

SAR TEST REPORT

Applicant Name:

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Date of Issue: 01. 20, 2017**Test Report No.:** HCT-A-1701-F004**Test Site:** HCT CO., LTD.**FCC ID:****XHG-R900****Equipment Type:**

Mobile Router

Model Name:

MHS900L

Testing has been carried out in accordance with:47CFR §2.1093
ANSI/ IEEE C95.1 – 1992
IEEE 1528-2013**Date of Test:**

01/06/2017 ~ 01/11/2017

This device has been shown to be capable of compliance for localized specific absorption rate (SAR) for uncontrolled environment/general population exposure limits specified in FCC KDB procedures and had been tested in accordance with the measurement procedures specified in FCC KDB procedures.

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

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Version

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Table of Contents

1. Attestation of Test Result of Device Under Test.....	4
2. Device Under Test Description.....	5
3. INTRODUCTION	9
4. DESCRIPTION OF TEST EQUIPMENT	10
5. SAR MEASUREMENT PROCEDURE.....	12
6. DESCRIPTION OF TEST POSITION.....	14
7. ANSI/ IEEE C95.1 - 1992 RF EXPOSURE LIMITS	16
8. FCC SAR GENERAL MEASUREMENT PROCEDURES	17
9. Output Power Specifications.....	20
10. SYSTEM VERIFICATION.....	24
11. SAR TEST DATA SUMMARY	25
12. Simultaneous SAR Analysis.....	29
13. SAR Measurement Variability and Uncertainty	30
14. MEASUREMENT UNCERTAINTY	31
15. SAR TEST EQUIPMENT	31
16. CONCLUSION.....	33
17. REFERENCES	34
Attachment 1. – SAR Test Plots	36
Attachment 2. – Dipole Verification Plots.....	37
Attachment 3. – Probe Calibration Data.....	46
Attachment 4. – Dipole Calibration Data	58
Attachment 5. – SAR Tissue Characterization.....	84
Attachment 6. – SAR SYSTEM VALIDATION.....	85

1. Attestation of Test Result of Device Under Test

Test Laboratory	
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Attestation of SAR test result			
Applicant Name:	Franklin Technology Inc.		
FCC ID:	XHG-R900		
Model:	MHS900L		
EUT Type:	Mobile Router		
Application Type:	Certification		
The Highest Reported SAR			
Band	Tx. Frequency (MHz)	Equipment Class	Reported 1g SAR (W/kg)
			Hotspot SAR
LTE 4	1 712.5 - 1 752.5	PCB	1.21
LTE 13	779.5 - 784.5	PCB	1.24
802.11b	2 412 - 2 462	DTS	0.18
Simultaneous SAR per KDB 690783 D01v01r03			1.40
Date(s) of Tests:	01/06/2017 ~ 01/11/2017		

2. Device Under Test Description

2.1 DUT specification

Device Wireless specification overview		
Band & Mode	Operating Mode	Tx Frequency
LTE Band 13	Data	779.5 – 784.5 MHz
LTE Band 4	Data	1 712.5 – 1 752.5 MHz
2.4 GHz WLAN	Data	2 412 – 2 462 MHz
Device Description		
Device Dimension	Overall (Length x Width) : 59.4 mm x 87.9 mm	
Battery Options	Standard (Li-ION Battery)	
	Battery Model Name: V604454AR	

2.2 LTE information

Item.		Description		
Frequency Range	LTE Band 13	779.5 MHz – 784.5 MHz		
	LTE Band 4	1 712.5 MHz – 1 752.5 MHz		
Channel Bandwidths	LTE Band 13	5 MHz, 10 MHz		
	LTE Band 4	5 MHz, 10 MHz, 15 MHz, 20 MHz		
Channel Numbers & Freq.(MHz)		Low	Mid	High
LTE Band 13	5 MHz	779.5(23205)	782(23230)	784.5(23255)
	10 MHz		782(23230)	
LTE Band 4	5 MHz	1 712.5 (19975)	1 732.5 (20175)	1 752.5 (20375)
	10 MHz	1 715 (20000)	1 732.5 (20175)	1 750 (20350)
	15 MHz	1 717.5 (20025)	1 732.5 (20175)	1 747.5 (20325)
	20 MHz	1 720 (20050)	1 732.5 (20175)	1 745 (20300)
UE Category	LTE Rel. 10, Category 4			
Modulations Supported in UL	QPSK, 16QAM			
LTE voice/data requirements	Data Only			
LTE MPR options	The EUT incorporates MPR as per 3GPP TS 36.101 sec. 6.2.3 ~ 6.2.5			
	The MPR is permanently built-in by design as a mandatory.			
	A-MPR is not implemented in the DUT.			
Power reduction explanation	This device doesn't implement power reduction.			
LTE Carrier Aggregation Additional Information	This device does not support LTE CA features on 3GPP Release 10. The following LTE Release 10 features are not supported. Relay, HetNet, Enhanced MIMO, eICL, WiFi offloading, MDH, eMBMA, Cross-Carrier Scheduling, Enhanced SC-FDMA.			
LTE Carrier Aggregation	This EUT does not support LTE CA.			

2.3 TEST METHODOLOGY and Procedures

The tests documented in this report were performed in accordance with IEEE Standard 1528-2013 & IEEE 1528-2005 and the following published KDB procedures.

- FCC KDB Publication 941225 D05 SAR for LTE Devices v02r05
- FCC KDB Publication 941225 D05A LTE Rel.10 KDB Inquiry sheet v01r02
- FCC KDB Publication 447498 D01 General SAR Guidance v06
- FCC KDB Publication 865664 D01 SAR measurement 100 MHz to 6 GHz v01r04
- FCC KDB Publication 248227 D01 802.11 Wi-Fi SAR v02r02
- FCC KDB Publication 865664 D02 SAR Reporting v01r02

2.4 Nominal and Maximum Output Power Specifications

This device operates using the following maximum output power specifications. SAR values were scaled to the maximum allowed power to determine compliance per KDB publication 447498 D01v06.

Mode / Band	Modulated Average (dBm)	
LTE Band 4	Maximum	23.0
	Nominal	22.5
LTE Band 13	Maximum	23.0
	Nominal	22.5
IEEE 802.11b (2.4 GHz)	Maximum	13.0
	Nominal	12.0
IEEE 802.11g (2.4 GHz)	Maximum	13.0
	Nominal	12.0
IEEE 802.11n (2.4 GHz)	Maximum	13.0
	Nominal	12.0

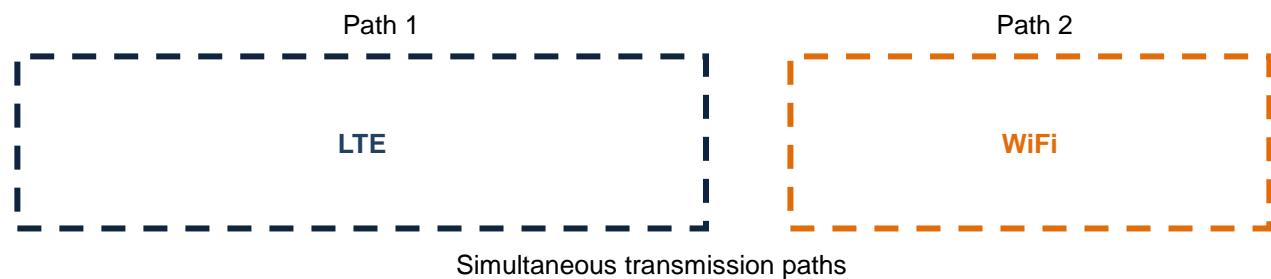
2.5 DUT Antenna Locations

Device Edges / Sides for SAR Testing						
Mode	Rear	Front	Left	Right	Bottom	Top
LTE Band 4	Yes	Yes	No	Yes	Yes	Yes
LTE Band 13	Yes	Yes	No	Yes	Yes	Yes
2.4 GHz WLAN	Yes	Yes	Yes	No	Yes	Yes

Note: All test configurations are based on front view.

2.6 SAR Summation Scenario

According to FCC KDB 447498 D01v06, transmitters are considered to be transmitting simultaneously when there is overlapping transmission, with the exception of transmissions during network hand-offs with maximum hand-off duration less than 30 seconds. Possible transmission paths for the EUT are shown below paths and are mode in same rectangle to indicate communication modes which share the same path. Modes which share the same transmission path cannot transmit simultaneously with one another.



This device contains multiple transmitters that may operate simultaneously, and therefore requires a simultaneous transmission analysis according to FCC KDB 447498 D01v06.

Simultaneous Transmission Scenarios	
Applicable Combination	Hotspot
LTE+ 2.4 GHz WiFi	Yes

1. All licensed modes share the same antenna path and cannot transmit simultaneously.
2. The highest reported SAR for each exposure condition is used for SAR summation purpose.

2.7 SAR Test Exclusions Applied

Licensed Transmitter(s)

LTE SAR for the higher modulations and lower bandwidths were not tested since the maximum average output power of all required channels and configurations was not more than 0.5 dB higher than the highest bandwidth; and the reported LTE SAR for the highest bandwidth was less than 1.45 W/kg for all configurations according to FCC KDB 941225 D05v02r05.

3. INTRODUCTION

The FCC has adopted the guidelines for evaluating the environmental effects of radio frequency radiation in ET Docket 93-62 on Aug. 6, 1996 to protect the public and workers from the potential hazards of RF emissions due to FCC-regulated portable devices.

The safety limits used for the environmental evaluation measurements are based on the criteria published by the American National Standards Institute (ANSI) for localized specific absorption rate (SAR) in IEEE/ANSI C95.1-1992 Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz. 1992 by the Institute of Electrical and Electronics Engineers, Inc., , New York 10017. The measurement procedure described in IEEE/ANSI C95.3-1992 Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave is used for guidance in measuring SAR due to the RF radiation exposure from the Equipment Under Test (EUT). These criteria for SAR evaluation are similar to those recommended by the National Council on Radiation Protection and Measurements (NCRP) in Biological Effects and Exposure Criteria for Radio frequency Electromagnetic Fields," NCRP Report No. 86 NCRP, 1986, Bethesda, MD 20814. SAR is a measure of the rate of energy absorption due to exposure to an RF transmitting source. SAR values have been related to threshold levels for potential biological hazards.

SAR Definition

Specific Absorption Rate (SAR) is defined as the time derivative of the incremental electromagnetic 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.

$$SAR = \frac{d}{d t} \left(\frac{d U}{d m} \right)$$

Figure 1. SAR Mathematical Equation

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

$$SAR = \sigma E^2 / \rho$$

Where:

σ = conductivity of the tissue-simulant material (S/m)
 ρ = mass density of the tissue-simulant material (kg/m³)
 E = Total 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.

4. DESCRIPTION OF TEST EQUIPMENT

4.1 SAR MEASUREMENT SETUP

These measurements are performed using the DASY4 & DASY5 automated dosimetric assessment system. It is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland. It consists of high precision robotics system (Staubli), robot controller, Pentium III computer, near-field probe, probe alignment sensor, and the generic twin phantom containing the brain 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 Figure.2).

A cell controller system contains the power supply, robot controller, teach pendant (Joystick), and remote control, is used to drive the robot motors. The PC with Windows XP or Windows 7 is working with SAR Measurement system DASY4 & DASY5, 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 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.

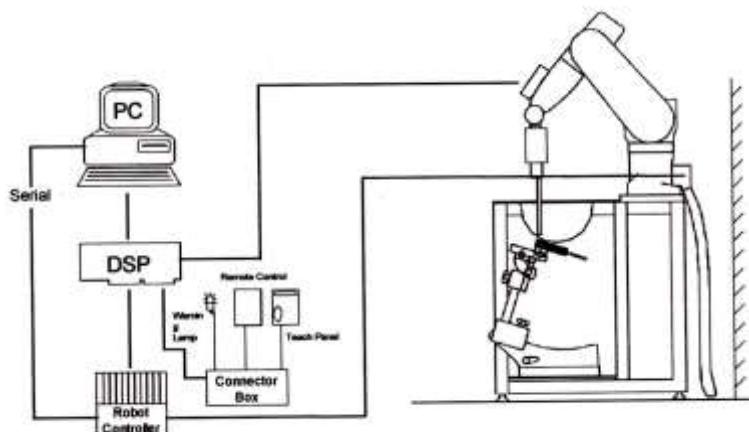


Figure 2. HCT SAR Lab. Test Measurement Set-up

The DAE 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.

4.2 Phantom

SAR PHANTOMS		
M F P	Name	MFP – Triple Modular Phantom
	Appearance	
	Material	Vinyl ester, Fiberglass reinforced (VE-GF)
	Liquid Compatibility	Compatible with all DGBE Type liquid
	Shell Thickness	2±0.2 mm
	Dimensions	Length : 292 mm Width : 178 mm Height : 178 mm Useable area : 280 x 175 mm
	Filling Volume	Approx. 8.1 liters (filling height 155 mm)

4.3 Device Holder for Transmitters

Device Holder – Mounting Device	
<p>In combination with the SAM Phantom, the Mounting Device enables the rotation of the mounted transmitter in spherical coordinates whereby the rotation points is the ear opening. The devices can be easily, accurately, and repeatable positioned according to the EN 50360:2001/A:2001 and FCC KDB specifications. The device holder can be locked at different phantom locations (left head, right head, flat phantom).</p> <p>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.</p>	

5. SAR MEASUREMENT PROCEDURE

The evaluation was performed with the following procedure:

1. The SAR distribution at the exposed side of the head or body was measured at a distance no more than 5.0 mm from the inner surface of the shell. The area covered the entire dimension of the DUT's head and body area and the horizontal grid resolution was depending on the FCC KDB 865664 D01v01r04 table 4-1 & IEEE 1528-2013.
2. Based on step, the area of the maximum absorption was determined by sophisticated interpolations routines implemented in DASY software. When an Area Scan has measured all reachable point. DASY system computes the field maximal found in the scanned are, within a range of the maximum. SAR at this fixed point was measured and used as a reference value.
3. Around this point, a volume was assessed according to the measurement resolution and volume size requirements of FCC KDB 865664 D01v01r04 table 4-1 and IEEE 1528-2013. On the basis of this data set, the spatial peak SAR value was evaluated with the following procedure (reference from the DASY manual.)
 - a. The data at the surface were extrapolated, since the center of the dipoles is no more than 2.7 mm away from the tip of the probe (it is different from the probe type) and the distance between the surface and the lowest measuring point is 1.2 mm. 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 (1 g or 10 g) were computed using the 3D-Spline interpolation algorithm. The 3D-spline is composed of three one-dimensional splines 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 10 x 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 2, was re-measured after the zoom scan. If the value changed by more than 5 %, the SAR evaluation and drift measurements were repeated.

Area scan and zoom scan resolution setting follow KDB 865664 D01v01r04 quoted below.

		≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface		5 ± 1 mm	$\frac{1}{2}\delta \cdot \ln(2) \pm 0.5$ mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location		$30^\circ \pm 1^\circ$	$20^\circ \pm 1^\circ$
		≤ 2 GHz: ≤ 15 mm 2-3 GHz: ≤ 12 mm	3-4 GHz: ≤ 12 mm 4-6 GHz: ≤ 10 mm
Maximum area scan Spatial resolution: $\Delta x_{\text{Area}}, \Delta y_{\text{Area}}$		When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be \leq the corresponding x or y dimension of the test device with at least one measurement point on the test device.	
Maximum zoom scan Spatial resolution: $\Delta x_{\text{zoom}}, \Delta y_{\text{zoom}}$		≤ 2 GHz: ≤ 8 mm 2-3 GHz: ≤ 5 mm*	3-4 GHz: ≤ 5 mm* 4-6 GHz: ≤ 4 mm*
Maximum zoom scan Spatial resolution normal to phantom surface	uniform grid: $\Delta z_{\text{zoom}}(n)$	≤ 5 mm	3-4 GHz: ≤ 4 mm 4-5 GHz: ≤ 3 mm 5-6 GHz: ≤ 2 mm
	graded grid	$\Delta z_{\text{zoom}}(1)$, between 1 st two Points closest to phantom surface	≤ 4 mm
		$\Delta z_{\text{zoom}}(n>1)$: between subsequent Points	$\leq 1.5 \cdot \Delta z_{\text{zoom}}(n-1)$
Minimum zoom scan volume	x, y, z	≥ 30 mm	3-4 GHz: ≥ 28 mm 4-5 GHz: ≥ 25 mm 5-6 GHz: ≥ 22 mm

Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details.

* When zoom scan is required and the reported SAR from the area scan based 1-g SAR estimation procedures of KDB 447498 is ≤ 1.4 W/kg, ≤ 8 mm, ≤ 7 mm and ≤ 5 mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.

6. DESCRIPTION OF TEST POSITION

6.1 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. A device with a headset output is tested with a headset connected to the device. Body dielectric parameters are used.

Accessories for Body-worn operation configurations are divided into two categories: those that do not contain metallic components and those that 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 tested with each accessory. If multiple accessory 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 with a separation distance between the back of the device and the flat phantom is used.

Since this EUT does not supply any body worn accessory to the end user a distance of 0.5 cm from the EUT back surface to the liquid interface is configured for the generic test.

"See the Test SET-UP Photo"

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

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

6.2 Body-Worn Accessory Configurations

Body-Worn operating configurations are tested with the belt-dips and holsters attached to the device and positioned against a flat phantom in a normal use configuration (see Figure 6-4). Per FCC KDB Publication 648474 D04v01r03 Body-Worn accessory exposure is typically related to voice mode operations when handsets are carried in body-Worn accessories. The body-Worn accessory procedures in FCC KDB Publication 447498 D01v06 should be used to test for body-Worn accessory SAR compliance, without a headset connected to it. This enables the test results for such configuration to be compatible with that required for hotspot mode when the body-Worn accessory test separation distance is greater than or equal to that required for hotspot mode, when applicable. When the reported SAR for a body- Worn accessory, measured without a headset connected to the handset, is > 1.2 W/kg, the highest reported SAR configuration for that wireless mode and frequency band should be repeated for that body- Worn accessory with a headset attached to the handset.



Figure 6-4
Sample Body-Worn Diagram

Accessories for Body-Worn operation configurations are divided into two categories: those that do not contain metallic components and those that do contain metallic components. When multiple accessories that do not contain metallic components are supplied with the device, the device is tested with only the accessory that dictates the closest spacing to the body. Then multiple accessories that contain metallic components are

tested with the device with each accessory. If multiple accessories share an identical metallic component (i.e. the same metallic belt-dip 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 with a separation distance between the back of the device and the flat phantom is used. Test position spacing was 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 in head fluid. 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.

7. ANSI/ IEEE C95.1 - 1992 RF EXPOSURE LIMITS

HUMAN EXPOSURE	UNCONTROLLED ENVIRONMENT General Population	CONTROLLED ENVIRONMENT Occupational
	(W/kg) or (mW/g)	(W/kg) or (mW/g)
SPATIAL PEAK SAR * (Brain)	1.60	8.00
SPATIAL AVERAGE SAR ** (Whole Body)	0.08	0.40
SPATIAL PEAK SAR *** (Hands / Feet / Ankle / Wrist)	4.00	20.00

Table 8.1 Safety Limits for Partial Body Exposure

NOTES:

- * The Spatial Peak value of the SAR averaged over any 1 g 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 Peak value of the SAR averaged over any 10 g of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

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 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.

8. FCC SAR GENERAL MEASUREMENT PROCEDURES

8.1 SAR Measurement Conditions for LTE

LTE modes are tested according to FCC KDB 941225 D05v02r05 publication. Establishing connections with base station simulators ensure a consistent means for testing SAR and are recommended for evaluation SAR [4]. The R&S CMW500 or Anritsu MT8820C simulators are used for LTE output power measurements and SAR testing. Closed loop power control was used so the UE transmits with maximum output power during SAR testing. SAR tests were performed with the same number of RB and RB offsets transmitting on all TTI frames (maximum TTI).

8.1.1 Spectrum Plots for RB Configurations

A properly configured base station simulator was used for SAR tests and power measurements. Therefore, spectrum plots for RB configurations were not required to be included in this report.

8.1.2 MPR

MPR is permanently implemented for this device by the manufacturer. The specific manufacturer target MPR is indicated alongside the SAR results. MPR is enabled for this device, according to 3GPP TS36.101 Section 6.2.3 – 6.2.5 under Table 6.2.3-1.

8.1.3 A-MPR

A-MPR(Additional MPR) has been disabled for all SAR tests by setting NS=01 on the base station simulator.

8.1.4 Required RB Size and RB offsets for SAR testing

According to FCC KDB 941225 D05v02r05

- a. Per sec 4.2.1, SAR is required for QPSK 1 RB Allocation for the largest bandwidth
 - i. The required channel and offset combination with the highest maximum output power is required for SAR.
 - ii. When the reported SAR is ≤ 0.8 W/Kg, testing of the remaining RB offset configurations and required test channels is not required. Otherwise, SAR is required for the remaining required test channels using the RB offset configuration with highest output power for that channel.
 - iii. When the reported SAR for a required test channel is > 1.45 W/kg, SAR is required for all RB offset configurations for that channel.
- b. Per Sec 4.2.2, SAR is required for 50% RB allocation using the largest bandwidth following the same procedures outlined in Sec 4.2.1.
- c. Per Sec. 4.2.3, QPSK SAR is not required for the 100% allocation when the highest maximum output power for the 100% allocation is less than the highest maximum output power of the 1 RB and 50% RB allocations and the reported SAR for the 1 RB and 50% RB allocations is < 0.8 W/kg.
- d. Per Sec. 4.2.4 and 4.3, SAR test for higher order modulations and lower bandwidths configurations are not required when the conducted power of the required test configurations determined by Sec. 4.2.1 through 4.2.3 is less than or equal to 1/2 dB higher than the equivalent configuration using QPSK modulation and when the QPSK SAR for those configurations is < 1.45 W/Kg.

8.2 SAR Testing with 802.11 Transmitters

The normal network operating configurations of 802.11 transmitters are not suitable for SAR measurements. Unpredictable fluctuations in network traffic and antenna diversity conditions can introduce undesirable variations in SAR results. The SAR for these devices should be measured using chipset based test mode software to ensure the results are consistent and reliable. See KDB Publication 248227 D01v02r02 for more details.

8.2.1 General Device Setup

Chipset based test mode software is hardware dependent and generally varies among manufacturers. The device operating parameters established in test mode for SAR measurements must be identical to those programmed in production units, including output power levels, amplifier gain settings and other RF performance tuning parameters.

A periodic duty factor is required for current generation SAR system to measure SAR. When 802.11 frame gaps are accounted for in the transmission, a maximum transmission duty factor of 92-96% is typically achievable in most test mode configurations. A minimum transmission duty factor of 85% is required to avoid certain hardware and device implementation issues related to wide range SAR scaling. The reported SAR is scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit.

8.2.3 Initial Test Position Procedure

For exposure conditions with multiple test positions, such as handset operating next to the ear, devices with hotspot mode or UMPC mini-tablet, procedures for initial test position can be applied. Using the transmission mode determined by the DSSS procedure or initial test configuration, area scans are measured for all positions in an exposure condition. The test position with the highest extrapolated (peak) SAR is used as the initial test position. When reported SAR for the initial test position is ≤ 0.4 W/kg for 1g SAR and ≤ 1.0 W/kg for 10g SAR, no additional testing for the remaining test position is required. Otherwise, SAR is evaluated at the subsequent highest peak SAR positions until the reported SAR result is ≤ 0.8 W/kg for 1g SAR and ≤ 2.0 W/kg for 10g SAR or all test positions are measured.

8.2.4 2.4 GHz SAR test Requirements

SAR is measured for 2.4 GHz 802.11b DSSS using either the fixed test position or, when applicable, the initial test position procedure. SAR test reduction is determined according to the following:

- 1) When the reported SAR of the highest measured maximum output power channel for the exposure configuration is ≤ 0.8 W/kg, no further SAR testing is required for 802.11b DSSS in that exposure configuration.
- 2) When the reported SAR is > 0.8 W/kg, SAR is required for that position using the next highest measured output power channel. When any reported SAR is > 1.2 W/kg, SAR is required for the third channel; i.e., all channels require testing.

2.4 GHz 802.11 g/n OFDM are additionally evaluated for SAR if the highest reported SAR for 802.11b, adjusted by the ratio of the OFDM to DSSS specified maximum output power, is > 1.2 W/kg. When SAR is required for OFDM modes in 2.4 GHz band, the Initial Test Configuration Procedures should be followed.

8.2.5 OFDM Transmission Mode and SAR Test channel Selection

For the 2.4 GHz, when the same maximum output power was specified for multiple OFDM transmission mode configurations in a frequency band or aggregated band, SAR is measured using the configuration with the largest channel bandwidth, lowest order modulation and lowest data rate and lowest order 802.11 g/n mode. When the maximum output power of a channel is the same for equivalent OFDM configurations; for example, 802.11g and 802.11n with the same channel bandwidth, modulation and data rate etc., the lower order 802.11 mode i.e., 802.11g then 802.11n, is used for SAR measurement. When the maximum output power are the same for multiple test channels, either according to the default or additional power measurement requirements, SAR is measured using the channel closest to the middle of the frequency band or aggregated band. When there are multiple channels with the same maximum output power, SAR is measured using the higher number channel.

8.2.6 Initial Test configuration Procedure

For OFDM, in both 2.4 GHz, an initial test configuration is determined for each frequency band and aggregated band, according to the transmission mode with the highest maximum output power specified for SAR measurements. When the same maximum output power is specified for multiple OFDM transmission mode configurations in a frequency band or aggregated band, SAR is measured using the configuration(s) with the largest channel bandwidth, lowest order modulation, and lowest data rate. If the average RF output powers of the highest identical transmission modes are within 0.25 dB of each other, mid channel of the transmission mode with highest average RF output power is the initial test channel. Otherwise, the channel of the transmission mode with the highest average RF output conducted power will be the initial test configuration.

When the reported SAR is ≤ 0.8 W/kg, no additional measurements on other test channels are required. Otherwise, SAR is evaluated using the subsequent highest average RF output channel until the reported SAR result is 1.2 W/kg or all channels are measured. When there are multiple untested channels having the same subsequent highest average RF output power, the channel with higher frequency from the lowest 802.11 mode is considered for SAR measurements.

8.2.7 Subsequent Test Configuration Procedures

For OFDM configurations in each frequency band and aggregated band, SAR is evaluated for initial test configuration using the fixed test position or the initial test position on procedure. When the highest reported SAR (for the initial test configuration), adjusted by the ratio of the specified maximum output power of the subsequent test configuration to initial test configuration, is ≤ 1.2 W/kg for 1g SAR and ≤ 3.0 W/kg for 10g SAR, no additional SAR tests for the subsequent test configurations are required.

9. Output Power Specifications

This device operates using the following maximum output power specifications. SAR values were scaled to the maximum allowed power to determine compliance per KDB publication 447498 D01v06.

9.1 LTE

- LTE Band 4

Bandwidth	Modulation	RB Size	RB Offset	Max.Average Power (dBm)			MPR Allowed Per 3GPP [dB]	MPR [dB]
				19975	20175	20375		
				1712.5 MHz	1732.5 MHz	1752.5 MHz		
5 MHz	QPSK	1	0	21.65	22.15	21.93	0	0
		1	12	21.84	22.21	22.28	0	0
		1	24	21.52	22.11	21.92	0	0
		12	0	20.84	21.30	21.07	0-1	1
		12	6	20.90	21.30	21.17	0-1	1
		12	11	20.80	21.28	21.12	0-1	1
		25	0	20.84	21.31	21.10	0-1	1
	16QAM	1	0	20.91	21.42	21.13	0-1	1
		1	12	21.16	21.48	21.49	0-1	1
		1	24	20.87	21.35	21.15	0-1	1
		12	0	19.98	20.41	20.16	0-2	2
		12	6	19.99	20.38	20.27	0-2	2
		12	11	19.95	20.38	20.22	0-2	2
		25	0	19.92	20.31	20.15	0-2	2

Bandwidth	Modulation	RB Size	RB Offset	Max.Average Power (dBm)			MPR Allowed Per 3GPP [dB]	MPR [dB]
				20000	20175	20350		
				1715 MHz	1732.5 MHz	1750 MHz		
10 MHz	QPSK	1	0	21.79	22.20	21.97	0	0
		1	24	22.41	22.71	22.61	0	0
		1	49	21.88	21.95	21.91	0	0
		25	0	21.09	21.57	21.38	0-1	1
		25	12	21.31	21.71	21.55	0-1	1
		25	24	21.21	21.51	21.35	0-1	1
		50	0	21.16	21.46	21.31	0-1	1
	16QAM	1	0	21.05	21.38	20.88	0-1	1
		1	24	21.60	21.91	21.50	0-1	1
		1	49	21.08	21.11	20.82	0-1	1
		25	0	20.09	20.68	20.40	0-2	2
		25	12	20.34	20.77	20.61	0-2	2
		25	24	20.27	20.61	20.41	0-2	2
		50	0	20.13	20.50	20.34	0-2	2

Bandwidth	Modulation	RB Size	RB Offset	Max.Average Power (dBm)			MPR Allowed Per 3GPP [dB]	MPR [dB]
				20025	20175	20325		
				1717.5 MHz	1732.5 MHz	1747.5 MHz		
15 MHz	QPSK	1	0	22.27	22.82	22.67	0	0
		1	36	22.57	22.88	22.63	0	0
		1	74	22.76	22.51	22.36	0	0
		36	0	21.25	21.84	21.56	0-1	1
		36	18	21.55	21.97	21.63	0-1	1
		36	38	21.55	21.75	21.43	0-1	1
		75	0	21.41	21.76	21.50	0-1	1
	16QAM	1	0	21.65	21.99	21.83	0-1	1
		1	36	21.96	22.00	21.83	0-1	1
		1	74	21.70	21.86	21.50	0-1	1
		36	0	20.19	20.75	20.48	0-2	2
		36	18	20.42	20.91	20.53	0-2	2
		36	38	20.46	20.67	20.33	0-2	2
		75	0	20.32	20.69	20.42	0-2	2

Bandwidth	Modulation	RB Size	RB Offset	Max.Average Power (dBm)			MPR Allowed Per 3GPP [dB]	MPR [dB]		
				20175						
				1732.5 MHz						
20 MHz	QPSK	1	0	22.93			0	0		
		1	49	22.43			0	0		
		1	99	22.67			0	0		
		50	0	21.84			0-1	1		
		50	25	21.69			0-1	1		
		50	49	21.70			0-1	1		
		100	0	21.71			0-1	1		
	16QAM	1	0	21.89			0-1	1		
		1	49	21.80			0-1	1		
		1	99	21.73			0-1	1		
		50	0	20.75			0-2	2		
		50	25	20.61			0-2	2		
		50	49	20.61			0-2	2		
		100	0	20.64			0-2	2		

Note: LTE Band 4 (AWS) at 20 MHz Bandwidth does not support three non-overlapping channels. Per KDB 941225 D05v02r05, when a device supports overlapping channel assignment in a channel bandwidth configuration, the mid channel of the group of overlapping channels should be selected for testing.

- LTE Band 13

Bandwidth	Modulation	RB Size	RB Offset	Max. Average Power (dBm)	MPR Allowed Per 3GPP	MPR
				23230	[dB]	[dB]
				782 MHz		
5 MHz	QPSK	1	0	22.35	0	0
		1	12	21.98	0	0
		1	24	22.36	0	0
		12	0	21.31	0-1	1
		12	6	21.18	0-1	1
		12	11	21.23	0-1	1
		25	0	21.39	0-1	1
	16QAM	1	0	21.73	0-1	1
		1	12	21.41	0-1	1
		1	24	21.76	0-1	1
		12	0	20.29	0-2	2
		12	6	20.18	0-2	2
		12	11	20.23	0-2	2
		25	0	20.41	0-2	2

Bandwidth	Modulation	RB Size	RB Offset	Max. Average Power (dBm)	MPR Allowed Per 3GPP	MPR [dB]
				23230	[dB]	[dB]
				782 MHz		
10 MHz	QPSK	1	0	22.78	0	0
		1	24	22.18	0	0
		1	49	22.24	0	0
		25	0	21.69	0-1	1
		25	12	21.58	0-1	1
		25	24	21.81	0-1	1
		50	0	21.84	0-1	1
	16QAM	1	0	21.98	0-1	1
		1	24	21.47	0-1	1
		1	49	21.55	0-1	1
		25	0	20.79	0-2	2
		25	12	20.70	0-2	2
		25	24	20.92	0-2	2
		50	0	20.98	0-2	2

Note: LTE Band 13 at 5MHz/10MHz Bandwidth does not support three non-overlapping channels. Per KDB 941225 D05v02r05, when a device supports overlapping channel assignment in a channel bandwidth configuration, the mid channel of the group of overlapping channels should be selected for testing.

The EUT enables maximum power reduction in accordance with 3GPP 36.101. The MPR settings are configured during the manufacture process and are not configurable by the network, carrier, or end user.

9.2 WiFi

IEEE 802.11 Average RF Power

Mode	Freq.	Channel	IEEE 802.11 (2.4 GHz) Conducted Power
	[MHz]		[dBm]
802.11b	2412	1	12.13
	2437	6	11.67
	2462	11	11.97
802.11g	2412	1	11.81
	2437	6	11.95
	2462	11	12.75
802.11n	2412	1	11.80
	2437	6	11.80
	2462	11	11.58

Justification for test configurations for WLAN per KDB Publication 248227 D01v02r02:

- Power measurements were performed for the transmission mode configuration with the highest maximum output power specified for production units.
- For transmission mode with the same maximum output power specification, powers were measured for the largest channel bandwidth, lowest order modulation and lowest data rate.
- For transmission modes with identical maximum specified output power, channel bandwidth, modulation and data rates, power measurements were required for all identical configurations.
- For each transmission mode configuration, powers were measured for the highest and lowest channels; and at the mid-band channel(s) when there were at least 3 channels supported. For configurations with multiple mid-band channels, due to an even number of channels, both channels were measured.

Test Configuration



10. SYSTEM VERIFICATION

10.1 Tissue Verification

The Head /body simulating material is calibrated by HCT using the DAKS 3.5 to determine the conductivity and permittivity.

Table for Body Tissue Verification									
Date of Tests	Tissue Temp. (°C)	Tissue Type	Freq. (MHz)	Measured Conductivity σ (S/m)	Measured Dielectric Constant, ϵ	Target Conductivity σ (S/m)	Target Dielectric Constant, ϵ	% dev σ	% dev ϵ
01/10/2017	20.9	750B	740	0.952	55.492	0.963	55.570	-1.14%	-0.14%
			750	0.961	55.388	0.963	55.530	-0.21%	-0.26%
			770	0.980	55.172	0.965	55.453	1.55%	-0.51%
			785	0.995	55.051	0.966	55.395	3.00%	-0.62%
01/06/2017	22.4	1800B	1710	1.448	53.500	1.463	53.537	-1.03%	-0.07%
			1750	1.475	53.461	1.488	53.432	-0.87%	0.05%
			1800	1.525	53.238	1.520	53.300	0.33%	-0.12%
01/11/2017	20.4	2450B	2400	1.895	52.403	1.902	52.770	-0.37%	-0.70%
			2450	1.962	52.138	1.950	52.700	0.62%	-1.07%
			2500	2.030	51.927	2.021	52.640	0.45%	-1.35%

10.2 System Verification

Prior to assessment, the system is verified to the $\pm 10\%$ of the specifications at 750 MHz, 1 800 MHz, 2 450 MHz by using the system Verification kit. (Graphic Plots Attached)

System Verification Results

Freq. [MHz]	Date	Probe (S/N)	Dipole (S/N)	Liquid	Amb. Temp. [°C]	Liquid Temp. [°C]	1 W Target SAR _{1g} (SPEAG)	Measured SAR _{1g} [W/kg]	1 W Normalized SAR _{1g} [W/kg]	Deviation [%]	Limit [%]
							[W/kg]				
750	01/10/2017	3967	1014	Body	21.1	20.9	8.74	0.886	8.86	+ 1.37	± 10
1 800	01/06/2017	3967	2d007	Body	22.6	22.4	37.6	3.72	37.2	- 1.06	± 10
2 450	01/11/2017	3967	965	Body	20.6	20.4	49.2	4.95	49.5	+ 0.61	± 10

10.3 System Verification Procedure

SAR measurement was prior to assessment, the system is verified to the $\pm 10\%$ of the specifications at each frequency band by using the system Verification kit. (Graphic Plots Attached)

- Cabling the system, using the Verification kit equipments.
- Generate about 100 mW Input Level from the Signal generator to the Dipole Antenna.
- Dipole Antenna was placed below the Flat phantom.
- The measured one-gram SAR at the surface of the phantom above the dipole feed-point should be within 10 % of the target reference value.
- The results are normalized to 1 W input power.

NOTE;

SAR Verification was performed according to the FCC KDB 865664 D01v01r04.

11. SAR TEST DATA SUMMARY

11.1 Hotspot SAR Measurement Results

LTE Band 4 Hotspot SAR															
Frequency		Mode	Band width	Tune-Up Limit	Meas. Power	Power Drift	Test Position	RB Size	RB offset	Duty Cycle	Distance	Meas. SAR	Scaling Factor	Scaled SAR	Plot No.
MHz	Ch.														
(MHz)	(dBm)	(dBm)	(dB)	(cm)	(W/kg)	(W/kg)									
1 732.5	20175	QPSK	20	23.0	22.93	0.05	Rear	1	0	1:1	0.5	0.962	1.016	0.977	-
1 732.5	20175	QPSK	20	22.0	21.84	-0.08	Rear	50	0	1:1	0.5	0.740	1.038	0.768	-
1 732.5	20175	QPSK	20	22.0	21.71	0.19	Rear	100	0	1:1	0.5	0.657	1.069	0.702	-
1 732.5	20175	QPSK	20	23.0	22.93	-0.06	Front	1	0	1:1	0.5	1.19	1.016	1.209	1
1 732.5	20175	QPSK	20	22.0	21.84	-0.09	Front	50	0	1:1	0.5	0.919	1.038	0.954	-
1 732.5	20175	QPSK	20	22.0	21.71	-0.05	Front	100	0	1:1	0.5	1.05	1.069	1.122	-
1 732.5	20175	QPSK	20	23.0	22.93	-0.07	Right -45	1	0	1:1	0.5	0.314	1.016	0.319	-
1 732.5	20175	QPSK	20	22.0	21.84	0.04	Right -45	50	0	1:1	0.5	0.224	1.038	0.233	-
1 732.5	20175	QPSK	20	23.0	22.93	0.01	Right	1	0	1:1	0.5	0.730	1.016	0.742	-
1 732.5	20175	QPSK	20	22.0	21.84	0.04	Right	50	0	1:1	0.5	0.570	1.038	0.592	-
1 732.5	20175	QPSK	20	23.0	22.93	-0.05	Right +45	1	0	1:1	0.5	0.528	1.016	0.536	-
1 732.5	20175	QPSK	20	22.0	21.84	-0.03	Right +45	50	0	1:1	0.5	0.417	1.038	0.433	-
1 732.5	20175	QPSK	20	23.0	22.93	-0.02	Top	1	0	1:1	0.5	0.315	1.016	0.320	-
1 732.5	20175	QPSK	20	22.0	21.84	0.07	Top	50	0	1:1	0.5	0.229	1.038	0.238	-
1 732.5	20175	QPSK	20	23.0	22.93	-0.13	Bottom	1	0	1:1	0.5	0.318	1.016	0.323	-
1 732.5	20175	QPSK	20	22.0	21.84	-0.05	Bottom	50	0	1:1	0.5	0.214	1.038	0.222	-
ANSI/ IEEE C95.1 - 1992– Safety Limit Spatial Peak Uncontrolled Exposure/ General Population								Body 1.6 W/kg Averaged over 1 gram							

LTE Band 13 Hotspot SAR															
Frequency		Mode	Band width (MHz)	Tune-Up Limit (dBm)	Meas. Power (dBm)	Power Drift (dB)	Test Position	RB Size	RB offset	Duty Cycle	Distance (cm)	Meas. SAR (W/kg)	Scaling Factor	Scaled SAR (W/kg)	Plot No.
MHz	Ch.														
782	23230	QPSK	10	23.0	22.78	-0.02	Rear	1	0	1:1	0.5	1.18	1.052	1.241	2
782	23230	QPSK	10	22.0	21.81	0.01	Rear	25	24	1:1	0.5	0.559	1.045	0.584	-
782	23230	QPSK	10	22.0	21.84	-0.08	Rear	50	0	1:1	0.5	0.784	1.038	0.814	-
782	23230	QPSK	10	23.0	22.78	-0.13	Front	1	0	1:1	0.5	0.826	1.052	0.869	-
782	23230	QPSK	10	22.0	21.81	0.05	Front	25	24	1:1	0.5	0.331	1.045	0.346	-
782	23230	QPSK	10	22.0	21.84	0.03	Front	50	0	1:1	0.5	0.499	1.038	0.518	-
782	23230	QPSK	10	23.0	22.78	0.13	Right -45	1	0	1:1	0.5	0.389	1.052	0.409	-
782	23230	QPSK	10	22.0	21.81	-0.01	Right -45	25	24	1:1	0.5	0.226	1.045	0.236	-
782	23230	QPSK	10	23.0	22.78	-0.04	Right	1	0	1:1	0.5	0.302	1.052	0.318	-
782	23230	QPSK	10	22.0	21.81	0.04	Right	25	24	1:1	0.5	0.138	1.045	0.144	-
782	23230	QPSK	10	23.0	22.78	-0.07	Right +45	1	0	1:1	0.5	0.343	1.052	0.361	-
782	23230	QPSK	10	22.0	21.81	-0.14	Right +45	25	24	1:1	0.5	0.160	1.045	0.167	-
782	23230	QPSK	10	23.0	22.78	0.07	Top	1	0	1:1	0.5	0.383	1.052	0.403	-
782	23230	QPSK	10	22.0	21.81	0.07	Top	25	24	1:1	0.5	0.194	1.045	0.203	-
782	23230	QPSK	10	23.0	22.78	0.08	Bottom	1	0	1:1	0.5	0.361	1.052	0.380	-
782	23230	QPSK	10	22.0	21.81	0.02	Bottom	25	24	1:1	0.5	0.173	1.045	0.181	-
ANSI/ IEEE C95.1 - 1992– Safety Limit Spatial Peak Uncontrolled Exposure/ General Population								Body 1.6 W/kg Averaged over 1 gram							

DTS Hotspot SAR																
Frequency		Mode	Band width (MHz)	Data Rate (Mbps)	Tune-Up Limit (dBm)	Meas. Power (dBm)	Power Drift (dB)	Test Position	Duty Cycle	Distance (cm)	Area Scan Peak SAR (W/kg)	Meas. SAR (W/kg)	Scaling Factor (Duty)	Scaling Factor (W/kg)	Scaled SAR (W/kg)	Plot No.
MHz	Ch.															
2 412	1	802.11b	22	1	13.0	12.13	-0.12	Rear	100	0.5	0.184	0.128	1.222	1.000	0.156	-
2 412	1	802.11b	22	1	13.0	12.13	-0.06	Front	100	0.5	0.194	0.143	1.222	1.000	0.175	3
2 412	1	802.11b	22	1	13.0	12.13	0.10	Left -45	100	0.5	0.109	0.073	1.222	1.000	0.089	-
2 412	1	802.11b	22	1	13.0	12.13	-0.10	Left	100	0.5	0.178	0.113	1.222	1.000	0.138	-
2 412	1	802.11b	22	1	13.0	12.13	0.01	Left +45	100	0.5	0.103	0.072	1.222	1.000	0.088	-
2 412	1	802.11b	22	1	13.0	12.13	0.07	Top	100	0.5	0.048	0.030	1.222	1.000	0.037	-
2 412	1	802.11b	22	1	13.0	12.13	0.04	Bottom	100	0.5	0.139	0.097	1.222	1.000	0.119	-
ANSI/ IEEE C95.1 - 1992– Safety Limit Spatial Peak Uncontrolled Exposure/ General Population								Body 1.6 W/kg (mW/g) Averaged over 1 gram								

11.2 SAR Test Notes

General Notes:

1. The test data reported are the worst-case SAR values according to test procedures specified in IEEE 1528-2013, FCC KDB Procedure.
2. Batteries are fully charged at the beginning of the SAR measurements. A standard battery was used for all SAR measurements.
3. Liquid tissue depth was at least 15.0 cm for all frequencies.
4. The manufacturer has confirmed that the device(s) tested have the same physical, mechanical and thermal characteristics and are within operational tolerances expected for production units.
5. SAR results were scaled to the maximum allowed power to demonstrate compliance per FCC KDB 447498 D01v06.
6. Device was tested using a fixed spacing for hotspot testing. A separation distance of 5 mm was considered because FCC KDB Publication 941225 D06v02r01 where SAR test consideration for devices(Lx W ≤9cm.x 5cm) are based on a composite test separation distance of 5 mm from the front, back and edges of the device containing transmitting antennas within 2.5cm of their edges.

LTE Notes:

1. LTE Considerations: LTE test configurations are determined according to SAR Evaluation Consideration for LTE Devices in FCC KDB 941225 D05v02r05.
2. According to FCC KDB 941225 D05v02r05.

When the reported SAR is ≤ 0.8 W/kg, testing of the 100%RB allocation and required test channels is not required. Otherwise, SAR is required for the remaining required test channels using the 1RB, 50%RB and 100%RB allocation with highest output power for that channel.

Only one channel, and as reported SAR values for 1RB allocation and 50%RB allocation were less than 1.45W/Kg only the highest power RB offset for each allocation was required.

3. MPR is permanently implemented for this device by the manufacturer. The specific manufacturer target MPR is indicated alongside the SAR results. MPR is enabled for this device, according to target MPR is indicated alongside the SAR results.
4. A-MPR was disabled for all SAR tests by setting NS=01 on the base station simulator.
5. Pre-installed VOIP applications are considered.
6. SAR test reduction is applied using the following criteria:

Start with the largest channel bandwidth and measure SAR for QPSK with 1 RB, and 50% RB allocation, using the RB offset and required test channel combination with the highest maximum output power among RB offsets at the upper edge, middle and lower edge of each required test channel. When the reported SAR is >0.8 W/kg, testing for other Channels is performed at the highest output power level for 1RB, and 50% RB configuration for that channel. Testing for 100% RB configuration is performed at the highest output power level for 100% RB configuration across the Low, Mid and High Channel when the highest reported SAR for 1 RB and 50% RB are >0.8 W/kg, Testing for the remaining required channels is not needed because the reported SAR for 100% RB Allocation <1.45 W/kg. Testing for 16-QAM modulation is not required because the reported SAR for QPSK is <1.45 W/kg and its output power is not more than 0.5 dB higher than that a QPSK. Testing for the other channel bandwidths is not required because the reported SAR for the highest channel bandwidth is <1.45 W/kg and its output power is not more than 0.5 dB higher than that of the highest channel bandwidth.

WLAN Notes:

1. For held-to-ear and hotspot operations, the initial test position procedures were applied. For initial test position, the highest extrapolated peak SAR will be used. When reported SAR for the initial test position is ≤ 0.4 W/kg for 1g SAR and ≤ 1.0 W/kg for 10g SAR, no additional testing for the remaining test positions was required. Otherwise, SAR is evaluated at the subsequent highest peak SAR positions until the reported SAR results is ≤ 0.8 W/kg for 1g SAR and ≤ 2.0 W/kg for 10g SAR or all test position are measured.
2. Per KDB 248227 D01v02r02 justification for test configurations of 2.4 GHz WiFi Single transmission chain operations, the highest measured maximum output power channel for DSSS was selected for SAR measurement. SAR for OFDM modes (2.4 GHz 802.11 g/n) was not required due to the maximum allowed powers and the highest reported DSSS SAR.
3. When the maximum reported 1g averaged SAR is ≤ 0.8 W/kg, SAR testing on additional channels was not required. Otherwise, SAR for the next highest output power channel was required until the reported SAR result was ≤ 1.20 W/kg or all test channels were measured.

12. Simultaneous SAR Analysis

12.1 Simultaneous Transmission Summation for Hotspot

Simultaneous Transmission Summation Scenario with 2.4 GHz WLAN					
Exposure condition	Band	Configuration	WWAN SAR	2.4 GHz WLAN SAR	\sum 1-g SAR
			(W/kg)	(W/kg)	(W/kg)
Body SAR	LTE Band 4	Rear	0.977	0.156	1.133
		Front	1.209	0.175	1.384
		Left		0.138	0.138
		Right	0.742		0.742
		Top	0.320	0.037	0.357
		Bottom	0.323	0.119	0.442
	LTE Band 13	Rear	1.241	0.156	1.397
		Front	0.869	0.175	1.044
		Left		0.138	0.138
		Right	0.409		0.409
		Top	0.403	0.037	0.440
		Bottom	0.380	0.119	0.499

Note:

The highest reported SAR for each exposure condition is used for SAR summation purpose.

12.2 Simultaneous Transmission Conclusion

The above numerical summed SAR results for all the worst-case simultaneous transmission conditions were below the SAR limit. Therefore, the above analysis is sufficient to determine that simultaneous transmission cases will not exceed the SAR limit. And therefore no measured volumetric simultaneous SAR summation is required per FCC KDB Publication 447498 D01v06 and IEEE 1528-2013.

13. SAR Measurement Variability and Uncertainty

In accordance with KDB procedure 865664 D01v01r04 SAR measurement 100 MHz to 6 GHz, SAR additional measurements are repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device should be returned to ambient conditions (normal room temperature) with the battery fully charged before it is re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results.

SAR Measurement variability was assessed using the following procedures for each frequency band:

- 1) Repeated measurement is not required when the original highest measured SAR is < 0.80 W/kg for 1g SAR or < 2.0 W/kg for 10g SAR ; steps 2) through 4) do not apply.
- 2) When the original highest measured 1g SAR is ≥ 0.80 W/kg or 10g SAR ≥ 2.0 W/kg, repeat that measurement once.
- 3) Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is ≥ 1.45 W/kg for 1g SAR or ≥ 3.625 W/kg for 10g SAR (~ 10% from the 1-g SAR limit).
- 4) Perform a third repeated measurement only if the original, first or second repeated measurement is ≥ 1.5 W/kg for 1g SAR or ≥ 3.75 W/kg for 10g SAR and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20 .

Frequency		Modulation	Battery	Configuration	Original SAR	Repeated SAR	Largest to Smallest SAR Ratio	Plot No.
MHz	Channel				(W/kg)	(W/kg)		
1 732.5	20175	LTE 4	Standard	Front (1RB, 0offset)	1.19	1.16	1.03	4
782	23230	LTE 13	Standard	Front (1RB, 0offset)	1.18	1.12	1.05	5

14. MEASUREMENT UNCERTAINTY

Error Description	Tol (\pm %)	Prob. dist.	Div.	c_i	Standard Uncertainty (\pm %)	v_{eff}
1. Measurement System						
Probe Calibration	6.55	N	1	1	6.55	∞
Axial Isotropy	4.70	R	1.73	0.70	1.90	∞
Hemispherical Isotropy	9.60	R	1.73	0.70	3.88	∞
Boundary Effects	2.00	R	1.73	1	1.15	∞
Linearity	4.70	R	1.73	1	2.71	∞
System Detection Limits	0.25	R	1.73	1	0.14	∞
Readout Electronics	0.30	N	1.00	1	0.30	∞
Response Time	0.80	R	1.73	1	0.46	∞
Integration Time	2.60	R	1.73	1	1.50	∞
RF Ambient Noise	3.00	R	1.73	1	1.73	∞
RF Ambient Reflections	3.00	R	1.73	1	1.73	∞
Probe Positioner	0.80	R	1.73	1	0.46	∞
Probe Positioning	6.70	R	1.73	1	3.87	∞
Max SAR Eval	4.00	R	1.73	1	2.31	∞
2. Test Sample Related						
Device Positioning	2.11	N	1.00	1	2.11	9
Device Holder	3.60	N	1.00	1	3.60	5
Power Drift	5.00	R	1.73	1	2.89	∞
Power Scaling	0.00	R	1.73	1	0.00	∞
3. Phantom and Setup						
Phantom Uncertainty	6.60	R	1.73	1	3.82	∞
Liquid Conductivity(target)	5.00	R	1.73	0.64	1.85	∞
Liquid Permitivity(target)	5.00	R	1.73	0.60	1.73	∞
Liquid Conductivity(meas.)	3.80	N	1	0.78	2.96	5
Liquid Permitivity(meas.)	2.60	N	1	0.23	0.60	5
Liquid Conductivity(temp.)	1.70	R	1.73	0.78	0.77	∞
Liquid Permitivity(temp.)	2.70	R	1.73	0.23	0.36	∞
Combind Standard Uncertainty						12.49
Coverage Factor for 95 %						$k=2$
Expanded STD Uncertainty						24.98

15. SAR TEST EQUIPMENT

Manufacturer	Type / Model	S/N	Calib. Date	Calib.Interval	Calib.Due
SPEAG	Triple Modular Phantom	-	N/A	N/A	N/A
HP	SAR System Control PC	-	N/A	N/A	N/A
Staubli	TX90 Xlspeag	F11/5K3RA1/A/01	N/A	N/A	N/A
Staubli	CS8Cspeag-TX90	F11/5K3RA1/C/01	N/A	N/A	N/A
Staubli	Teach Pendant (Joystick)	D21142603	N/A	N/A	N/A
SPEAG	DAE4	648	05/11/2016	Annual	05/11/2017
SPEAG	E-Field Probe EX3DV4	3967	12/14/2016	Annual	12/14/2017
SPEAG	Dipole D750V3	1014	07/22/2016	Annual	07/22/2017
SPEAG	Dipole D1800V2	2d007	11/16/2016	Annual	11/16/2017
SPEAG	Dipole D2450V2	965	04/19/2016	Annual	04/19/2017
Agilent	Power Meter N1911A	MY45101406	09/28/2016	Annual	09/28/2017
HP	Power Sensor 8481A	2702A72055	05/27/2016	Annual	05/27/2017
SPEAG	DAKS 3.5	1038	05/31/2016	Annual	05/31/2017
HP	Directional Bridge	86205A	05/18/2016	Annual	05/18/2017
Agilent	Base Station E5515C	GB44400269	02/05/2016	Annual	02/05/2017
HP	Signal Generator N5182A	MY47070230	05/13/2016	Annual	05/13/2017
Hewlett Packard	11636B/Power Divider	58698	02/27/2016	Annual	02/27/2017
TESTO	175-H1/Thermometer	40332651310	02/12/2016	Annual	02/12/2017
TESTO	175-H1/Thermometer	40331939309	02/12/2016	Annual	02/12/2017
EMPOWER	RF Power amplifier	1011	10/17/2016	Annual	10/17/2017
Agilent	Attenuator(3dB)	52744	10/16/2016	Annual	10/16/2017
Agilent	Attenuator(20dB)	52664	10/16/2016	Annual	10/16/2017
HP	Notebook(DAKS)	-	N/A	N/A	N/A
HP	Dual Directional Coupler	16072	10/16/2016	Annual	10/16/2017
R&S	Wideband Radio Communication Tester CMW500	101519	09/07/2016	Annual	09/07/2017
Anritsu	Radio Communication Analyzer/ MT8820C	6200628628	07/05/2016	Annual	07/05/2017
Anritsu	Radio Communication Analyzer/ MT8820C	6200576565	07/05/2016	Annual	07/05/2017

NOTE:

1. The E-field probe was calibrated by SPEAG, by the waveguide technique procedure. Dipole Verification measurement is performed by HCT Lab. before each test. The brain/body simulating material is calibrated by HCT using the DAKS 3.5 to determine the conductivity and permittivity (dielectric constant) of the brain/body-equivalent material.

16. CONCLUSION

The SAR measurement indicates that the EUT complies with the RF radiation exposure limits of the ANSI/IEEE C95.1 1992.

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

17. REFERENCES

- [1] IEEE Standards Coordinating Committee 34 – IEEE Std. 1528-2013, IEEE Recommended Practice or Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body from Wireless Communications Devices.
- [2] Federal Communications Commission, ET Docket 93-62, Guidelines for Evaluating the Environmental Effects of Radio frequency Radiation, Aug. 1996.
- [3] ANSI/IEEE C95.1 - 1991, American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 300 kHz to 100 GHz, New York: IEEE, Aug. 1992
- [4] ANSI/IEEE C 95.1 - 2005, American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 3 kHz to 300 GHz, New York: IEEE, 2006.
- [5] ANSI/IEEE C95.3 - 1991, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave, New York: IEEE, 1992.
- [6] NCRP, National Council on Radiation Protection and Measurements, Biological Effects and Exposure Criteria for Radio Frequency Electromagnetic Fields, NCRP Report No. 86, 1986. Reprinted Feb. 1995.
- [7] T. Schmid, O. Egger, N. Kuster, Automated E-field scanning system for dosimetric assessments, IEEE Transaction on Microwave Theory and Techniques, vol. 44, Jan. 1996, pp. 105-113.
- [8] K. Pokovic, T. Schmid, N. Kuster, Robust setup for precise calibration of E-field probes in tissue simulating liquids at mobile communications frequencies, ICECOM97, Oct. 1997, pp. 120-124.
- [9] K. Pokovic, T. Schmid, and N. Kuster, E-field Probe with improved isotropy in brain simulating liquids, Proceedings of the ELMAR, Zadar, Croatia, June 23-25, 1996, pp. 172-175.
- [10] Schmid & Partner Engineering AG, Application Note: Data Storage and Evaluation, June 1998, p2.
- [11] V. Hombach, K. Meier, M. Burkhardt, E. Kuhn, N. Kuster, The Dependence of EM Energy Absorption upon Human Head Modeling at 900 MHz, IEEE Transaction on Microwave Theory and Techniques, vol. 44 no. 10, Oct. 1996, pp. 1865-1873.
- [12] N. Kuster and Q. Balzano, Energy absorption mechanism by biological bodies in the near field of dipole antennas above 300 MHz, IEEE Transaction on Vehicular Technology, vol. 41, no. 1, Feb. 1992, pp. 17-23.
- [13] G. Hartsgrove, A. Kraszewski, A. Surowiec, Simulated Biological Materials for Electromagnetic Radiation Absorption Studies, University of Ottawa, Bioelectromagnetics, Canada: 1987, pp. 29-36.
- [14] Q. Balzano, O. Garay, T. Manning Jr., Electromagnetic Energy Exposure of Simulated Users of Portable Cellular Telephones, IEEE Transactions on Vehicular Technology, vol. 44, no.3, Aug. 1995.
- [15] W. Gander, Computer mathematick, Birkhaeuser, Basel, 1992.
- [16] W.H. Press, S.A. Teukolsky, W.T. Vetterling, and B.P. Flannery, Numerical Receipes in C, The Art of Scientific Computing, Second edition, Cambridge University Press, 1992.
- [17] N. Kuster, R. Kastle, T. Schmid, Dosimetric evaluation of mobile communications equipment with known precision, IEEE Transaction on Communications, vol. E80-B, no. 5, May 1997, pp. 645-652.
- [18] CENELEC CLC/SC111B, European Prestandard (prENV 50166-2), Human Exposure to Electromagnetic Fields High-frequency: 10 kHz-300 GHz, Jan. 1995.
- [19] Prof. Dr. Niels Kuster, ETH, Eidgenössische Technische Hochschule Zürich, Dosimetric Evaluation of the Cellular Phone.

- [20] IEC 62209-1, Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices – Human models, instrumentation and procedures – Part 1:Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz), Feb. 2005.
- [21] IEC 62209-2, Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices – Human models, instrumentation, and procedures – Part 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) Mar. 2010.
- [22] Industry Canada RSS-102 Radio Frequency Exposure Compliance of Radiocommunication Apparatus (All Frequency Band) Issue 5, March 2015.
- [23] Health Canada Safety Code 6 Limits of Human Exposure to Radio Frequency Electromagnetic Fields in the Frequency Range from 3 kHz – 300 GHz, 2009
- [24] FCC SAR Test procedures for 2G-3G Devices, Mobile Hotspot and UMPC Device KDB 941225 D01.
- [25] SAR Measurement Guidance for IEEE 802.11 transmitters, KDB 248227 D01.
- [26] SAR Evaluation of Handsets with Multiple Transmitters and Antennas KDB 648474 D03, D04.
- [27] SAR Evaluation for Laptop, Notebook, Netbook and Tablet computers KDB 616217 D04.
- [28] SAR Measurement and Reporting Requirements for 100 MHz – 6 GHz, KDB 865664 D01, D02.
- [29] FCC General RF Exposure Guidance and SAR procedures for Dongles, KDB 447498 D01, D02.

Attachment 1. – SAR Test Plots

Test Laboratory: HCT CO., LTD
EUT Type: Mobile Router
Liquid Temperature: 22.4 °C
Ambient Temperature: 22.6 °C
Test Date: 01/06/2017
Plot No.: 1

DUT: MHS900L; Type: Router

Communication System: UID 0, LTE Band 4 (0); Frequency: 1732.5 MHz; Duty Cycle: 1:1
Medium parameters used (interpolated): $f = 1732.5$ MHz; $\sigma = 1.467$ S/m; $\epsilon_r = 53.451$; $\rho = 1000$ kg/m³
Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3967; ConvF(8.19, 8.19, 8.19); Calibrated: 2016-12-14;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn648; Calibrated: 2016-05-11
- Phantom: Triple Flat Phantom
- Measurement SW: DASY52, Version 52.8 (8);

MHS900L/LTE Band 4 Body Front QPSK 20MHz 1RB 0offset 20175ch/Area Scan (10x7x1):

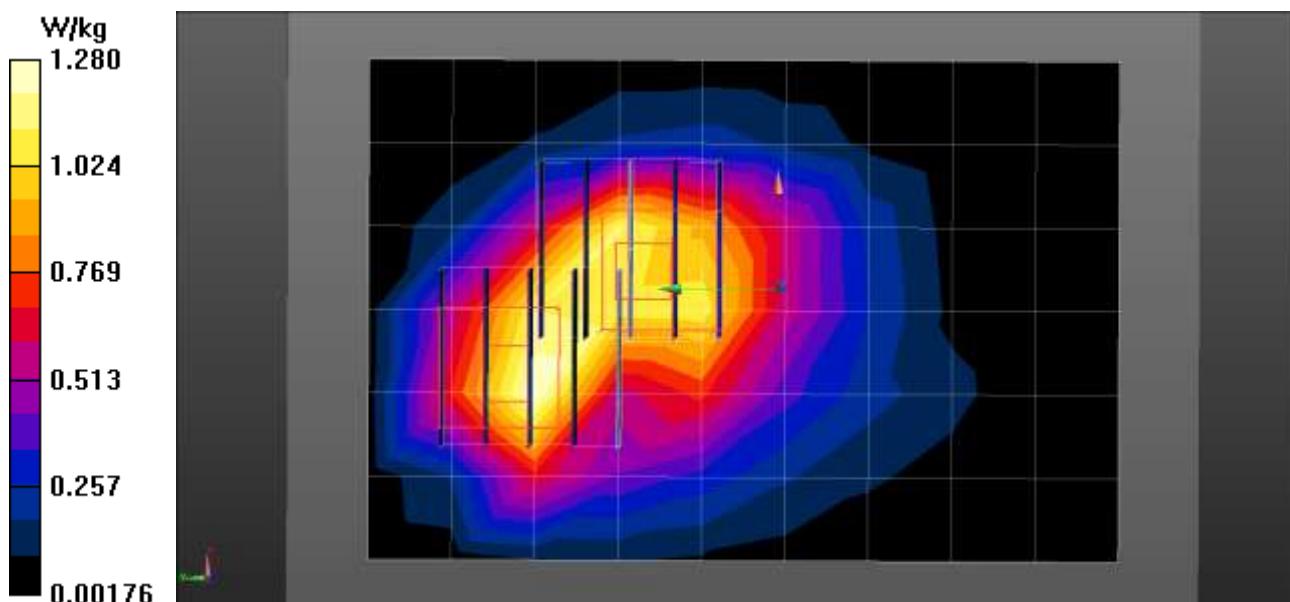
Measurement grid: dx=15mm, dy=15mm
Maximum value of SAR (measured) = 1.28 W/kg

MHS900L/LTE Band 4 Body Front QPSK 20MHz 1RB 0offset 20175ch/Zoom Scan (5x5x7)/Cube 0:

Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 23.59 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 2.16 W/kg
SAR(1 g) = 1.19 W/kg; SAR(10 g) = 0.586 W/kg
Maximum value of SAR (measured) = 1.49 W/kg

MHS900L/LTE Band 4 Body Front QPSK 20MHz 1RB 0offset 20175ch/Zoom Scan (5x5x7)/Cube 1:

Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 23.59 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 1.86 W/kg
SAR(1 g) = 1.16 W/kg; SAR(10 g) = 0.668 W/kg
Maximum value of SAR (measured) = 1.42 W/kg



Test Laboratory: HCT CO., LTD
EUT Type: Mobile Router
Liquid Temperature: 20.9 °C
Ambient Temperature: 21.1 °C
Test Date: 01/10/2017
Plot No.: 2

DUT: MHS900L; Type: Router

Communication System: UID 0, LTE Band 13 (0); Frequency: 782 MHz; Duty Cycle: 1:1
Medium parameters used (interpolated): $f = 782$ MHz; $\sigma = 0.991$ S/m; $\epsilon_r = 55.087$; $\rho = 1000$ kg/m³
Phantom section: Center Section

DASY Configuration:

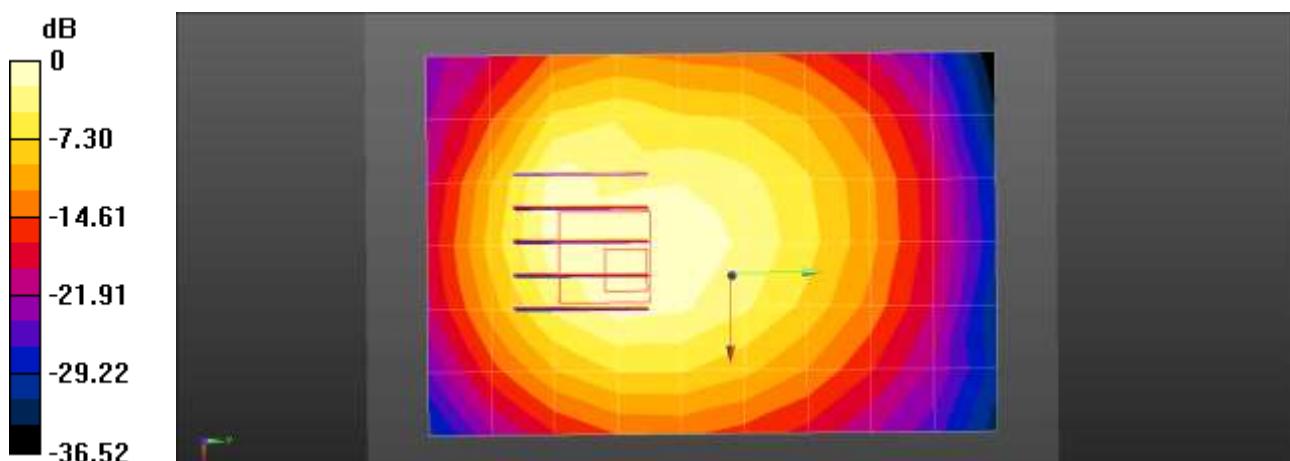
- Probe: EX3DV4 - SN3967; ConvF(9.79, 9.79, 9.79); Calibrated: 2016-12-14;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn648; Calibrated: 2016-05-11
- Phantom: Triple Flat Phantom
- Measurement SW: DASY52, Version 52.8 (8);

MHS900L/LTE Band 13 Body Rear QPSK 10MHz 1RB 0offset 23230ch/Area Scan (10x7x1):

Measurement grid: dx=15mm, dy=15mm
Maximum value of SAR (measured) = 1.47 W/kg

MHS900L/LTE Band 13 Body Rear QPSK 10MHz 1RB 0offset 23230ch/Zoom Scan (5x5x7)/Cube 0:

Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 32.56 V/m; Power Drift = -0.02 dB
Peak SAR (extrapolated) = 2.03 W/kg
SAR(1 g) = 1.18 W/kg; SAR(10 g) = 0.689 W/kg
Maximum value of SAR (measured) = 1.60 W/kg



0 dB = 1.47 W/kg = 1.68 dBW/kg

Test Laboratory: HCT CO., LTD
EUT Type: Mobile Router
Liquid Temperature: 20.4 °C
Ambient Temperature: 20.6 °C
Test Date: 01/11/2017
Plot No.: 3

DUT: MHS900L; Type: Router

Communication System: UID 0, 2450MHz FCC (0); Frequency: 2412 MHz; Duty Cycle: 1:1
Medium parameters used (interpolated): $f = 2412$ MHz; $\sigma = 1.913$ S/m; $\epsilon_r = 52.264$; $\rho = 1000$ kg/m³
Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3967; ConvF(7.49, 7.49, 7.49); Calibrated: 2016-12-14;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn648; Calibrated: 2016-05-11
- Phantom: Triple Flat Phantom
- Measurement SW: DASY52, Version 52.8 (8);

MHS900L/802.11b Body Front 1Mbps 1ch/Area Scan (11x8x1): Measurement grid: dx=12mm, dy=12mm
Maximum value of SAR (measured) = 0.187 W/kg

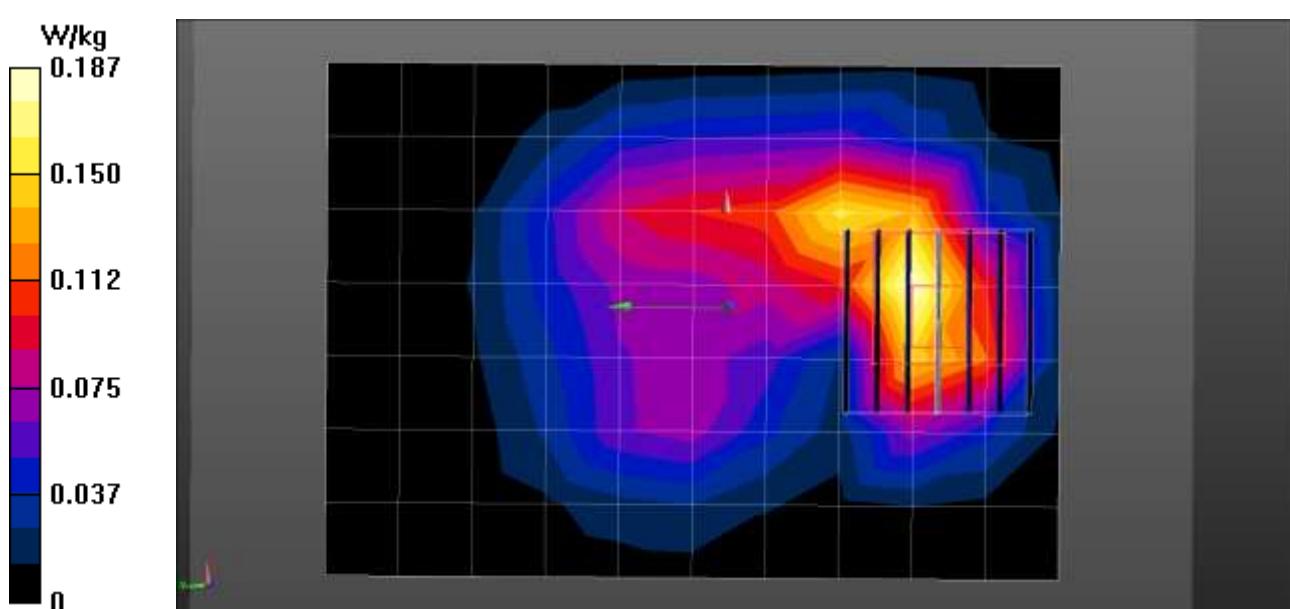
MHS900L/802.11b Body Front 1Mbps 1ch/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 6.030 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 0.297 W/kg

SAR(1 g) = 0.143 W/kg; SAR(10 g) = 0.065 W/kg

Maximum value of SAR (measured) = 0.219 W/kg



Test Laboratory: HCT CO., LTD
EUT Type: Mobile Router
Liquid Temperature: 22.4 °C
Ambient Temperature: 22.6 °C
Test Date: 01/06/2017
Plot No.: 4

DUT: MHS900L; Type: Router

Communication System: UID 0, LTE Band 4 (0); Frequency: 1732.5 MHz; Duty Cycle: 1:1
Medium parameters used (interpolated): $f = 1732.5$ MHz; $\sigma = 1.467$ S/m; $\epsilon_r = 53.451$; $\rho = 1000$ kg/m³
Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3967; ConvF(8.19, 8.19, 8.19); Calibrated: 2016-12-14;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn648; Calibrated: 2016-05-11
- Phantom: Triple Flat Phantom
- Measurement SW: DASY52, Version 52.8 (8);

MHS900L/LTE Band 4 Body Front QPSK 20MHz 1RB 0offset 20175ch/Area Scan (10x7x1):

Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (measured) = 1.27 W/kg

MHS900L/LTE Band 4 Body Front QPSK 20MHz 1RB 0offset 20175ch/Zoom Scan (5x5x7)/Cube 0:

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

Reference Value = 23.55 V/m; Power Drift = -0.17 dB

Peak SAR (extrapolated) = 2.06 W/kg

SAR(1 g) = 1.16 W/kg; SAR(10 g) = 0.568 W/kg

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

MHS900L/LTE Band 4 Body Front QPSK 20MHz 1RB 0offset 20175ch/Zoom Scan (5x5x7)/Cube 1:

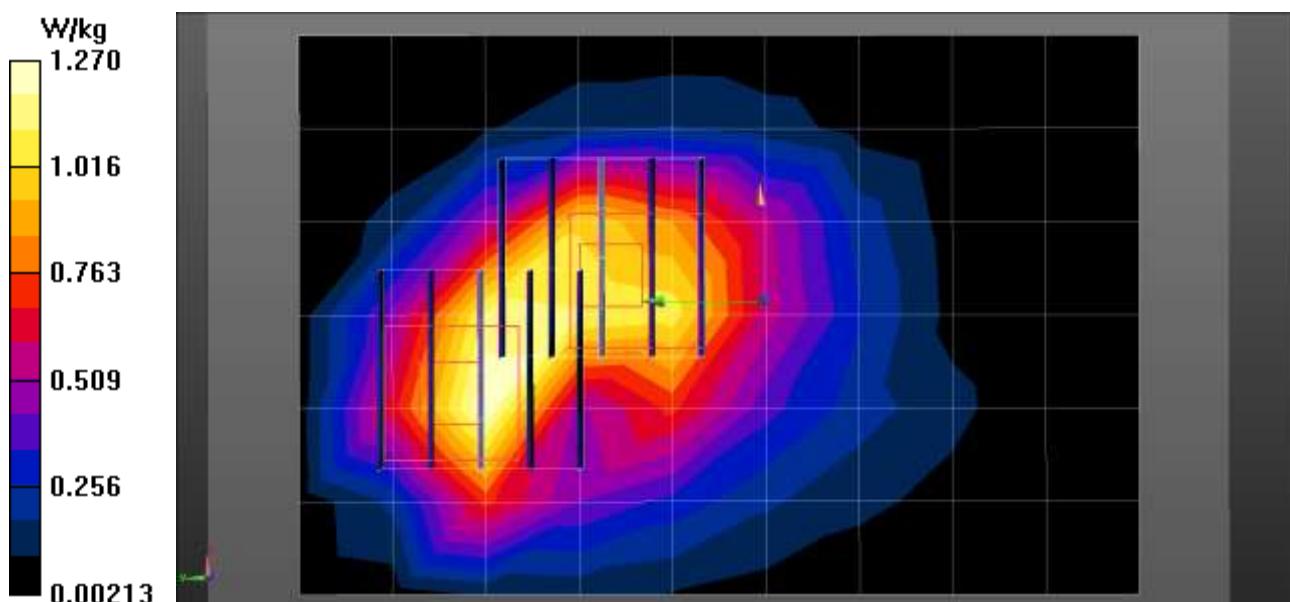
Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 23.55 V/m; Power Drift = -0.17 dB

Peak SAR (extrapolated) = 1.82 W/kg

SAR(1 g) = 1.12 W/kg; SAR(10 g) = 0.647 W/kg

Maximum value of SAR (measured) = 1.40 W/kg



Test Laboratory: HCT CO., LTD
EUT Type: Mobile Router
Liquid Temperature: 20.9 °C
Ambient Temperature: 21.1 °C
Test Date: 01/10/2017
Plot No.: 5

DUT: MHS900L; Type: Router

Communication System: UID 0, LTE Band 13 (0); Frequency: 782 MHz; Duty Cycle: 1:1
Medium parameters used (interpolated): $f = 782$ MHz; $\sigma = 0.991$ S/m; $\epsilon_r = 55.087$; $\rho = 1000$ kg/m³
Phantom section: Center Section

DASY Configuration:

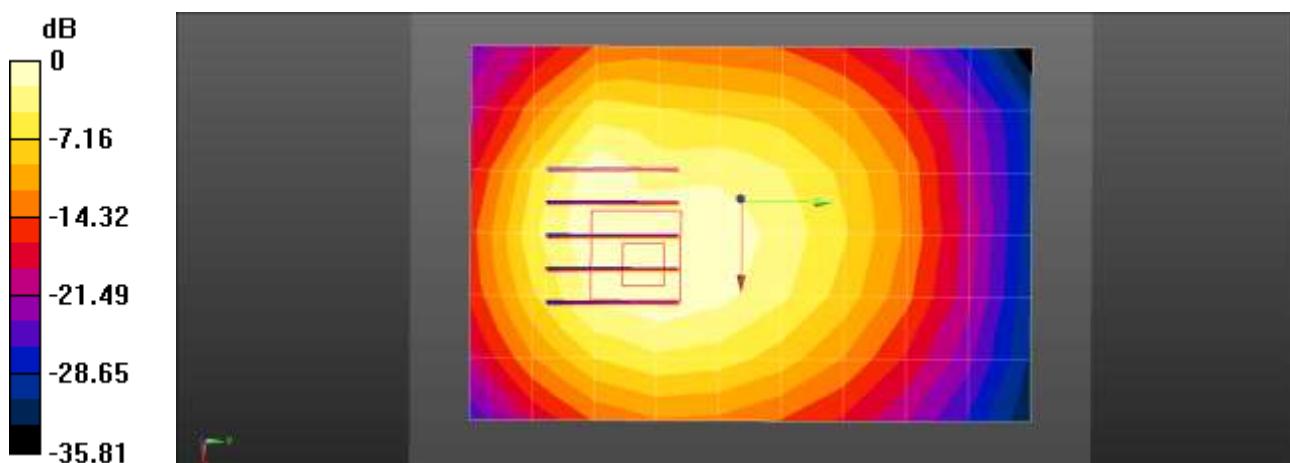
- Probe: EX3DV4 - SN3967; ConvF(9.79, 9.79, 9.79); Calibrated: 2016-12-14;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn648; Calibrated: 2016-05-11
- Phantom: Triple Flat Phantom
- Measurement SW: DASY52, Version 52.8 (8);

MHS900L/LTE Band 13 Body Rear QPSK 10MHz 1RB 0offset 23230ch/Area Scan (10x7x1):

Measurement grid: dx=15mm, dy=15mm
Maximum value of SAR (measured) = 1.31 W/kg

MHS900L/LTE Band 13 Body Rear QPSK 10MHz 1RB 0offset 23230ch/Zoom Scan (5x5x7)/Cube 0:

Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 31.82 V/m; Power Drift = -0.13 dB
Peak SAR (extrapolated) = 1.92 W/kg
SAR(1 g) = 1.12 W/kg; SAR(10 g) = 0.675 W/kg
Maximum value of SAR (measured) = 1.50 W/kg



Attachment 2. – Dipole Verification Plots

■ Verification Data (750 MHz Body)

Test Laboratory: HCT CO., LTD

Input Power 100 mW (20 dBm)

Liquid Temp: 20.9 °C

Test Date: 01/10/2017

DUT: Dipole 750 MHz D750V3; Type: D750V3

Communication System: UID 0, CW (0); Frequency: 750 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 750$ MHz; $\sigma = 0.961$ S/m; $\epsilon_r = 55.388$; $\rho = 1000$ kg/m³

Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3967; ConvF(9.79, 9.79, 9.79); Calibrated: 2016-12-14;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn648; Calibrated: 2016-05-11
- Phantom: Triple Flat Phantom
- Measurement SW: DASY52, Version 52.8 (8);

750MHz Body Verification/Area Scan (13x7x1): Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (measured) = 1.05 W/kg

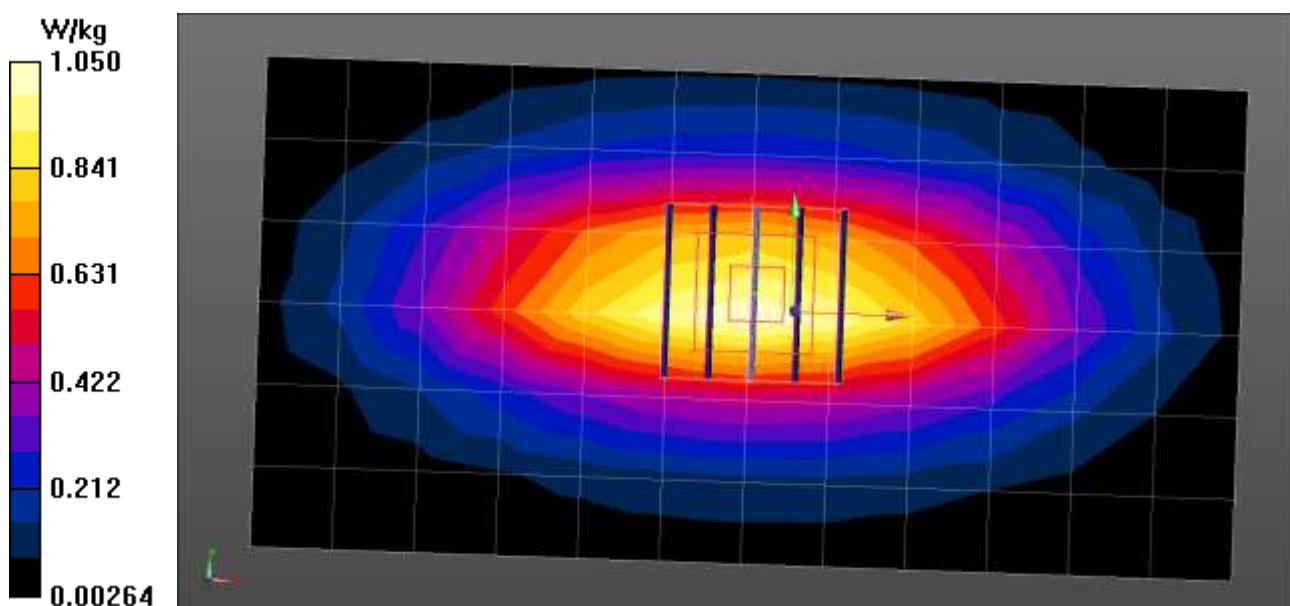
750MHz Body Verification/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 33.91 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 1.27 W/kg

SAR(1 g) = 0.886 W/kg; SAR(10 g) = 0.598 W/kg

Maximum value of SAR (measured) = 1.11 W/kg



■ Verification Data (1 800 MHz Body)

Test Laboratory: HCT CO., LTD

Input Power 100 mW (20 dBm)

Liquid Temp: 22.4 °C

Test Date: 01/06/2017

DUT: Dipole 1800 MHz D1800V2; Type: D1800V2

Communication System: UID 0, CW (0); Frequency: 1800 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 1800$ MHz; $\sigma = 1.525$ S/m; $\epsilon_r = 53.238$; $\rho = 1000$ kg/m³

Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3967; ConvF(8.19, 8.19, 8.19); Calibrated: 2016-12-14;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn648; Calibrated: 2016-05-11
- Phantom: Triple Flat Phantom
- Measurement SW: DASY52, Version 52.8 (8);

1800MHz Body Verification/Area Scan (7x7x1): Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (measured) = 3.90 W/kg

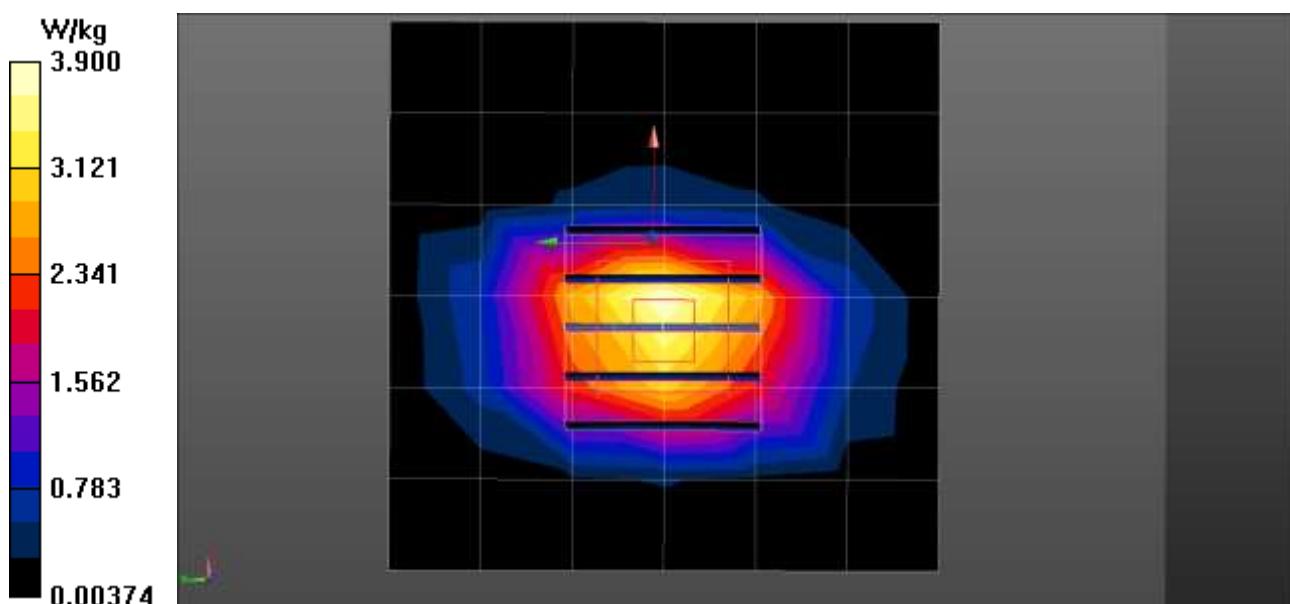
1800MHz Body Verification/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 51.59 V/m; Power Drift = 0.04 dB

Peak SAR (extrapolated) = 6.54 W/kg

SAR(1 g) = 3.72 W/kg; SAR(10 g) = 1.98 W/kg

Maximum value of SAR (measured) = 5.25 W/kg



■ Verification Data (2 450 MHz Body)

Test Laboratory: HCT CO., LTD

Input Power 100 mW (20 dBm)

Liquid Temp: 20.4 °C

Test Date: 01/11/2017

DUT: Dipole 2450 MHz D2450V2; Type: D2450V2

Communication System: UID 0, CW; Frequency: 2450 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.962$ S/m; $\epsilon_r = 52.138$; $\rho = 1000$ kg/m³

Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3967; ConvF(7.49, 7.49, 7.49); Calibrated: 2016-12-14;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn648; Calibrated: 2016-05-11
- Phantom: Triple Flat Phantom
- Measurement SW: DASY52, Version 52.8 (8);

2450MHz Body Verification/Area Scan (9x9x1): Measurement grid: dx=12mm, dy=12mm

Maximum value of SAR (measured) = 7.60 W/kg

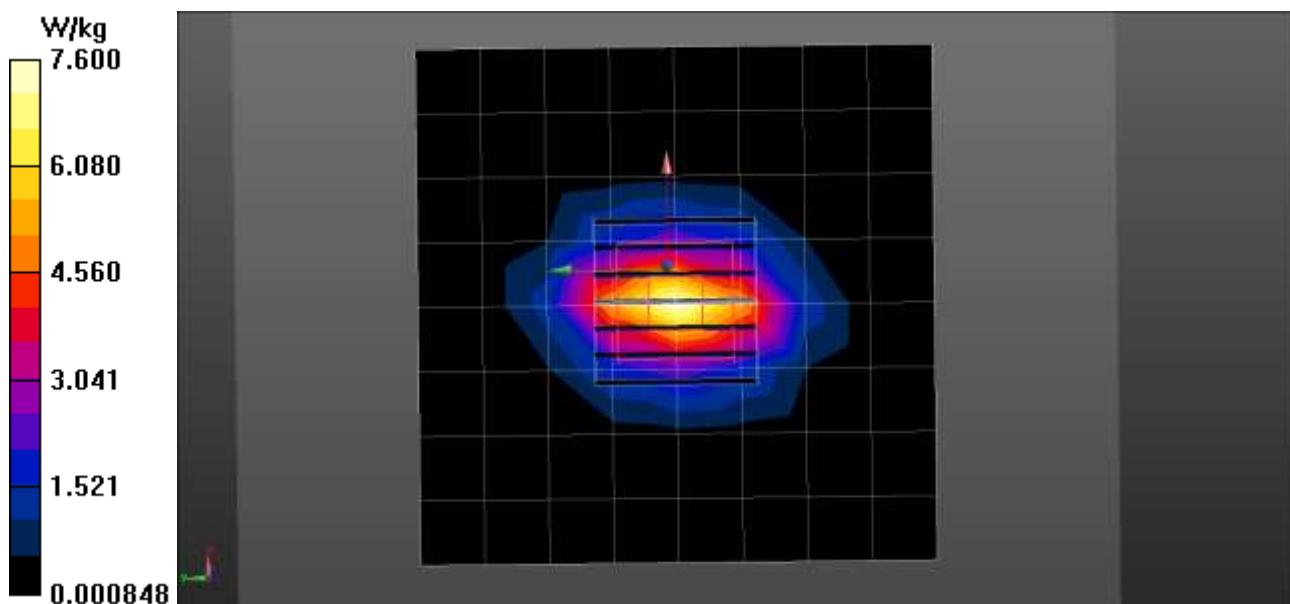
2450MHz Body Verification/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 63.46 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 10.1 W/kg

SAR(1 g) = 4.95 W/kg; SAR(10 g) = 2.31 W/kg

Maximum value of SAR (measured) = 6.85 W/kg



Attachment 3. – Probe Calibration Data

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



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Multilateral Agreement for the recognition of calibration certificates.

Accreditation No.: SCS 0108

Client HCT (Dymstec)

Certificate No: EX3-3967_Dec16

CALIBRATION CERTIFICATE (Replacement of No: EX3-3967_Nov16)

Object EX3DV4 - SN:3967

Calibration procedure(s) QA CAL-01.v9, QA CAL-12.v9, QA CAL-14.v4, QA CAL-23.v5,
QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

Calibration date: December 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 $(22 \pm 3)^\circ\text{C}$ 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: 55277 (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 (in house check Jun-16)	In house check: Jun-18
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-16)	In house check: Jun-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-16)	In house check: Oct-17

Calibrated by:	Name: Jeton Kastrati	Function: Laboratory Technician	Signature:
Approved by:	Name: Katja Pokovic	Function: Technical Manager	Signature:

Issued: December 14, 2016

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

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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 β	β rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\beta = 0$ 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:

- $NORM_{x,y,z}$: Assessed for E-field polarization $\beta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). $NORM_{x,y,z}$ are only intermediate values, i.e., the uncertainties of $NORM_{x,y,z}$ does not affect the E-field uncertainty inside TSL (see below *ConvF*).
- $NORM(f)x,y,z = NORM_{x,y,z} * frequency_response$ (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
- $Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z$: VR_{x,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 $NORM_{x,y,z} * ConvF$ 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 $NORM_x$ (no uncertainty required).

EX3DV4 – SN:3967

December 14, 2016

Probe EX3DV4

SN:3967

Manufactured: September 30, 2013
Calibrated: December 14, 2016

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

EX3DV4- SN:3967

December 14, 2016

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3967**Basic Calibration Parameters**

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.53	0.40	0.47	$\pm 10.1\%$
DCP (mV) ^B	99.3	99.1	100.0	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc ^C (k=2)
0	CW	X	0.0	0.0	1.0	0.00	143.8	$\pm 3.0\%$
		Y	0.0	0.0	1.0		143.7	
		Z	0.0	0.0	1.0		153.3	

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.

^C 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:3967

December 14, 2016

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3967

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)
150	52.3	0.76	12.93	12.93	12.93	0.00	1.00	± 13.3 %
300	45.3	0.87	12.06	12.06	12.06	0.10	1.20	± 13.3 %
450	43.5	0.87	11.12	11.12	11.12	0.15	1.20	± 13.3 %
750	41.9	0.89	10.53	10.53	10.53	0.56	0.80	± 12.0 %
835	41.5	0.90	10.07	10.07	10.07	0.43	0.80	± 12.0 %
900	41.5	0.97	9.94	9.94	9.94	0.50	0.81	± 12.0 %
1450	40.5	1.20	8.48	8.48	8.48	0.42	0.80	± 12.0 %
1750	40.1	1.37	8.44	8.44	8.44	0.31	0.80	± 12.0 %
1900	40.0	1.40	8.22	8.22	8.22	0.37	0.80	± 12.0 %
2300	39.5	1.67	7.74	7.74	7.74	0.35	0.80	± 12.0 %
2450	39.2	1.80	7.48	7.48	7.48	0.34	0.85	± 12.0 %
2600	39.0	1.96	7.23	7.23	7.23	0.40	0.86	± 12.0 %
3500	37.9	2.91	7.41	7.41	7.41	0.48	0.85	± 13.1 %
5250	35.9	4.71	5.49	5.49	5.49	0.30	1.80	± 13.1 %
5600	35.5	5.07	4.78	4.78	4.78	0.40	1.80	± 13.1 %
5750	35.4	5.22	5.09	5.09	5.09	0.40	1.80	± 13.1 %

^c Frequency validity above 300 MHz or \leq 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to \leq 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 \pm 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 \pm 110 MHz.

^f At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to \pm 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 \pm 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 \pm 1% for frequencies below 3 GHz and below \pm 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

EX3DV4- SN:3967

December 14, 2016

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3967

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 ^h (mm)	Unc (k=2)
150	61.9	0.80	12.24	12.24	12.24	0.00	1.00	± 13.3 %
300	58.2	0.92	11.89	11.89	11.89	0.05	1.15	± 13.3 %
450	56.7	0.94	11.82	11.82	11.82	0.08	1.15	± 13.3 %
750	55.5	0.96	9.79	9.79	9.79	0.35	1.07	± 12.0 %
835	55.2	0.97	9.62	9.62	9.62	0.35	0.98	± 12.0 %
1750	53.4	1.49	8.19	8.19	8.19	0.43	0.80	± 12.0 %
1900	53.3	1.52	7.87	7.87	7.87	0.43	0.80	± 12.0 %
2300	52.9	1.81	7.68	7.68	7.68	0.48	0.80	± 12.0 %
2450	52.7	1.95	7.49	7.49	7.49	0.38	0.80	± 12.0 %
2600	52.5	2.16	7.28	7.28	7.28	0.37	0.80	± 12.0 %
3500	51.3	3.31	6.82	6.82	6.82	0.53	0.79	± 13.1 %
5250	48.9	5.36	4.71	4.71	4.71	0.40	1.90	± 13.1 %
5600	48.5	5.77	4.00	4.00	4.00	0.50	1.90	± 13.1 %
5750	48.3	5.94	4.24	4.24	4.24	0.50	1.90	± 13.1 %

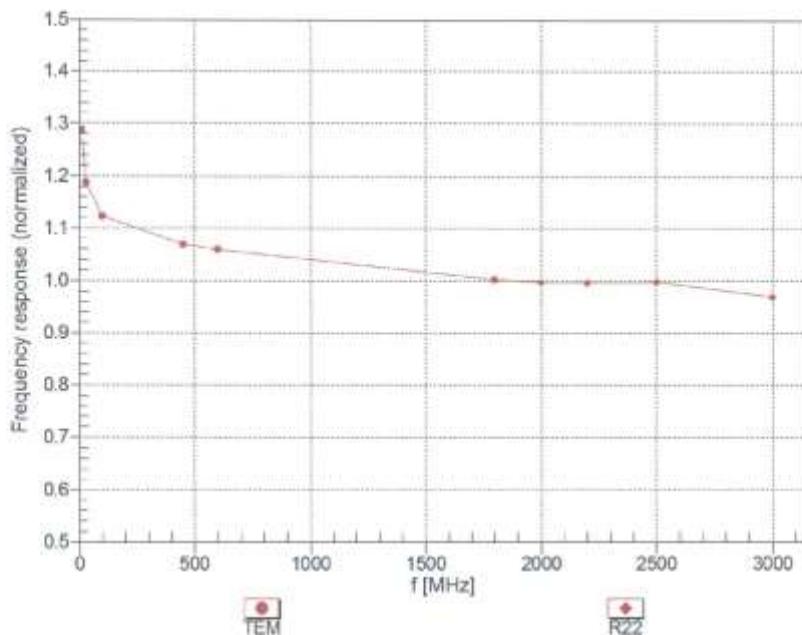
^c Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 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:3967

December 14, 2016

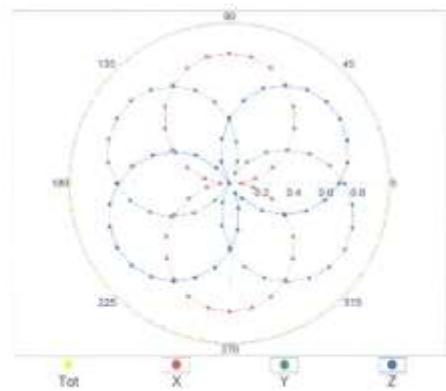
Frequency Response of E-Field
(TEM-Cell:ifi110 EXX, Waveguide: R22)Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

EX3DV4~ SN:3967

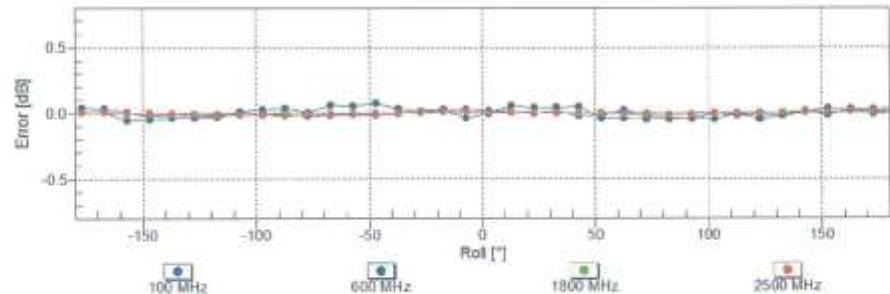
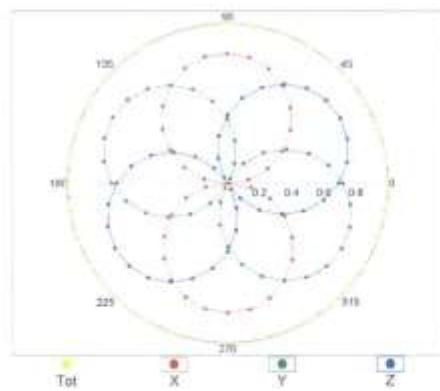
December 14, 2016

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

f=600 MHz, TEM

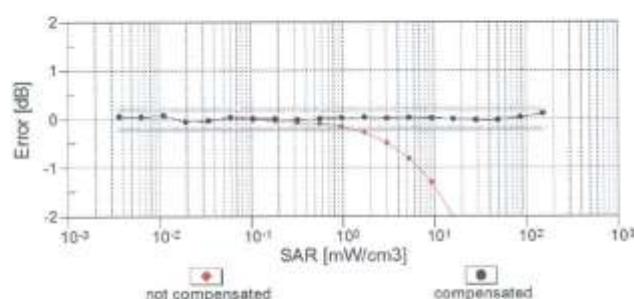
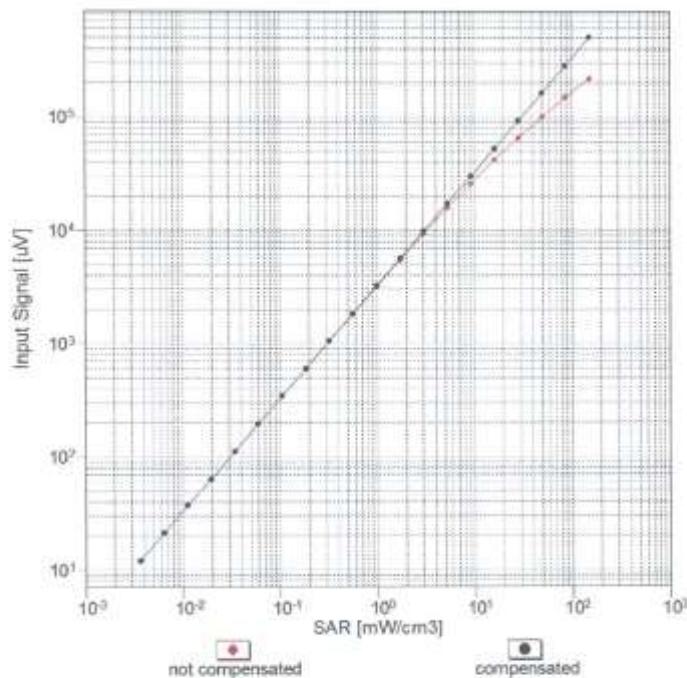


f=1800 MHz, R22

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

EX3DV4- SN:3967

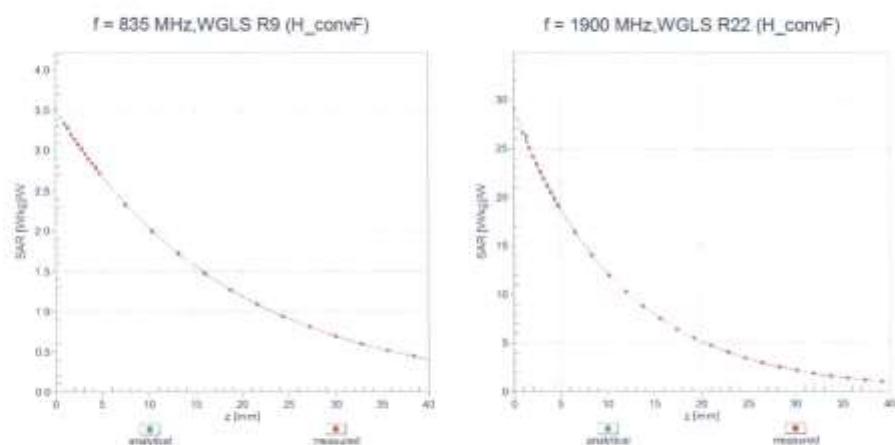
December 14, 2016

Dynamic Range f(SAR_{head})
(TEM cell, f_{eval}= 1900 MHz)Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

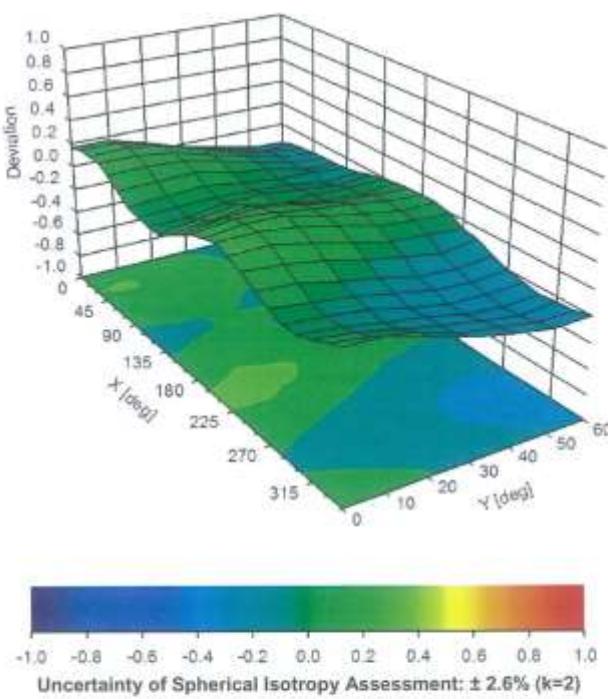
EX3DV4- SN:3967

December 14, 2016

Conversion Factor Assessment



Deviation from Isotropy in Liquid Error (ϕ, θ), $f = 900 \text{ MHz}$



EX3DV4-SN:3967

December 14, 2016

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3967**Other Probe Parameters**

Sensor Arrangement	Triangular
Connector Angle (°)	-27.1
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

Attachment 4. – Dipole Calibration Data

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Accreditation No.: SCS 0108

Client HCT (Dymstec)

Certificate No: D750V3-1014_Jul16

CALIBRATION CERTIFICATE

Object D750V3 - SN:1014

Calibration procedure(s) QA CAL-05.v9
Calibration procedure for dipole validation kits above 700 MHz

Calibration date: July 22, 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 EX3DV4	SN: 7349	15-Jun-16 (No. EX3-7349_Jun16)	Jun-17
DAE4	SN: 601	30-Dec-15 (No. DAE4-601_Dec15)	Dec-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (No. 217-02222)	In house check: Oct-16
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (No. 217-02222)	In house check: Oct-16
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (No. 217-02223)	In house check: Oct-16
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Jun-15)	In house check: Oct-16
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

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

Issued: July 26, 2016

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Accreditation No.: SCS 0108

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 1528-2013, "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	Modular Flat Phantom	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	750 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	41.9	0.89 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	40.9 ± 6 %	0.91 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	2.12 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	8.29 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	Condition	
SAR measured	250 mW input power	1.39 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	5.46 W/kg ± 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	55.5	0.96 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	55.1 ± 6 %	0.98 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	2.24 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	8.74 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	Condition	
SAR measured	250 mW input power	1.46 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	5.72 W/kg ± 16.5 % (k=2)

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

Impedance, transformed to feed point	54.7 Ω + 2.2 $j\Omega$
Return Loss	- 26.1 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	49.6 Ω - 0.8 $j\Omega$
Return Loss	- 41.1 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.033 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	March 22, 2010

DASY5 Validation Report for Head TSL

Date: 21.07.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 750 MHz D750V3; Type: D750V3; Serial: D750V3 - SN:1014

Communication System: UID 0 - CW; Frequency: 750 MHz

Medium parameters used: $f = 750$ MHz; $\sigma = 0.91$ S/m; $\epsilon_r = 40.9$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.07, 10.07, 10.07); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

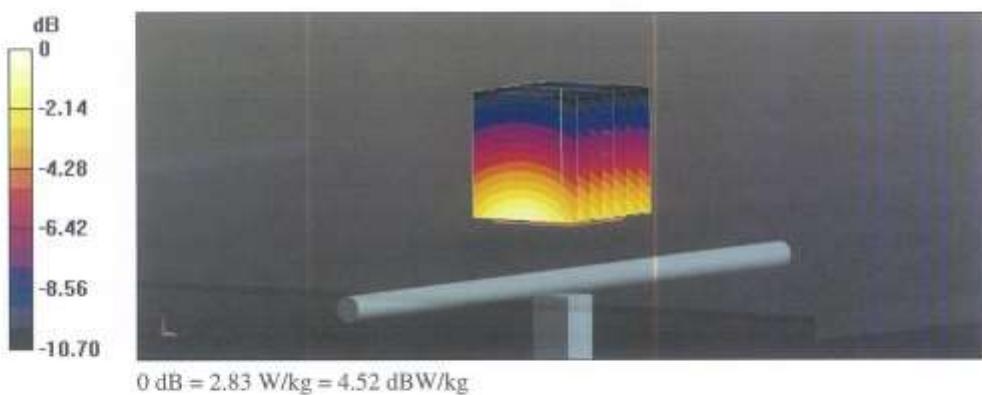
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 58.75 V/m; Power Drift = 0.01 dB

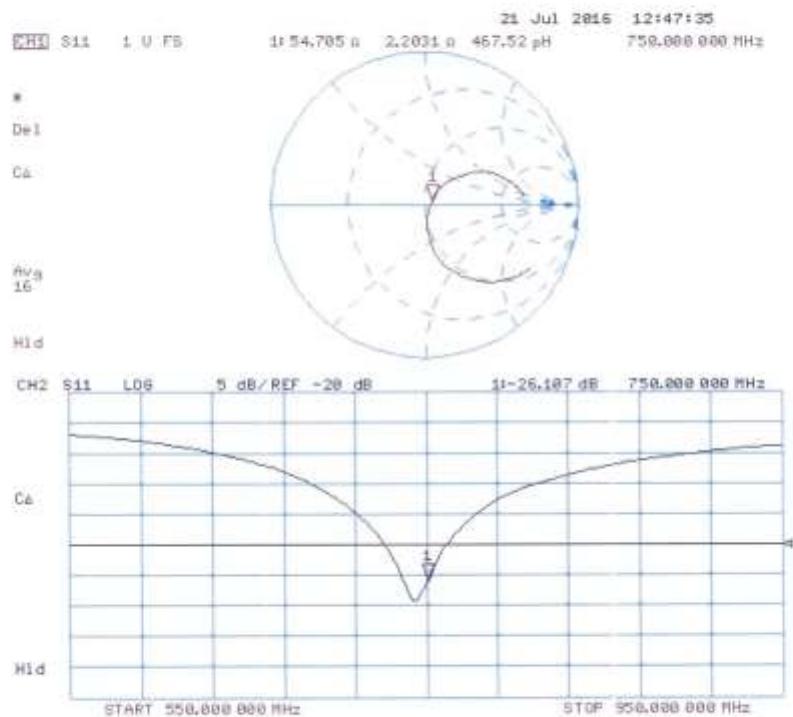
Peak SAR (extrapolated) = 3.19 W/kg

SAR(1 g) = 2.12 W/kg; SAR(10 g) = 1.39 W/kg

Maximum value of SAR (measured) = 2.83 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 22.07.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 750 MHz D750V3; Type: D750V3; Serial: D750V3 - SN:1014

Communication System: UID 0 - CW; Frequency: 750 MHz

Medium parameters used: $f = 750$ MHz; $\sigma = 0.99$ S/m; $\epsilon_r = 55.1$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.99, 9.99, 9.99); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

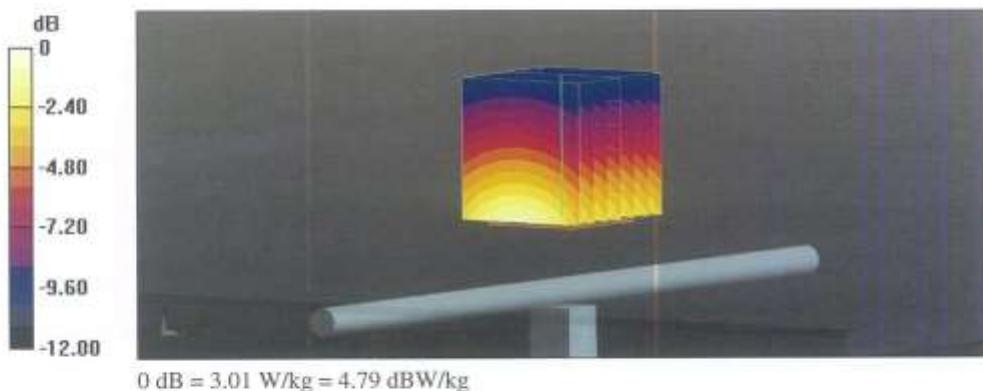
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 57.48 V/m; Power Drift = 0.00 dB

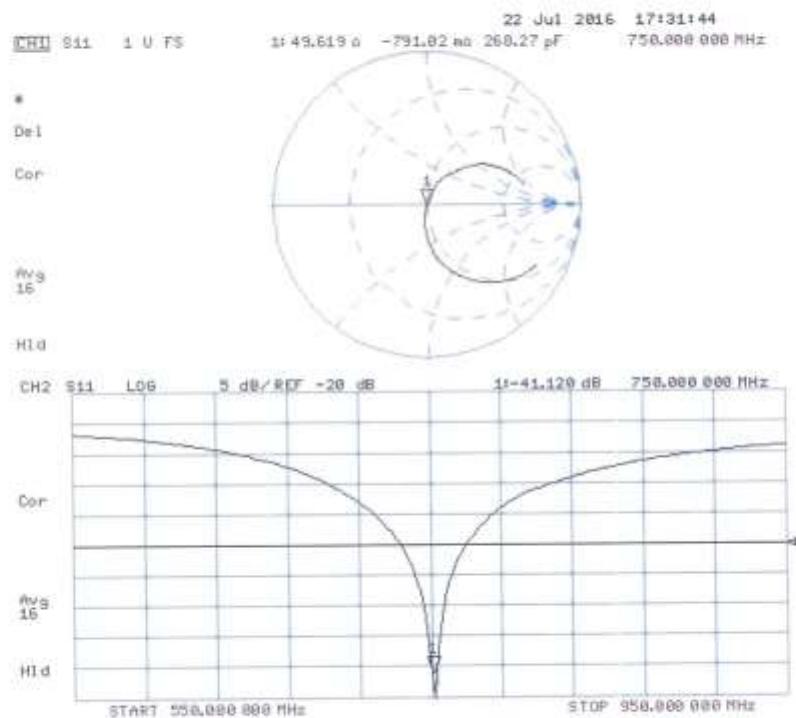
Peak SAR (extrapolated) = 3.42 W/kg

SAR(1 g) = 2.24 W/kg; SAR(10 g) = 1.46 W/kg

Maximum value of SAR (measured) = 3.01 W/kg



Impedance Measurement Plot for Body TSL



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Accreditation No.: **SCS 0108**

Client **HCT (Dymstec)**

Certificate No: **D1800V2-2d007_Nov16**

CALIBRATION CERTIFICATE

Object **D1800V2 - SN:2d007**

Calibration procedure(s) **QA CAL-05.v9**
Calibration procedure for dipole validation kits above 700 MHz

Calibration date: **November 16, 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 $(22 \pm 3)^\circ\text{C}$ 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)	06-Apr-16 (No. 217-02292)	Apr-17
Type-N mismatch combination	SN: 5047.2 / 06327	06-Apr-16 (No. 217-02295)	Apr-17
Reference Probe EX3DV4	SN: 7349	15-Jun-16 (No. EX3-7349_Jun16)	Jun-17
DAE4	SN: 601	30-Dec-15 (No. DAE4-601_Dec15)	Dec-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-16 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 5753E	SN: US37390585	18-Oct-01 (in house check Oct-16)	In house check: Oct-17

Calibrated by:	Name	Function	Signature
	Claudio Leubler	Laboratory Technician	

Approved by:	Name	Function	Signature
	Katja Pokovic	Technical Manager	

Issued: November 17, 2016

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Accreditation No.: SCS 0108

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 1528-2013, "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	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1800 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.0	1.40 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	39.1 ± 6 %	1.39 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	9.47 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	37.8 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	4.95 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	19.8 W/kg ± 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.3	1.52 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	53.6 ± 6 %	1.52 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	9.39 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	37.6 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	4.97 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	19.9 W/kg ± 16.5 % (k=2)

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

Impedance, transformed to feed point	47.2 Ω - 8.4 $j\Omega$
Return Loss	- 20.9 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	43.9 Ω - 6.2 $j\Omega$
Return Loss	- 20.7 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1,203 ns
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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	July 23, 2001

DASY5 Validation Report for Head TSL

Date: 15.11.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1800 MHz; Type: D1800V2; Serial: D1800V2 - SN:2d007

Communication System: UID 0 - CW; Frequency: 1800 MHz

Medium parameters used: $f = 1800$ MHz; $\sigma = 1.39$ S/m; $\epsilon_r = 39.1$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.26, 8.26, 8.26); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

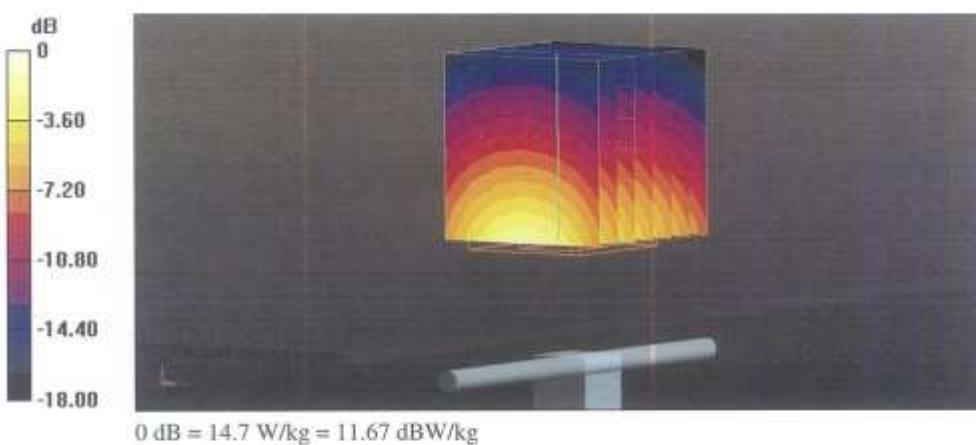
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 105.8 V/m; Power Drift = -0.04 dB

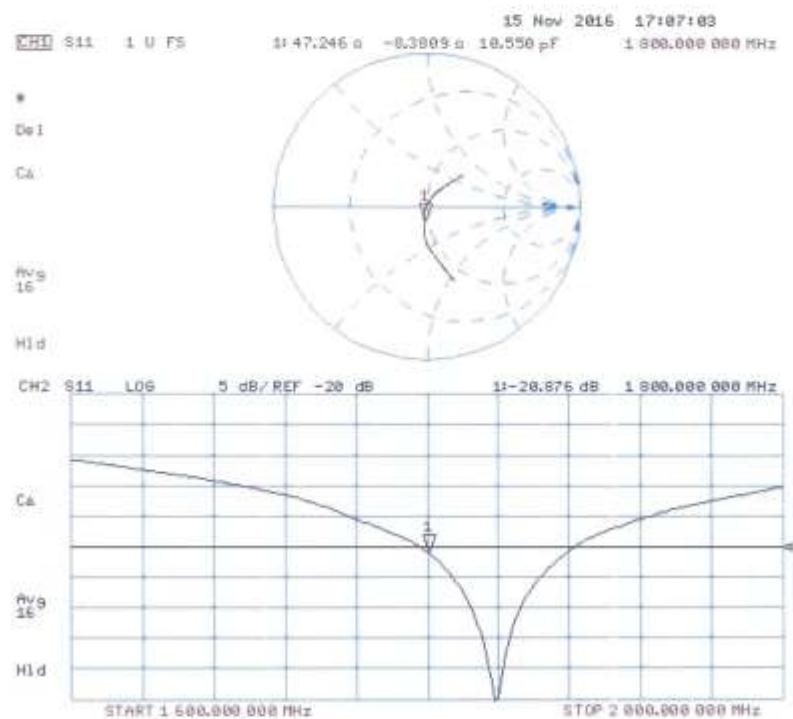
Peak SAR (extrapolated) = 17.5 W/kg

SAR(1 g) = 9.47 W/kg; SAR(10 g) = 4.95 W/kg

Maximum value of SAR (measured) = 14.7 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 16.11.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1800 MHz; Type: D1800V2; Serial: D1800V2 - SN:2d007

Communication System: UID 0 - CW; Frequency: 1800 MHz

Medium parameters used: $f = 1800$ MHz; $\sigma = 1.52$ S/m; $\epsilon_r = 53.6$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.17, 8.17, 8.17); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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 = 101.5 V/m; Power Drift = -0.03 dB

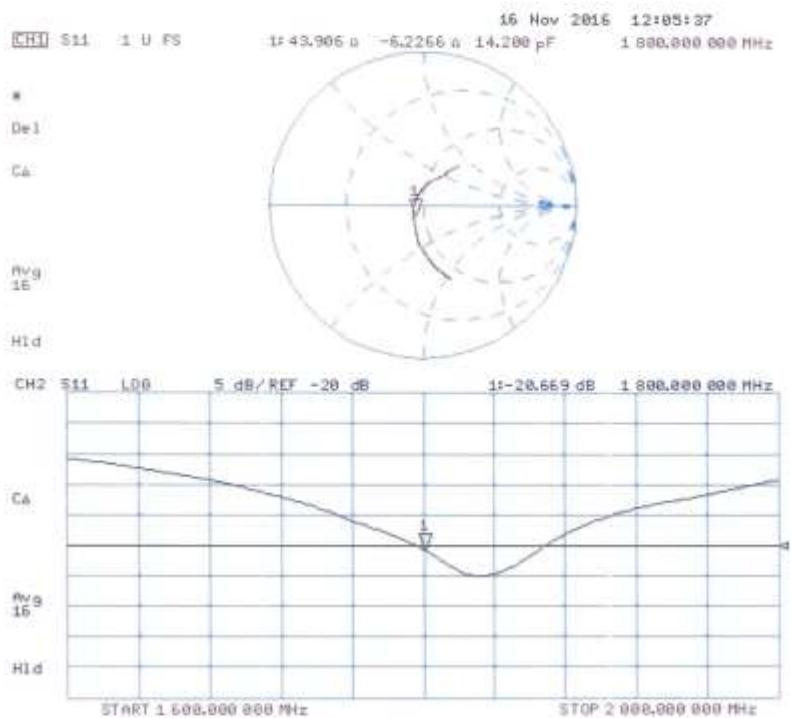
Peak SAR (extrapolated) = 16.3 W/kg

SAR(1 g) = 9.39 W/kg; SAR(10 g) = 4.97 W/kg

Maximum value of SAR (measured) = 14.1 W/kg



Impedance Measurement Plot for Body TSL



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Accreditation No.: **SCS 0108**

Client **HCT (Dymstec)**

Certificate No: **D2450V2-965_Apr16**

CALIBRATION CERTIFICATE

Object **D2450V2 - SN: 965**

Calibration procedure(s) **QA.CAL-05.v9**
Calibration procedure for dipole validation kits above 700 MHz

Calibration date: **April 19, 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 ($22 \pm 3^\circ\text{C}$ 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-Z81	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 EX30V4	SN: 7349	31-Dec-15 (No. EX3-7349_Dec15)	Dec-16
DAE4	SN: 601	30-Dec-15 (No. DAE4-601_Dec15)	Dec-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (No. 217-02222)	In house check; Oct-16
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (No. 217-02222)	In house check; Oct-16
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (No. 217-02223)	In house check; Oct-16
RF generator R&S SMT-08	SN: 100972	15-Jun-15 (In house check Jun-15)	In house check; Oct-16
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-15)	In house check; Oct-16

Calibrated by:	Name	Function	Signature
	Michael Weber	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: April 20, 2016

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Accreditation No.: SCS 0108

Glossary:

TS	tissue simulating liquid
ConvF	sensitivity in TS / 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 TS:* 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 TS parameters:* The measured TS 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	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz \pm 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 \pm 0.2) °C	40.0 \pm 6 %	1.83 mho/m \pm 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	12.7 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	50.6 W/kg \pm 17.0 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	5.89 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.5 W/kg \pm 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 \pm 0.2) °C	52.7 \pm 6 %	1.98 mho/m \pm 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	12.4 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	49.2 W/kg \pm 17.0 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.78 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	23.0 W/kg \pm 16.5 % (k=2)

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

Impedance, transformed to feed point	54.6 Ω + 3.8 $j\Omega$
Return Loss	-24.8 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	51.0 Ω + 5.9 $j\Omega$
Return Loss	-24.5 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.162 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	November 19, 2014

DASY5 Validation Report for Head TSL

Date: 19.04.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 965

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.83$ S/m; $\epsilon_r = 40$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.76, 7.76, 7.76); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

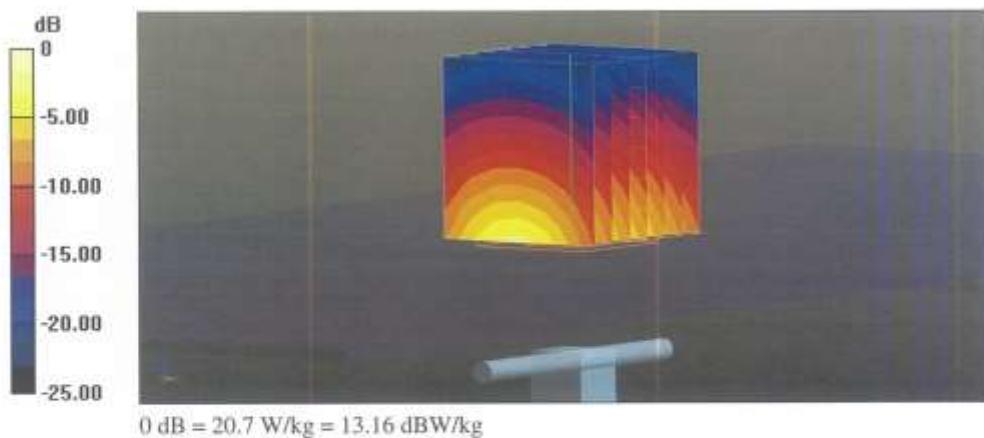
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 112.4 V/m; Power Drift = 0.02 dB

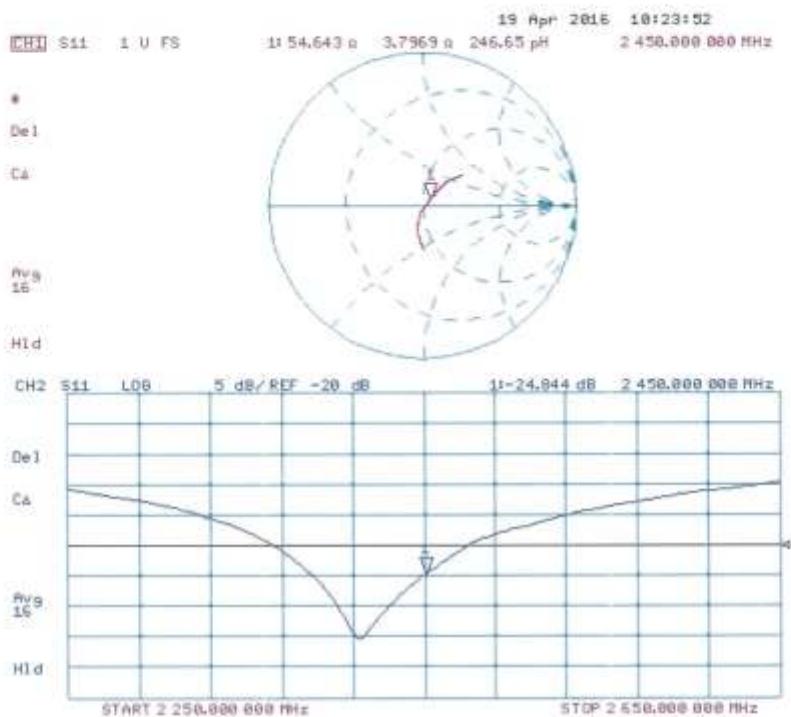
Peak SAR (extrapolated) = 25.6 W/kg

SAR(1 g) = 12.7 W/kg; SAR(10 g) = 5.89 W/kg

Maximum value of SAR (measured) = 20.7 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 19.04.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 965

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.98$ S/m; $\epsilon_r = 52.7$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.79, 7.79, 7.79); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

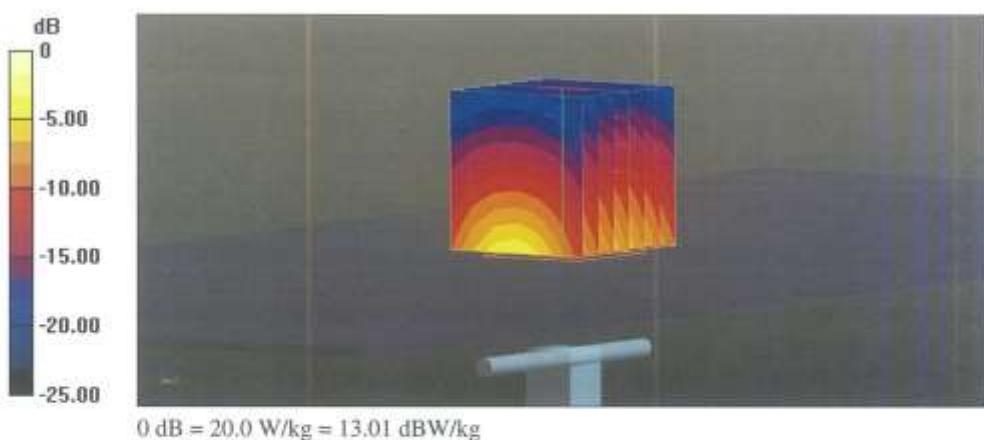
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 104.7 V/m; Power Drift = 0.01 dB

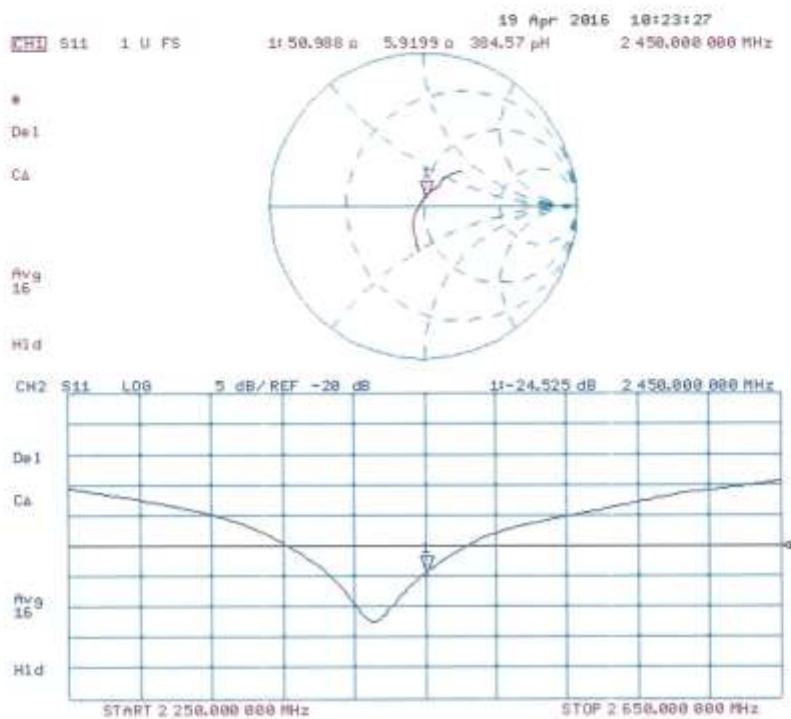
Peak SAR (extrapolated) = 24.7 W/kg

SAR(1 g) = 12.4 W/kg; SAR(10 g) = 5.78 W/kg

Maximum value of SAR (measured) = 20.0 W/kg



Impedance Measurement Plot for Body TSL



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s p e a g

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Certificate of conformity / First Article Inspection

Item	Triple Modular Flat Phantom V5.1
Type No	QD 000 P51 C
Series No	1100 and higher
Manufacturer / Origin	Untersee Composites Knebelstrasse 8, CH-8268 Mannenbach, Switzerland

Tests

The sub-units of item 1100 are identified with the designation 1100/1, 1100/2 and 1100/3. Tests were conducted on all 3 sub-units of this phantom.

Test	Requirement	Details	Units tested
Material thickness	Compliant with the standard requirements.	2 mm +/- 0.2 mm 30 points over the bottom area	all
Material parameters	Dielectric parameters for required frequencies	200 MHz – 6 GHz – Relative permittivity 3 - 5 Loss tangent < 0.05.	Material sample
Material resistivity	The material is compatible with the liquids defined in the standards if handled and cleaned according to the instructions.	DGBE based simulating liquids. Observe Technical Note for material compatibility.	Material Samples
Shape	Internal dimensions	Internal height: > 175 mm Bottom internal length: 280 mm Bottom internal width: 175 mm Nominal filling height: 155 mm Nominal volume: 9.2 l	Pre-series, design
Sagging	Depending on standard	No initial sagging (negative preshaped, change < 0.5 mm)	1100/2

Standards

- [1] IEEE 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- [2] IEC 62209 – 1, "Specific Absorption Rate (SAR) in the frequency range of 300 MHz to 3 GHz – Measurement Procedure, Part 1: Hand-held mobile wireless communication devices", February 2005
- [3] IEC 62209 – 2, "Evaluation of Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices in the Frequency Range of 30 MHz to 6 GHz: Human models, Instrumentation and Procedures, Part 2: Procedure to determine the Specific Absorption Rate (SAR) for ... including accessories and multiple transmitters", March 2010
- [4] KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Conformity

Based on the dimensions and sample tests above, we certify that this item is in compliance with the standards [1] to [4] for frequencies > 700 MHz, if operated according to the specific requirements.

Date

16.07.2015

Signature / Stamp**s p e a g**

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Attachment 5. – SAR Tissue Characterization

The brain and muscle mixtures consist of a viscous gel using hydrox-ethyl cellulose (HEC) gelling agent and saline solution (see Table 3.1). Preservation with a bactericide is added and visual inspection is made to make sure air bubbles are not trapped during the mixing process. The mixture is calibrated to obtain proper dielectric constant (permittivity) and conductivity of the desired tissue. The mixture characterizations used for the brain and muscle tissue simulating liquids are according to the data by C. Gabriel and G. Hartsgrave.

Ingredients (% by weight)	Frequency (MHz)					
	750		1 900		2 450 – 2 700	
Tissue Type	Head	Body	Head	Body	Head	Body
Water	41.1	51.7	54.9	70.17	71.88	73.2
Salt (NaCl)	1.4	0.9	0.18	0.39	0.16	0.1
Sugar	57.0	47.2	0.0	0	0.0	0.0
HEC	0.2	0	0.0	0	0.0	0.0
Bactericide	0.2	0.1	0.0	0	0.0	0.0
Triton X-100	0.0	0.0	0.0	0.0	19.97	0.0
DGBE	0.0	0.0	44.92	29.44	7.99	26.7
Diethylene glycol hexyl ether	-	-	-	-	-	-

Salt: 99 % Pure Sodium Chloride Sugar: 98 % Pure Sucrose
Water: De-ionized, 16M resistivity HEC: Hydroxyethyl Cellulose
DGBE: 99 % Di(ethylene glycol) butyl ether,[2-(2-butoxyethoxy) ethanol]
Triton X-100(ultra pure): Polyethylene glycol mono[4-(1,1,3,3-tetramethylbutyl)phenyl] ether

Composition of the Tissue Equivalent Matter

Attachment 6. – SAR SYSTEM VALIDATION

Per FCC KCB 865664 D02v01r02, SAR system validation status should be document 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 has been included.

SAR System No.	Probe	Probe Type	Probe Calibration Point		Dipole	Date	Dielectric Parameters		CW Validation			Modulation Validation		
			Measured Permittivity	Measured Conductivity			Sensitivity	Probe Linearity	Probe Isotropy	MOD. Type	Duty Factor	PAR		
8	3967	EX3DV4	Body	750	1014	2016.12.30	56.0	0.98	PASS	PASS	PASS	N/A	N/A	N/A
8	3967	EX3DV4	Body	1800	2d007	2016.12.30	53.4	1.53	PASS	PASS	PASS	N/A	N/A	N/A
8	3967	EX3DV4	Body	2450	965	2016.12.30	52.5	2.00	PASS	PASS	PASS	OFDM	N/A	PASS

SAR System Validation Summary 1g

Note:

All measurement were performed using probes calibrated for CW signal only. Modulations in the table above represent test configurations for which the measurement system has been validated per FCC KDB Publication 865664 D01v01r04. SAR system were validated for modulated signals with a periodic duty cycle, such as GMSK, or with a high peak to average ratio (>5 dB), such as OFDM according to KDB 865664 D01v01r04.