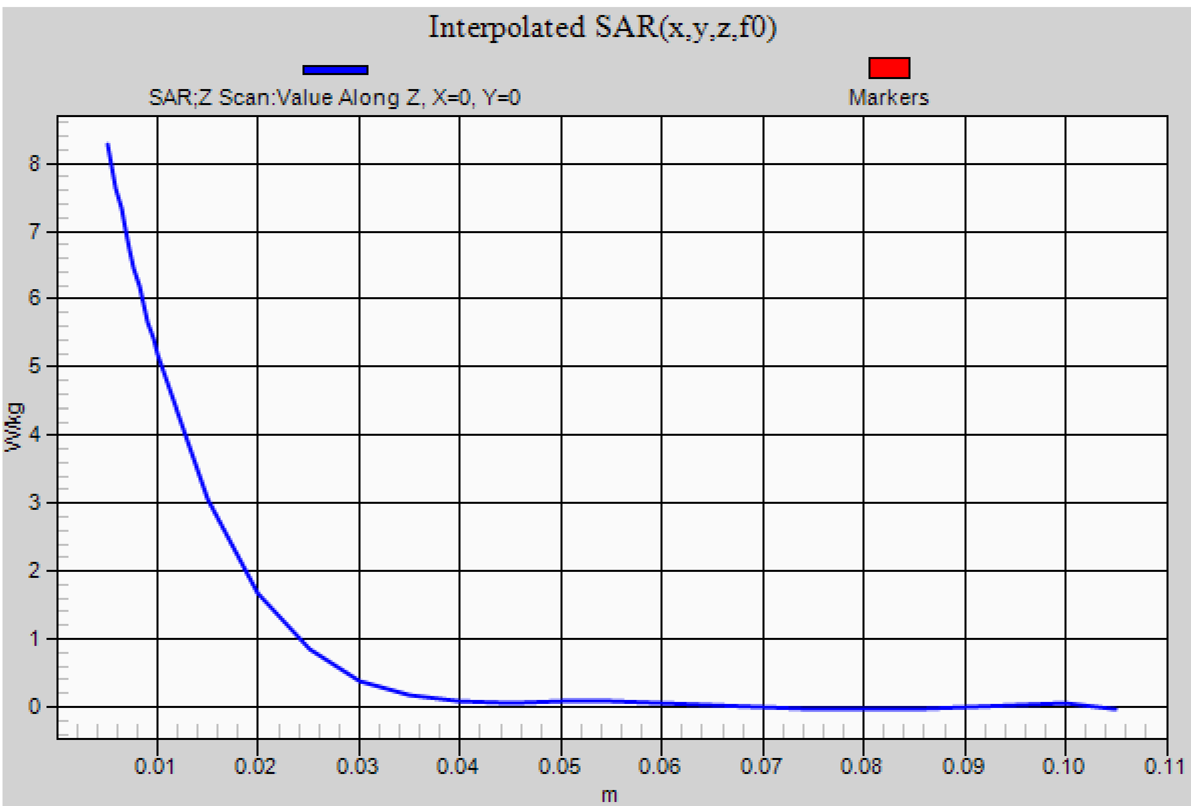
2450 MHz Body Validation/2450 MHz Body Validation/Area Scan (61x61x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 18.4 W/kg
2450 MHz Body Validation/2450 MHz Body Validation/Zoom Scan (7x7x8)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=4mm
Reference Value = 80.876 V/m; Power Drift = 0.28 dB
Peak SAR (extrapolated) = 26.2 W/kg
SAR(1 g) = 12.7 W/kg; SAR(10 g) = 5.87 W/kg
Maximum value of SAR (measured) = 19.3 W/kg



0 dB = 19.3 W/kg = 12.86 dBW/kg

DUT: Dipole 2450 MHz D2450V2; Frequency: 2450 MHz; Duty Cycle: 1:1

Medium: MSL2450; Medium parameters used (interpolated): f = 2450 MHz; σ = 1.948 S/m; ε_r = 52.768; ρ = 1000 kg/m^3
Phantom section: Flat Section
Date: 1/21/2014
Probe: EX3DV4 - SN3833; ConvF(6.69, 6.69, 6.69); Calibrated: 3/11/2013;
Sensor-Surface: 0mm (Fix Surface)
Electronics: DAE4 Sn1321; Calibrated: 3/5/2013
Phantom: SAM 1; Type: SAM Twin Phantom
Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)
2450 MHz Body Validation/2450 MHz Body Validation/Z Scan (1x1x31): Measurement grid: dx=20mm, dy=20mm, dz=5mm
Maximum value of SAR (interpolated) = 8.30 W/kg

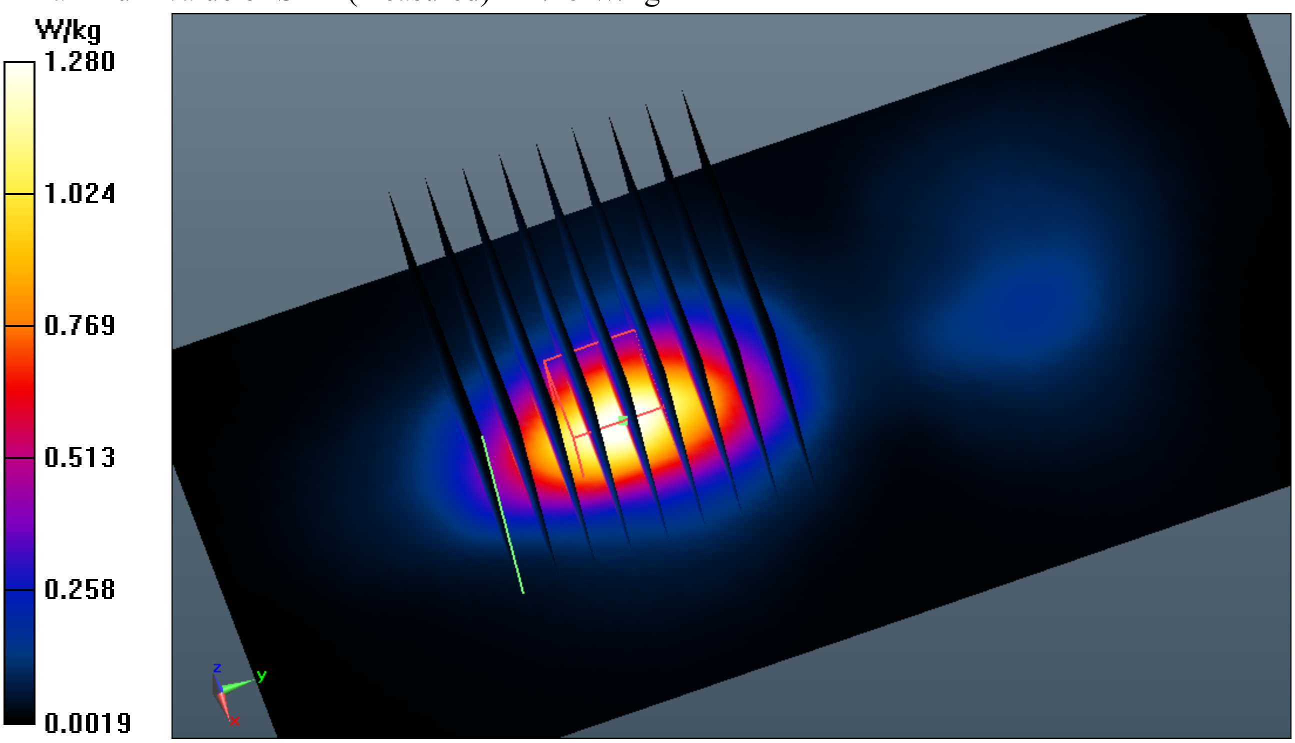


Appendix B – SAR test data plots

DUT: BCM943142Y With Zanzibar; Type: 802.11bgn Module; Serial: 00108E2EB21
Procedure Name: 5 mm Right
Communication System: UID 0, 802.11b - 1 Mbps; Frequency: 2437 MHz; Duty Cycle: 1:1
Medium parameters used: f = 2437 MHz; σ = 1.93 S/m; ε_r = 52.793; ρ = 1000 kg/m^3
Phantom section: Flat Section
Test Date: 1/21/2014
DASY5 Configuration:

- Probe: EX3DV4 - SN3833; ConvF(6.69, 6.69, 6.69); Calibrated: 3/11/2013;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1321; Calibrated: 3/5/2013
- Phantom: SAM 1; Type: SAM Twin Phantom
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

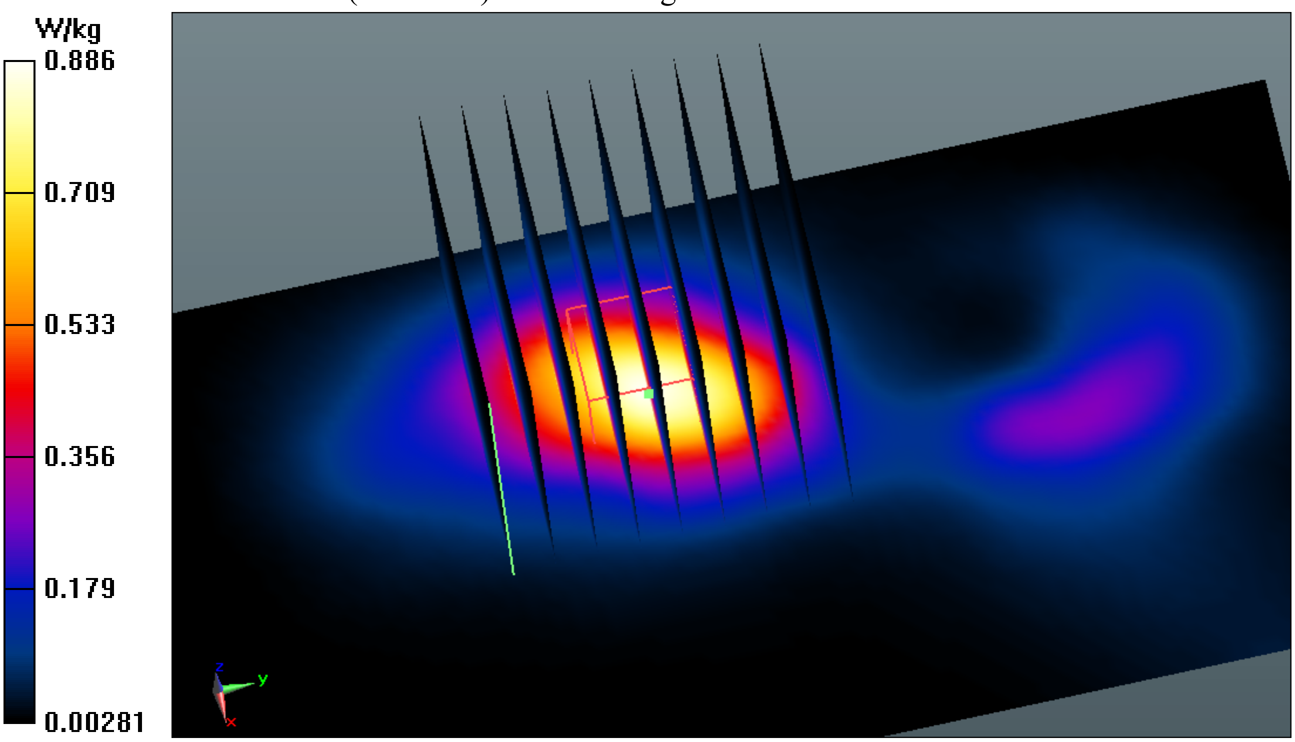
BCM943142Y with Zanzibar/5 mm Right/Area Scan (61x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 1.36 W/kg
BCM943142Y with Zanzibar/5 mm Right/Zoom Scan (9x9x9)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=4mm
Reference Value = 13.068 V/m; Power Drift = -0.10 dB
Peak SAR (extrapolated) = 1.84 W/kg
SAR(1 g) = 0.728 W/kg
Maximum value of SAR (measured) = 1.28 W/kg



DUT: BCM943142Y With Zanzibar; Type: 802.11bgn Module; Serial: 00108E2EB21
Procedure Name: 5 mm Left
Communication System: UID 0, 802.11b - 1 Mbps; Frequency: 2437 MHz; Duty Cycle: 1:1
Medium parameters used: f = 2437 MHz; σ = 1.93 S/m; ε_r = 52.793; ρ = 1000 kg/m^3
Phantom section: Flat Section
Test Date: 1/21/2014
DASY5 Configuration:

- Probe: EX3DV4 - SN3833; ConvF(6.69, 6.69, 6.69); Calibrated: 3/11/2013;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1321; Calibrated: 3/5/2013
- Phantom: SAM 1; Type: SAM Twin Phantom
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

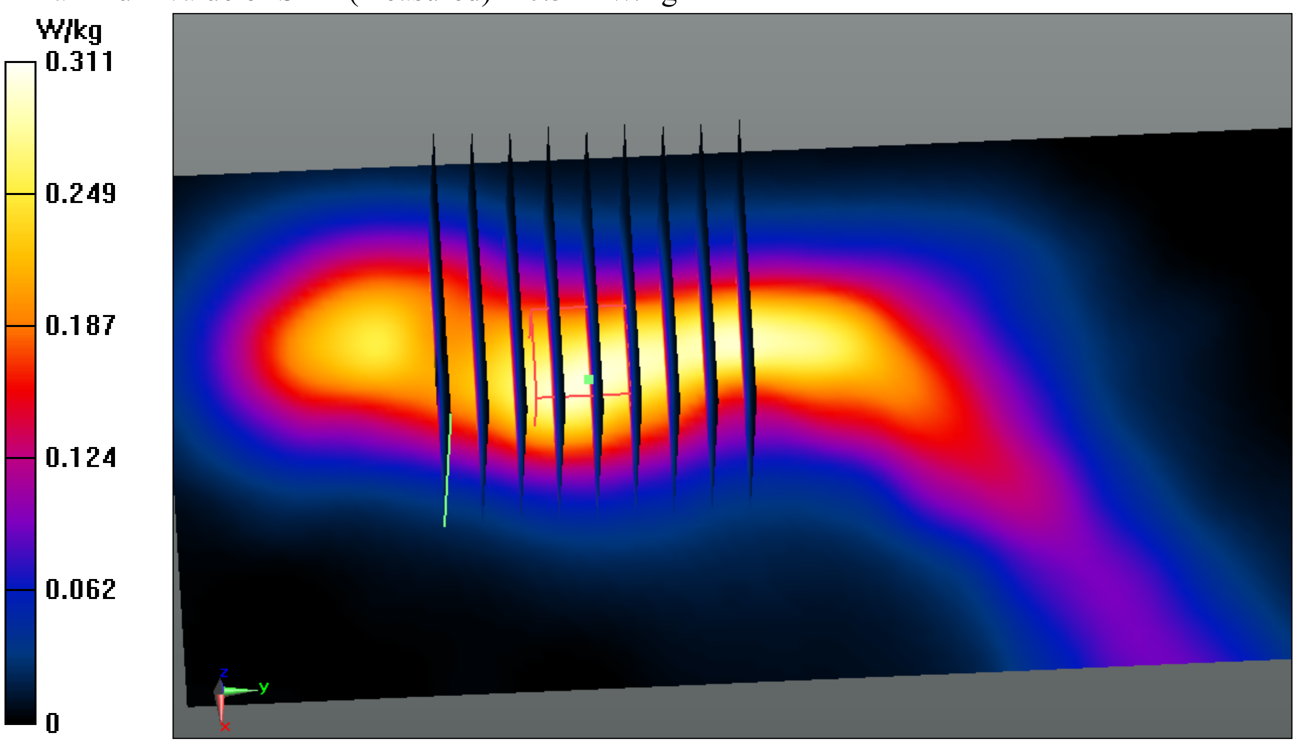
BCM943142Y with Zanzibar/5 mm Left/Area Scan (61x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 0.878 W/kg
BCM943142Y with Zanzibar/5 mm Left/Zoom Scan (9x9x9)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=4mm
Reference Value = 10.165 V/m; Power Drift = 0.14 dB
Peak SAR (extrapolated) = 1.27 W/kg
SAR(1 g) = 0.649 W/kg
Maximum value of SAR (measured) = 0.886 W/kg



DUT: BCM943142Y With Zanzibar; Type: 802.11bgn Module; Serial: 00108E2EB21
Procedure Name: 5 mm Front
Communication System: UID 0, 802.11b - 1 Mbps; Frequency: 2437 MHz; Duty Cycle: 1:1
Medium parameters used: f = 2437 MHz; σ = 1.93 S/m; ε_r = 52.793; ρ = 1000 kg/m^3
Phantom section: Flat Section
Test Date: 1/21/2014
DASY5 Configuration:

- Probe: EX3DV4 - SN3833; ConvF(6.69, 6.69, 6.69); Calibrated: 3/11/2013;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1321; Calibrated: 3/5/2013
- Phantom: SAM 1; Type: SAM Twin Phantom
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

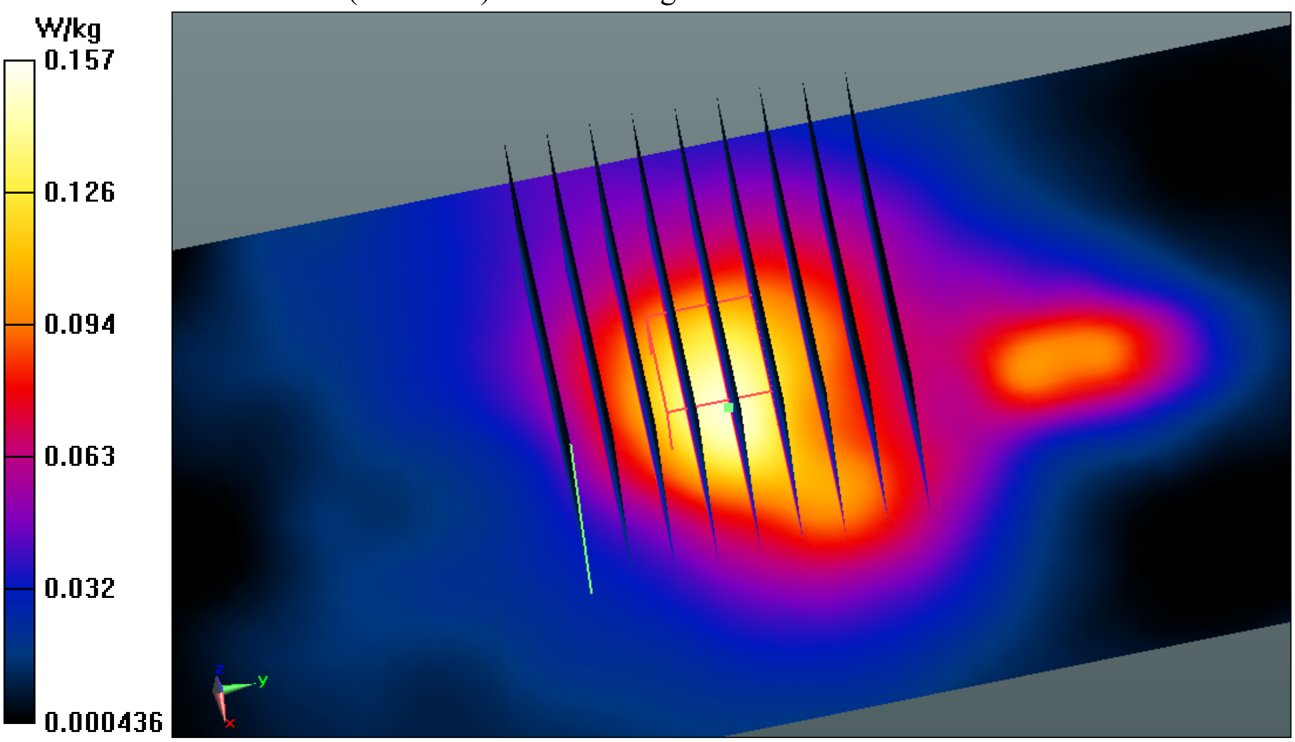
BCM943142Y with Zanzibar/5 mm Front/Area Scan (61x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 0.303 W/kg
BCM943142Y with Zanzibar/5 mm Front/Zoom Scan (9x9x9)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=4mm
Reference Value = 7.725 V/m; Power Drift = -0.59 dB
Peak SAR (extrapolated) = 0.515 W/kg
SAR(1 g) = 0.206 W/kg
Maximum value of SAR (measured) = 0.311 W/kg



DUT: BCM943142Y With Zanzibar; Type: 802.11bgn Module; Serial: 00108E2EB21
Procedure Name: 5 mm Back
Communication System: UID 0, 802.11b - 1 Mbps; Frequency: 2437 MHz; Duty Cycle: 1:1
Medium parameters used: f = 2437 MHz; σ = 1.93 S/m; ε_r = 52.793; ρ = 1000 kg/m^3
Phantom section: Flat Section
Test Date: 1/21/2014
DASY5 Configuration:

- Probe: EX3DV4 - SN3833; ConvF(6.69, 6.69, 6.69); Calibrated: 3/11/2013;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1321; Calibrated: 3/5/2013
- Phantom: SAM 1; Type: SAM Twin Phantom
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

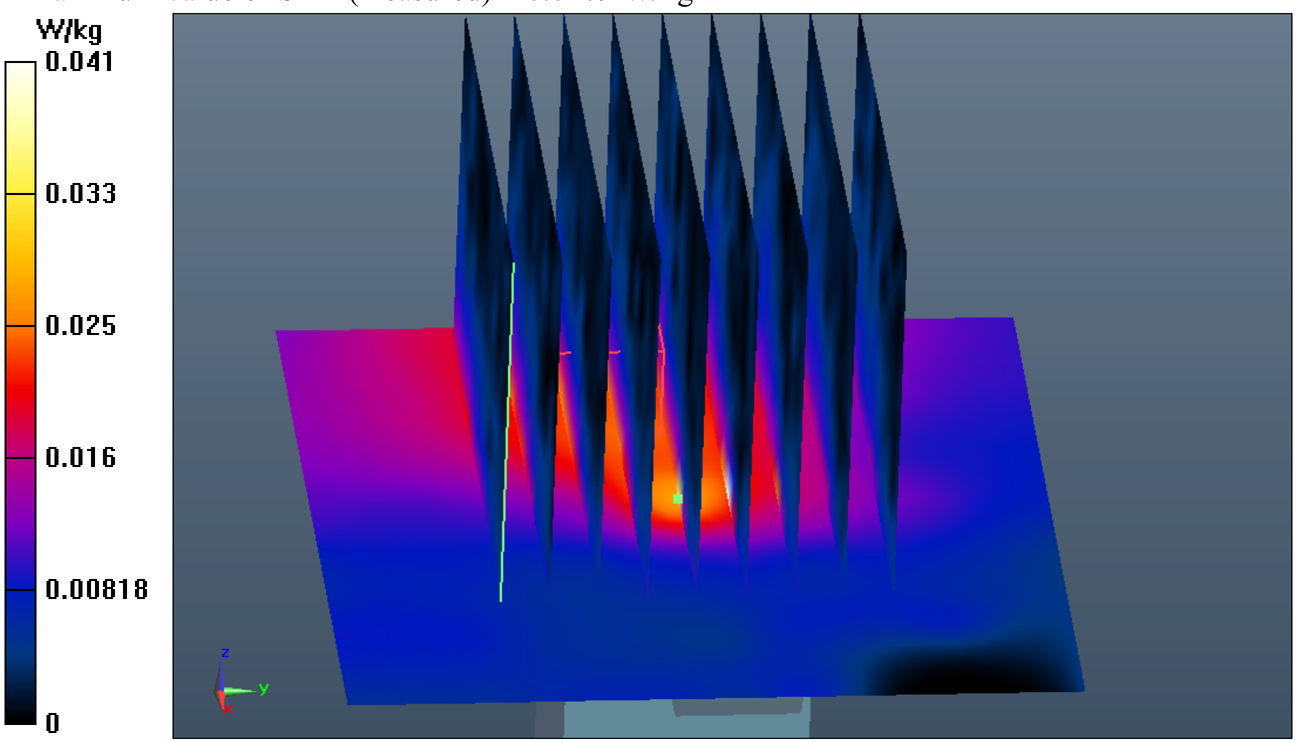
BCM943142Y with Zanzibar/5 mm Back/Area Scan (61x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 0.151 W/kg
BCM943142Y with Zanzibar/5 mm Back/Zoom Scan (9x9x9)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=4mm
Reference Value = 7.406 V/m; Power Drift = 0.06 dB
Peak SAR (extrapolated) = 0.230 W/kg
SAR(1 g) = 0.101 W/kg
Maximum value of SAR (measured) = 0.157 W/kg



DUT: BCM943142Y With Zanzibar; Type: 802.11bgn Module; Serial: 00108E2EB21
Procedure Name: 5 mm Top
Communication System: UID 0, 802.11b - 1 Mbps; Frequency: 2437 MHz; Duty Cycle: 1:1
Medium parameters used: f = 2437 MHz; σ = 1.93 S/m; ε_r = 52.793; ρ = 1000 kg/m^3
Phantom section: Flat Section
Test Date: 1/21/2014
DASY5 Configuration:

- Probe: EX3DV4 - SN3833; ConvF(6.69, 6.69, 6.69); Calibrated: 3/11/2013;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1321; Calibrated: 3/5/2013
- Phantom: SAM 1; Type: SAM Twin Phantom
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

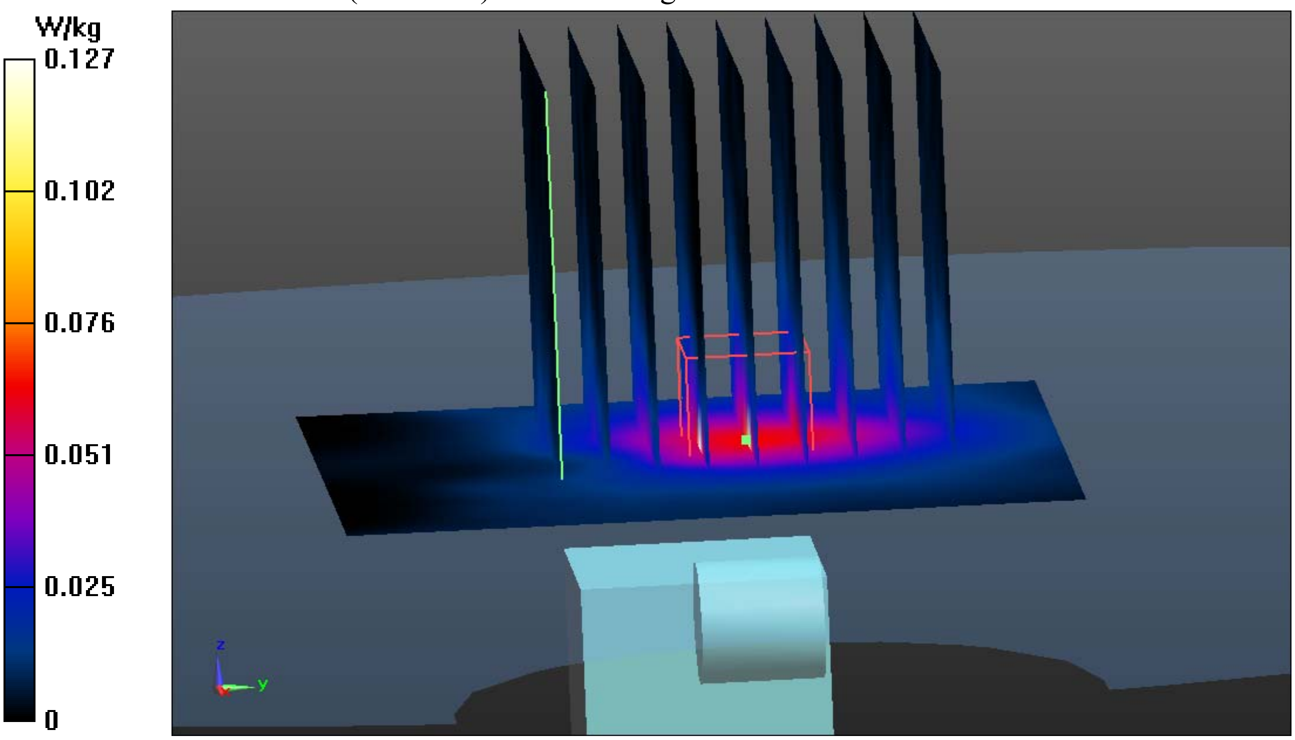
BCM943142Y with Zanzibar/5 mm Top/Area Scan (61x61x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 0.0267 W/kg
BCM943142Y with Zanzibar/5 mm Top/Zoom Scan (11x9x9)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=4mm
Reference Value = 2.784 V/m; Power Drift = -0.16 dB
Peak SAR (extrapolated) = 0.131 W/kg
SAR(1 g) = 0.018 W/kg
Maximum value of SAR (measured) = 0.0409 W/kg



DUT: BCM943142Y With Zanzibar; Type: 802.11bgn Module; Serial: 00108E2EB21
Procedure Name: 5 mm Bottom
Communication System: UID 0, 802.11b - 1 Mbps; Frequency: 2437 MHz; Duty Cycle: 1:1
Medium parameters used: f = 2437 MHz; σ = 1.93 S/m; ε_r = 52.793; ρ = 1000 kg/m^3
Phantom section: Flat Section
Test Date: 1/21/2014
DASY5 Configuration:

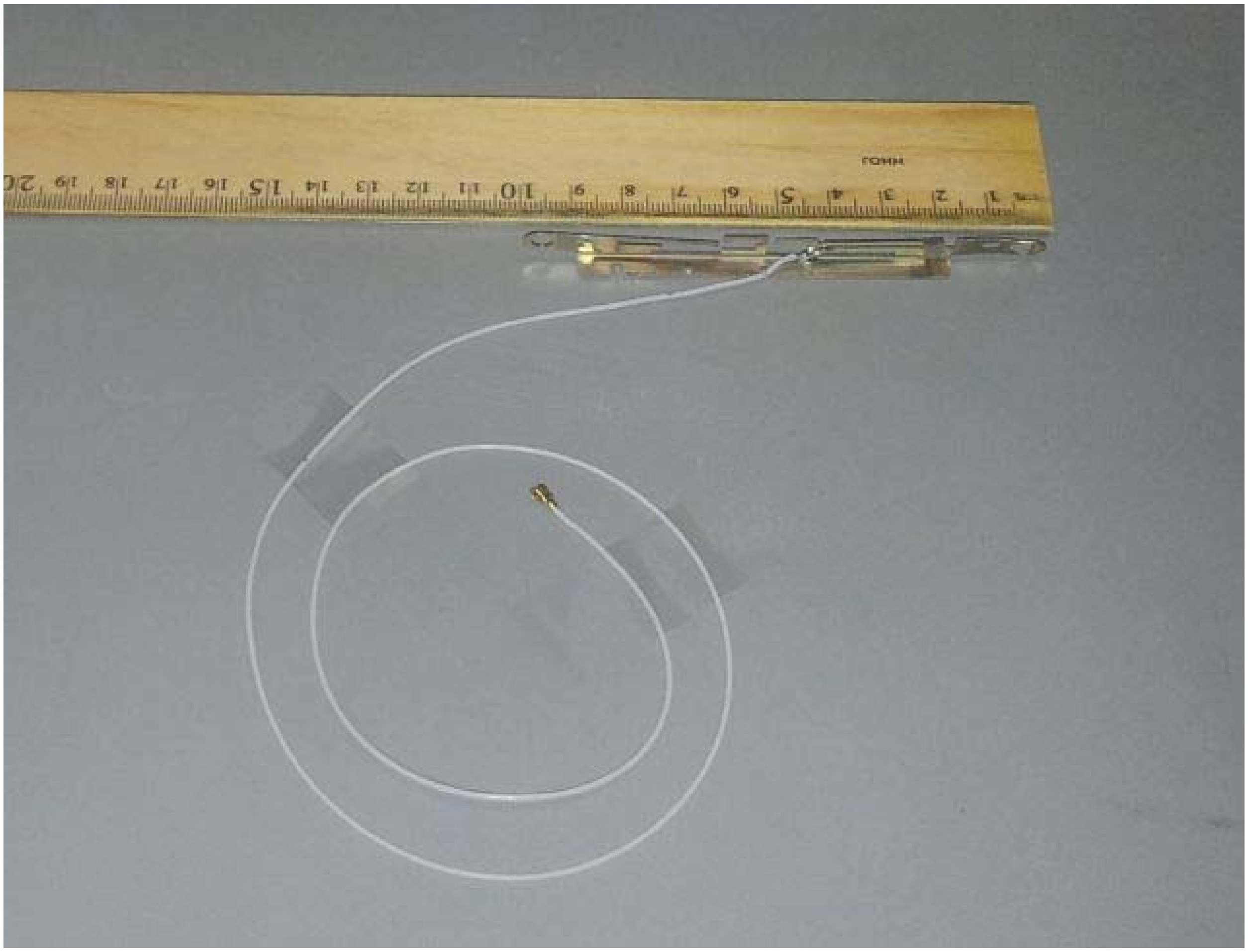
- Probe: EX3DV4 - SN3833; ConvF(6.69, 6.69, 6.69); Calibrated: 3/11/2013;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1321; Calibrated: 3/5/2013
- Phantom: SAM 1; Type: SAM Twin Phantom
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

BCM943142Y with Zanzibar/5 mm Bottom/Area Scan (61x61x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 0.0639 W/kg
BCM943142Y with Zanzibar/5 mm Bottom/Zoom Scan (9x9x9)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=4mm
Reference Value = 3.571 V/m; Power Drift = 0.42 dB
Peak SAR (extrapolated) = 0.294 W/kg
SAR(1 g) = 0.051 W/kg
Maximum value of SAR (measured) = 0.127 W/kg



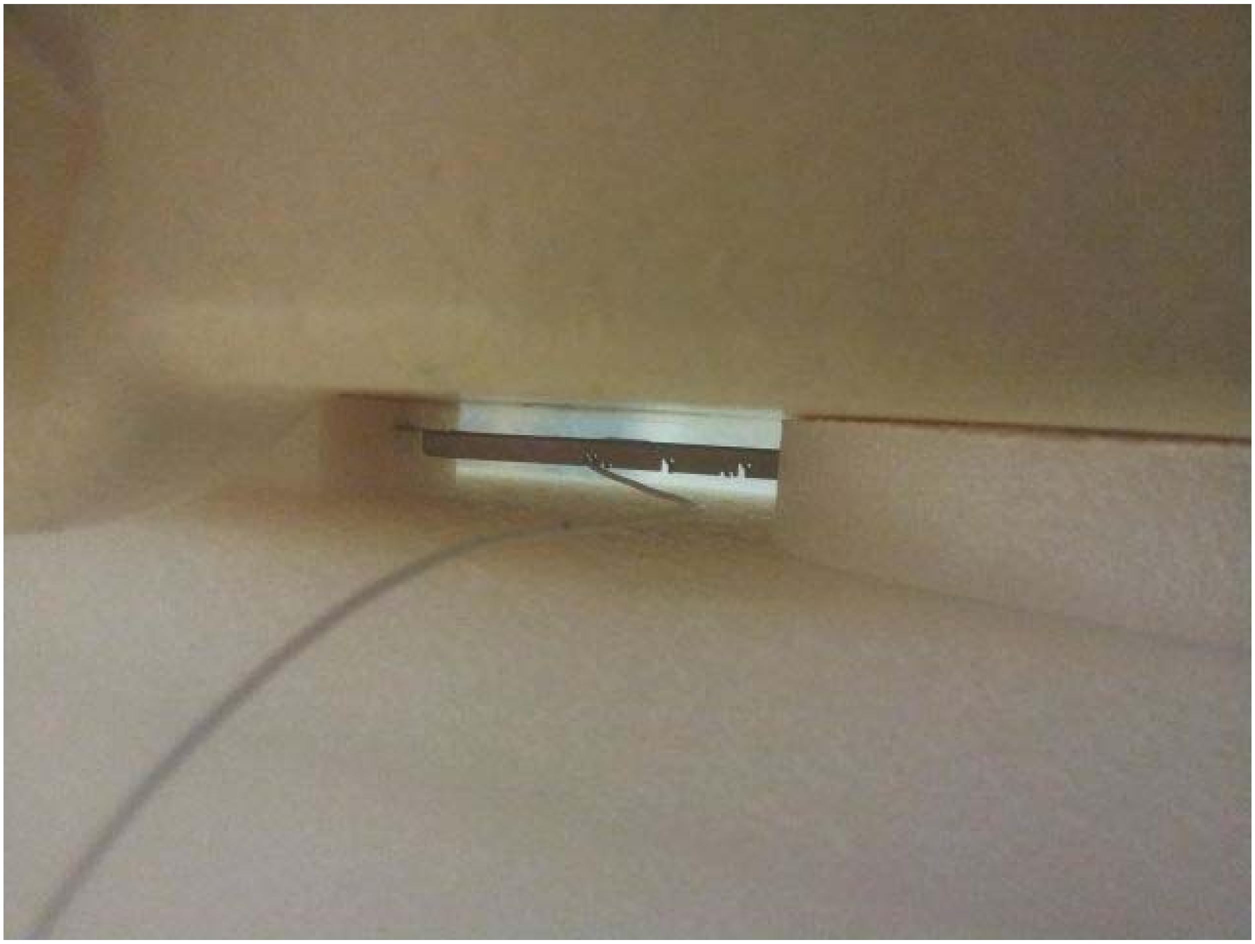
Appendix C – SAR Test Setup Photos

Picture 1: Hitachi HMT05 (Zanzibar) antenna

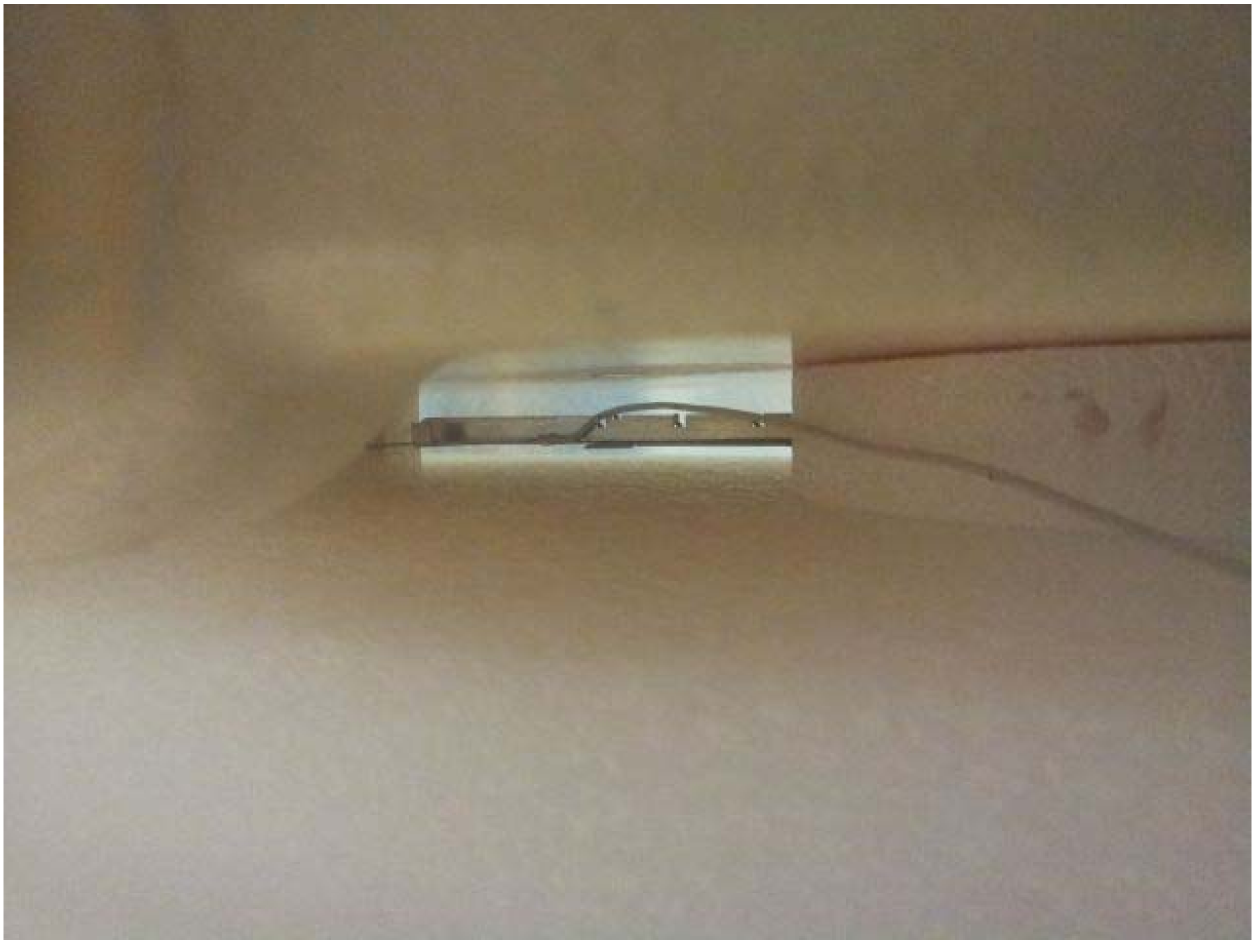


Picture 2: Hitachi HMT05 (Zanzibar) antenna, Orientation = Right

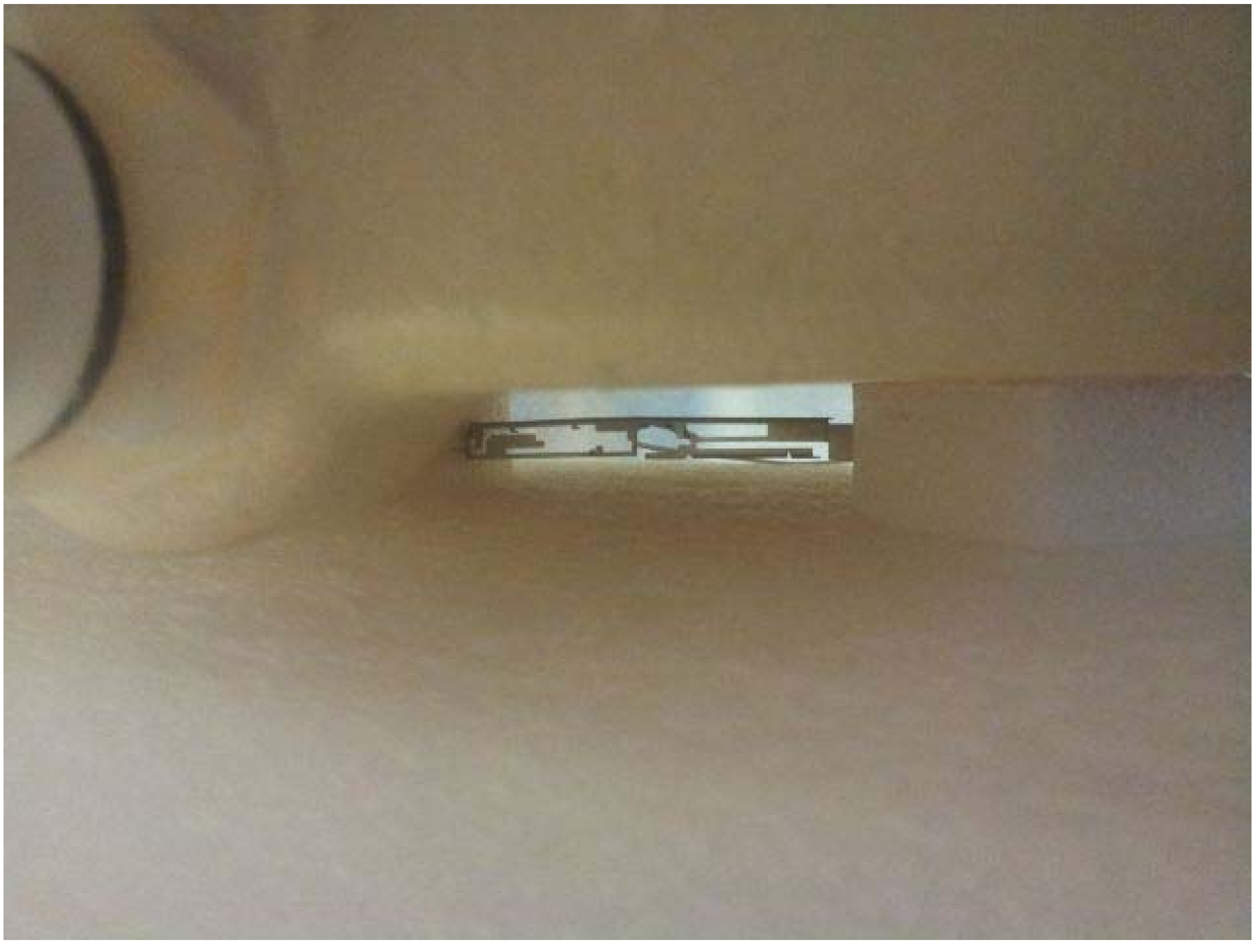
Picture 3: Hitachi HMT05 (Zanzibar) antenna, Orientation = Left



Picture 4: Hitachi HMT05 (Zanzibar) antenna, Orientation = Front

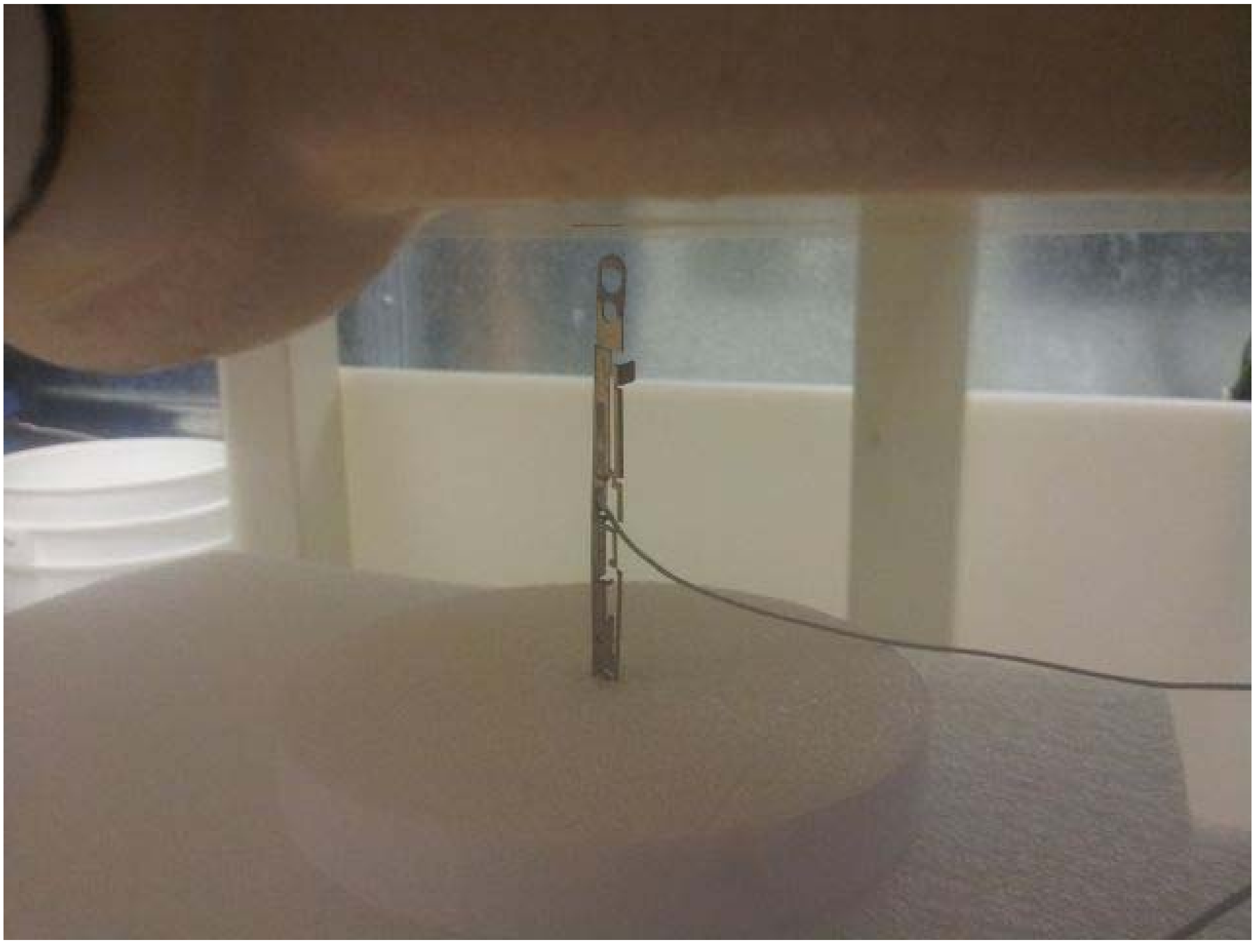


Picture 5: Hitachi HMT05 (Zanzibar) antenna, Orientation = Back



Picture 6: Hitachi HMT05 (Zanzibar) antenna, Orientation = Top

Picture 7: Hitachi HMT05 (Zanzibar) antenna, Orientation = Bottom



Picture 8: EUT setup

Appendix D – Probe Calibration Data Sheets

#2650

Calibration Laboratory of
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Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

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Swiss Calibration Service

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Accreditation No.: **SCS 108**

Client **NTS**

Certificate No: **EX3-3833_Mar13**

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:3833
Calibration procedure(s)	QA CAL-01.v8, QA CAL-14.v3, QA CAL-23.v4, QA CAL-25.v4 Calibration procedure for dosimetric E-field probes
Calibration date:	March 11, 2013

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 E4419B	GB41293874	29-Mar-12 (No. 217-01508)	Apr-13
Power sensor E4412A	MY41498087	29-Mar-12 (No. 217-01508)	Apr-13
Reference 3 dB Attenuator	SN: S5054 (3c)	27-Mar-12 (No. 217-01531)	Apr-13
Reference 20 dB Attenuator	SN: S5086 (20b)	27-Mar-12 (No. 217-01529)	Apr-13
Reference 30 dB Attenuator	SN: S5129 (30b)	27-Mar-12 (No. 217-01532)	Apr-13
Reference Probe ES3DV2	SN: 3013	28-Dec-12 (No. ES3-3013_Dec12)	Dec-13
DAE4	SN: 660	31-Jan-13 (No. DAE4-660_Jan13)	Jan-14
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-11)	In house check: Apr-13
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-12)	In house check: Oct-13

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

Issued: March 12, 2013

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

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Accreditation No.: **SCS 108**

Glossary:

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,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., ϑ = 0 is normal to probe axis

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
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

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 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 ≤ 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.

Probe EX3DV4

SN:3833

Manufactured: November 7, 2011
Calibrated: March 11, 2013

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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3833

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)[A]	0.47	0.49	0.35	± 10.1 %
DCP (mV)[B]	101.1	101.3	101.2	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB√μV	C	D dB	VR mV	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	154.8	±3.5 %
		Y	0.0	0.0	1.0		154.2	
		Z	0.0	0.0	1.0		133.1	

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 NormX,Y,Z do not affect the E^2-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:3833

March 11, 2013

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3833

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	Depth (mm)	Unct. (k=2)
750	41.9	0.89	9.31	9.31	9.31	0.28	1.05	± 12.0 %
835	41.5	0.90	8.91	8.91	8.91	0.37	0.89	± 12.0 %
900	41.5	0.97	8.77	8.77	8.77	0.27	1.00	± 12.0 %
1750	40.1	1.37	7.47	7.47	7.47	0.48	0.72	± 12.0 %
1900	40.0	1.40	7.22	7.22	7.22	0.37	0.82	± 12.0 %
2450	39.2	1.80	6.71	6.71	6.71	0.39	0.76	± 12.0 %
5200	36.0	4.66	4.78	4.78	4.78	0.30	1.80	± 13.1 %
5300	35.9	4.76	4.55	4.55	4.55	0.30	1.80	± 13.1 %
5600	35.5	5.07	4.01	4.01	4.01	0.40	1.80	± 13.1 %
5800	35.3	5.27	3.90	3.90	3.90	0.50	1.80	± 13.1 %

[C] Frequency validity 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.
[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.

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3833

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	Depth (mm)	Unct. (k=2)
750	55.5	0.96	9.00	9.00	9.00	0.37	0.90	± 12.0 %
835	55.2	0.97	8.93	8.93	8.93	0.35	1.00	± 12.0 %
900	55.0	1.05	8.75	8.75	8.75	0.80	0.60	± 12.0 %
1750	53.4	1.49	7.21	7.21	7.21	0.75	0.63	± 12.0 %
1900	53.3	1.52	6.97	6.97	6.97	0.31	0.99	± 12.0 %
2450	52.7	1.95	6.69	6.69	6.69	0.80	0.57	± 12.0 %
5200	49.0	5.30	4.25	4.25	4.25	0.30	1.90	± 13.1 %
5300	48.9	5.42	4.06	4.06	4.06	0.30	1.90	± 13.1 %
5600	48.5	5.77	3.57	3.57	3.57	0.40	1.90	± 13.1 %
5800	48.2	6.00	3.64	3.64	3.64	0.50	1.90	± 13.1 %

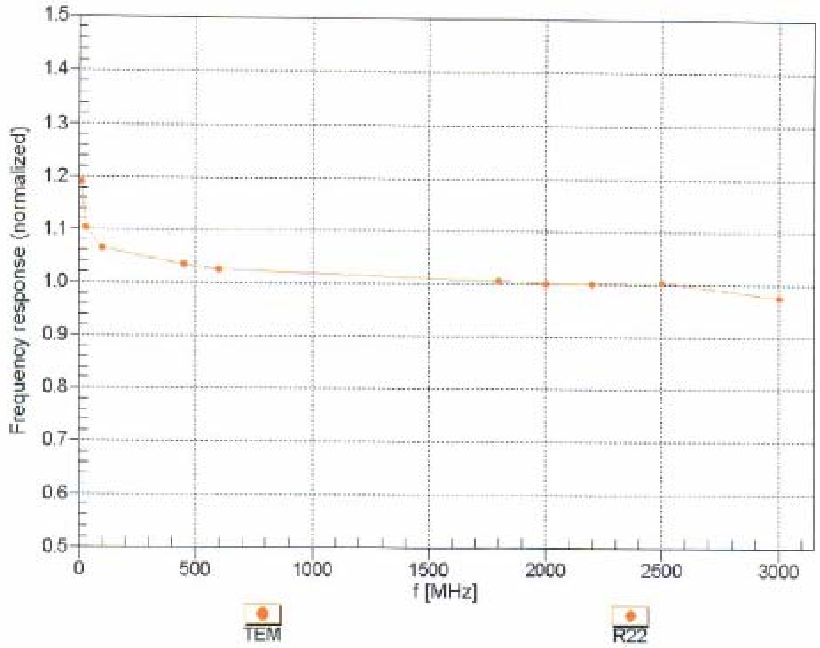
[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of 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.

EX3DV4– SN:3833

March 11, 2013

Frequency Response of E-Field

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



Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)

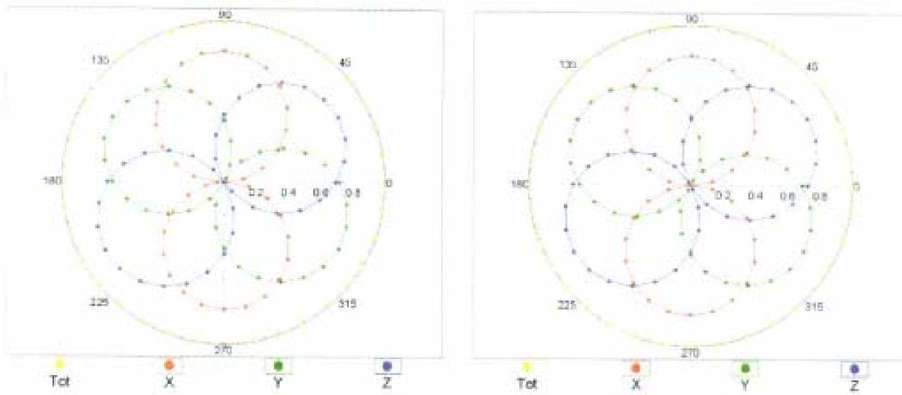
EX3DV4– SN:3833

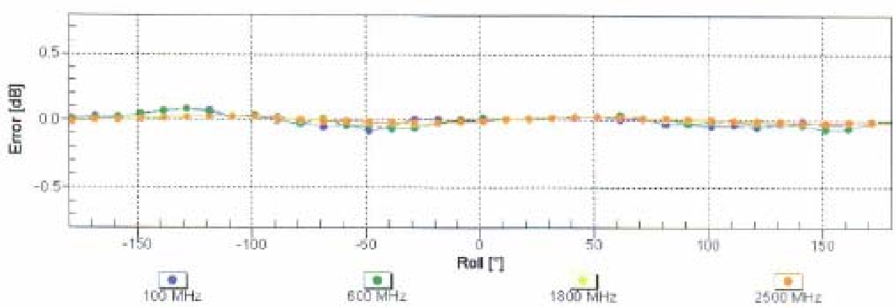
March 11, 2013

Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM

f=1800 MHz,R22

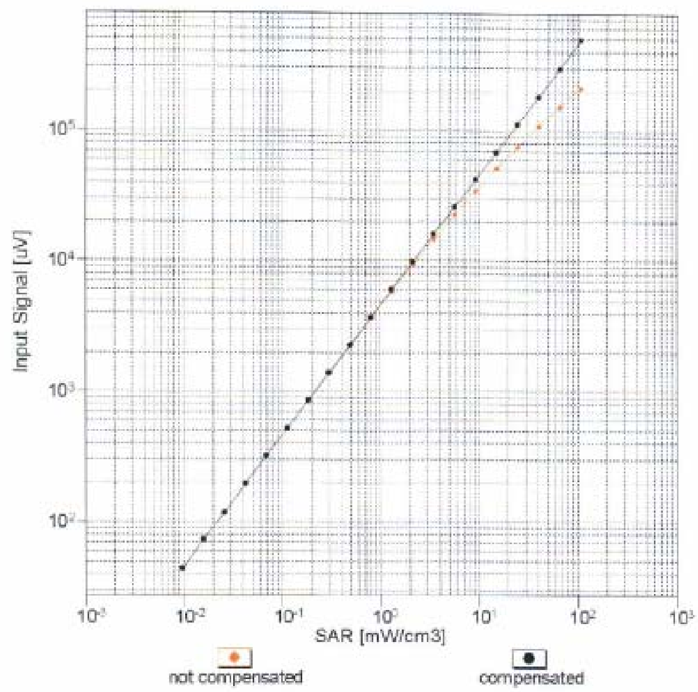


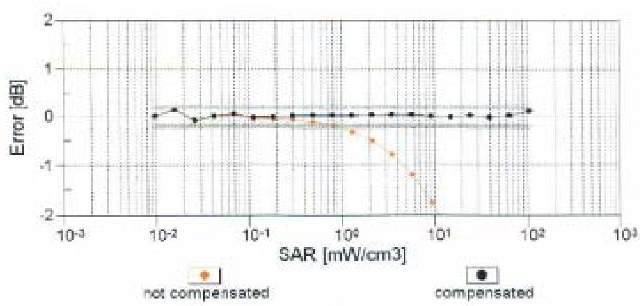


Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

EX3DV4– SN:3833 March 11, 2013

Dynamic Range f(SAR_{head})
(TEM cell , f = 900 MHz)





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

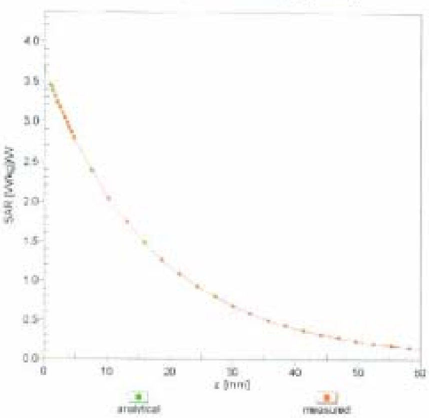
Certificate No: EX3-3833_Mar13 Page 9 of 11

EX3DV4– SN:3833

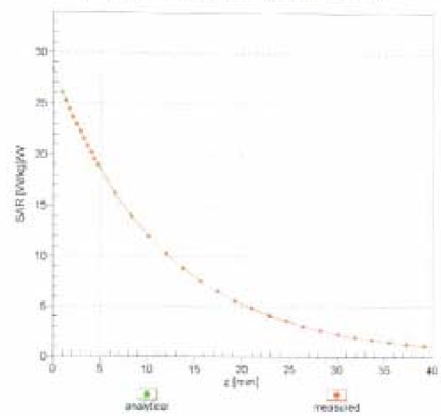
March 11, 2013

Conversion Factor Assessment

f = 900 MHz,WGLS R9 (H_convF)

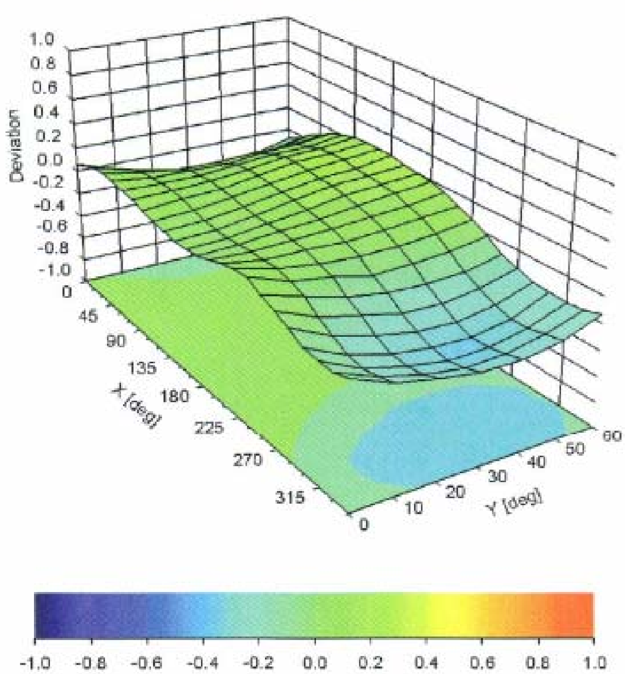


f = 1900 MHz,WGLS R22 (H_convF)



Deviation from Isotropy in Liquid

Error (φ, ϑ), f = 900 MHz



Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)

Certificate No: EX3-3833_Mar13 Page 10 of 11

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3833

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	11.5
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	2 mm

Appendix E – Dipole Calibration Data Sheets

#2654

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

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Accreditation No.: **SCS 108**

Client **NTS**

Certificate No: **D2450V2-881_Feb12**

CALIBRATION CERTIFICATE

Object: D2450V2 - SN: 881

Calibration procedure(s): QA CAL-05.v8
Calibration procedure for dipole validation kits above 700 MHz

Calibration date: February 07, 2012

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 EPM-442A	GB37480704	05-Oct-11 (No. 217-01451)	Oct-12
Power sensor HP 8481A	US37292783	05-Oct-11 (No. 217-01451)	Oct-12
Reference 20 dB Attenuator	SN: 5086 (20g)	29-Mar-11 (No. 217-01368)	Apr-12
Type-N mismatch combination	SN: 5047.2 / 06327	29-Mar-11 (No. 217-01371)	Apr-12
Reference Probe ES3DV3	SN: 3205	30-Dec-11 (No. ES3-3205_Dec11)	Dec-12
DAE4	SN: 601	04-Jul-11 (No. DAE4-601_Jul11)	Jul-12

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power sensor HP 8481A	MY41092317	18-Oct-02 (in house check Oct-11)	In house check: Oct-13
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-11)	In house check: Oct-13
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-11)	In house check: Oct-12

	Name	Function	Signature
Calibrated by:	Israe El-Naouq	Laboratory Technician	Israe El-Naouq
Approved by:	Katja Pokovic	Technical Manager	

Issued: February 7, 2012

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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Glossary:

TSL	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 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
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) Federal Communications Commission Office of Engineering & Technology (FCC OET), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields; Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", Supplement C (Edition 01-01) to Bulletin 65

Additional Documentation:

d) 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.

Measurement Conditions

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

DASY Version	DASY5	V52.8.0
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	38.9 ± 6 %	1.86 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	13.5 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	**53.1 mW /g ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.23 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	**24.7 mW /g ± 16.5 % (k=2)**

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	52.3 ± 6 %	2.02 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	12.8 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	**50.3 mW / g ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.93 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	**23.5 mW / g ± 16.5 % (k=2)**

Appendix

Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.6 Ω + 3.1 jΩ
Return Loss	- 26.7 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	50.7 Ω + 4.6 jΩ
Return Loss	- 26.7 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.154 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	August 18, 2010

DASY5 Validation Report for Head TSL

Date: 07.02.2012

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 881

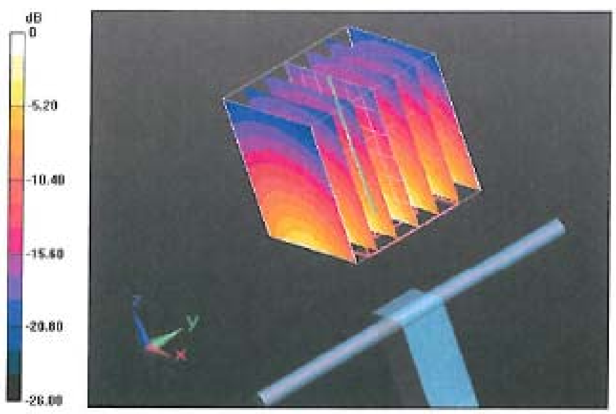
Communication System: CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 1.86 mho/m; ε_r = 38.9; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.45, 4.45, 4.45); Calibrated: 30.12.2011
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.07.2011
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.0(692); SEMCAD X 14.6.4(4989)

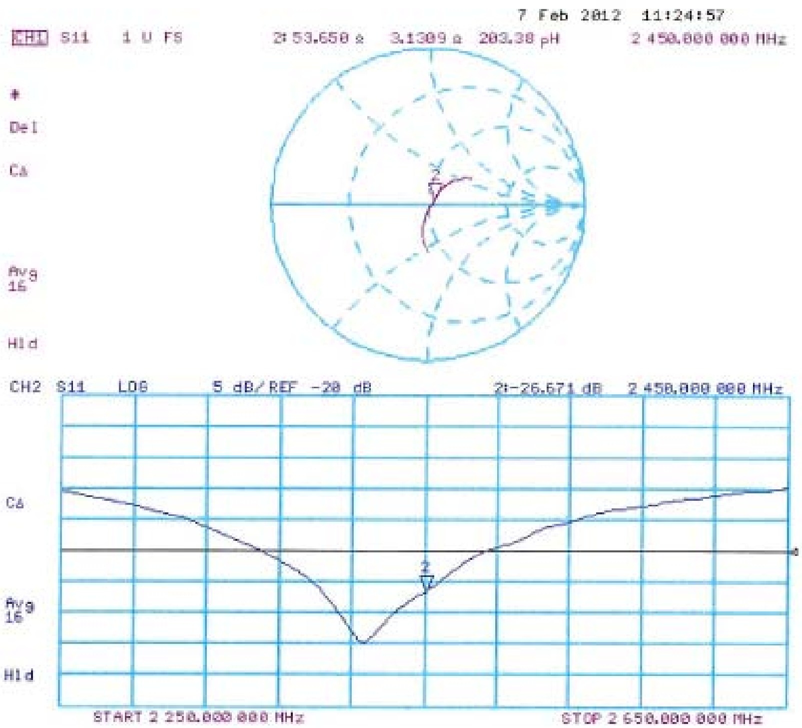
Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 100.0 V/m; Power Drift = 0.06 dB
Peak SAR (extrapolated) = 28.2110
SAR(1 g) = 13.5 mW/g; SAR(10 g) = 6.23 mW/g
Maximum value of SAR (measured) = 17.226 mW/g



0 dB = 17.230mW/g = 24.73 dB mW/g

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 07.02.2012

Test Laboratory: SPEAG, Zurich, Switzerland

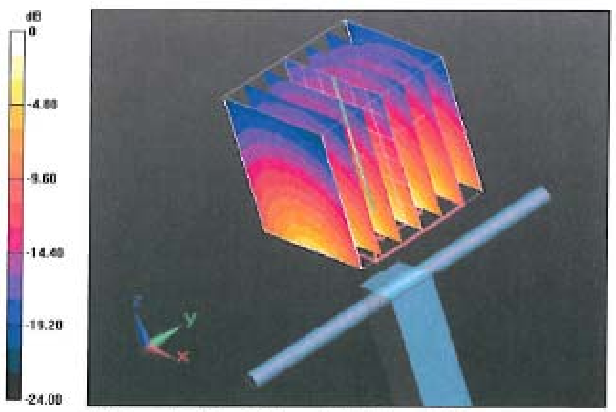
DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 881

Communication System: CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 2.02 mho/m; ε_r = 52.3; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

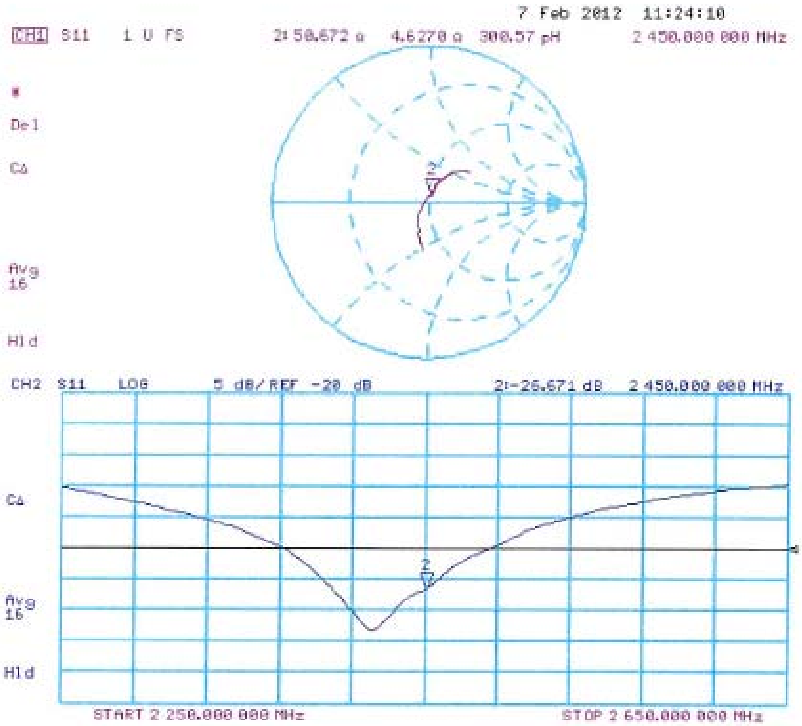
- Probe: ES3DV3 - SN3205; ConvF(4.26, 4.26, 4.26); Calibrated: 30.12.2011
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.07.2011
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.0(692); SEMCAD X 14.6.4(4989)

Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:
Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 94.726 V/m; Power Drift = 0.00039 dB
Peak SAR (extrapolated) = 26.1450
SAR(1 g) = 12.8 mW/g; SAR(10 g) = 5.93 mW/g
Maximum value of SAR (measured) = 16.781 mW/g



0 dB = 16.780mW/g = 24.50 dB mW/g

Impedance Measurement Plot for Body TSL



Calibration extension for SAR Dipoles
Usage of SAR dipoles calibrated less than 3 years ago but more than 1 year ago were confirmed in maintaining return loss and impedance requirements per extended calibrations in KDB 450824 D02 Dipole SAR Validation Verification v01r01 (4/4/2012)

Maximum allowed return loss: < 20 dB and deviates by less than 20% annually from the previous measurements
Maximum allowed impedance deviation: deviates by less than 5 Ohm from the previous measurement

Test Equipment used for Dipole verification
Hewlett Packard 8722C Network Analyzer, Asset #2627, Recent Cal Date: 31-Jan 2013

Dipole: SPEAG D2450V2 SN:881

Measurement Date	Frequency	Tissue	Return Loss (dB)	Deviation (%)	Impedance (Ω)	Deviation (Ω)	Measured by
2/7/2012*	2450 MHz	Body	-26.7	-	50.7	-	SPEAG
4/10/2013			-26.5	-4.0	52.4	-1.7	Deniz Demirci
8/16/2013			-26.6	-1.6	51.6	-0.9	Deniz Demirci

* Calibration date

End of test report