FCC SAR Test Report

Product	:	**Wireless 802.11AC Dual band USB Adapter**
Trade mark	:	**N/A**
Model/Type reference	:	**DC29**
Serial Number	:	**WS1604180562**
Report Number	:	**EED32I00268703**
FCC ID	:	**2AHDI-DC29**
Date of Issue:	:	**Nov. 25, 2016**
Test Standards	:	**Refer to Section 1.5**
Test result	:	**PASS**

Prepared for:

Shenzhen TOMTOP Technology Co., Ltd

G-4 Zone 5/F, No.1 Exchange Square, Huanan City, Pinghu Town, Longgang Dist, Shenzhen, China

Prepared by:

Centre Testing International Group Co., Ltd.

Hongwei Industrial Zone, Bao'an 70 District, Shenzhen, Guangdong, China

TEL: +86-755-3368 3668

FAX: +86-755-3368 3385

CENTRE TESTING INTERNATIONAL GROUP CO.,LTD. CTI Report Seal

Compiled by:	Kevin lan	Reviewed by:	Tom Tang
Approved by:	Sheek Luo Sheek Luo Lab supervisor	Date:	Nov. 25, 2016

Check No.: 2457586783

Table of contents

1 General information.......... 5

1.1 Notes.......... 5
1.2 Application details.......... 5
1.3 Statement of Compliance.......... 6
1.4 EUT Information.......... 7
1.5 Test standard/s.......... 8
1.6 RF exposure limits.......... 9
1.7 SAR Definition.......... 9
1.8 Testing laboratory.......... 10
1.9 Test Environment.......... 10
1.10 Applicant and Manufacturer.......... 10

2 SAR Measurement System Description and Setup.......... 11

2.1 The Measurement System Description.......... 11
2.2 Probe description.......... 12
2.3 Data Acquisition Electronics description.......... 13
2.4 SAM Twin Phantom description.......... 14
2.5 ELI4 Phantom description.......... 15
2.6 Device Holder description.......... 16

3 SAR Test Equipment List.......... 17

4 SAR Measurement Procedures.......... 18

4.1 Spatial Peak SAR Evaluation.......... 18
4.2 Data Storage and Evaluation.......... 19
4.3 Data Storage and Evaluation.......... 23

5 SAR Verification Procedure.......... 25

5.1 Tissue Verification.......... 25
5.2 System check procedure.......... 27
5.3 System check results.......... 28

6 SAR Measurement variability and uncertainty.......... 29

6.1 SAR measurement variability.......... 29
6.2 SAR measurement uncertainty.......... 29

7 SAR Test Configuration.......... 30

7.1 WIFI 2.4G Test Configurations.......... 31
7.2 WIFI 5G Test Configurations.......... 32

8 SAR Test Results.......... 35

8.1 Conducted Power Measurements **35**
8.1.1 Conducted power of WiFi 5G 35
8.1.2 Conducted Power of WiFi 2.4G 38
8.2 SAR test results **40**
8.2.1 Results overview of WiFi 5G 41
8.2.2 Results overview of WiFi 2.4G 42
8.3 Multiple Transmitter Information **43**
8.4 Stand-alone SAR **44**
8.5 Simultaneous Transmission Conlcusion **44**
Annex A: Appendix A: SAR System performance Check Plots **45**
Annex B: Appendix B: SAR Measurement results Plots **45**
Annex C: Appendix C: Calibration reports **45**
Annex D: Appendix D: Photo documentation **45**

Modified History

REV.	Modification Description	Issued Date	Remark
REV.1.0	Initial Test Report Relesse	Nov. 25, 2016	

1 General information

1.1 Notes

The test results of this test report relate exclusively to the test item specified in this test report.

Centre Testing International Group Co., Ltd. does not assume responsibility for any conclusions and generalisations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item. The test report is not to be reproduced or published in full without the prior written permission.

1.2 Application details

Date of receipt of test item:	2016-10-15
Start of test:	2016-10-21
End of test:	2016-11-04

1.3 Statement of Compliance

The maximum results of Specific Absorption Rate (SAR) found during testing for Shenzhen TOMTOP Technology Co., Ltd. Model Name: DC29 are as below:

Band		
	Test Position	MAX Reported $SAR_{1\text{-}g}$ (W/kg)
WIFI 2.4G	1-g Body (5 mm)	0.517
WIFI 5G	1-g Body (5 mm)	0.159

Note:

The device is in compliance with Specific Absorption Rate （SAR） for general population/uncontrolled exposure limits according to the FCC rule §2.1093, the ANSI/IEEE C95.1:1992, the NCRP Report Number 86 for uncontrolled environment, according to the Industry Canada Radio Standards Specification RSS-102 for General Population/Uncontrolled exposure, and had been tested in accordance with the measurement methods and procedures specified in IEEE Std 1528-2013

1.4 EUT Information

<table>
<tr><td colspan="4">Device Information：</td></tr>
<tr><td>Product Name:</td><td colspan="3">Wireless 802.11AC Dual band USB Adapter</td></tr>
<tr><td>Model:</td><td colspan="3">DC29</td></tr>
<tr><td>FCC ID:</td><td colspan="3">2AHDI-DC29</td></tr>
<tr><td>SN:</td><td colspan="3">WS1604180562</td></tr>
<tr><td>Device Type:</td><td colspan="3">Portable device</td></tr>
<tr><td>Exposure Category:</td><td colspan="3">uncontrolled environment / general population</td></tr>
<tr><td>Hardware version:</td><td colspan="3">N/A</td></tr>
<tr><td>Software version :</td><td colspan="3">N/A</td></tr>
<tr><td>Antenna Type :</td><td colspan="3">internal antenna</td></tr>
<tr><td colspan="4">Device Operating Configurations:</td></tr>
<tr><td>Supporting Mode(s) :</td><td colspan="3">WIFI 2.4G: b/g/n(HT20/HT40)
WIFI 5G 802.11a; WIFI 5G 802.11n(20MHz/40MHz);
WIFI 5G 802.11ac(20MHz/40MHz/80MHz)</td></tr>
<tr><td>Duty Cycle used for SAR testing</td><td colspan="3">WIFI: 100%</td></tr>
<tr><td>Modulation:</td><td colspan="3">DSSS,OFDM,</td></tr>
<tr><td rowspan="3">Operating Frequency Range(s)</td><td>Band</td><td>TX(MHz)</td><td>RX(MHz)</td></tr>
<tr><td>WIFI 2.4G</td><td colspan="2">2412~2462</td></tr>
<tr><td>WIFI 5G</td><td colspan="2">5150-5250
5725-5850</td></tr>
<tr><td rowspan="4">Test Channels (low-mid-high):</td><td colspan="3">WIFI 2.4G 802.11b/g/n(20M):1-6-11; 3-6-9n(40M)</td></tr>
<tr><td colspan="3">WIFI 5G 802.11a/n/ac(20M):
36-40-44-48-149-153-157-161-165</td></tr>
<tr><td colspan="3">WIFI 5G 802.11 n/ac (40M): 38-46-151-159</td></tr>
<tr><td colspan="3">WIFI 5G 802.11ac 80M:42-155</td></tr>
<tr><td>Used Host Products:</td><td colspan="3">ThinkPad T61</td></tr>
</table>

Remark: The tested samples and the sample information are provided by the client.

1.5 Test standard/s

ANSI Std C95.1-1992	Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.
IEEE Std 1528-2013	Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques
RSS-102	Radio Frequency Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands (Issue 5 of March 2015)
KDB 248227 D01	SAR guidance for IEEE 802.11(Wi-Fi) transmitters v02r02
KDB 447498 D01	General RF Exposure Guidance v06
KDB 447498 D02	SAR Procedures for Dongle Xmtr v02r01
KDB 690783 D01	SAR Listings on Grants v01r03
KDB 865664 D01	SAR Measurement 100 MHz to 6 GHz v01r04
KDB 865664 D02	RF Exposure Reporting v01r02

1.6 RF exposure limits

Human Exposure	Uncontrolled Environment General Population	Controlled Environment Occupational
Spatial Peak SAR* (Brain/Body/Arms/Legs)	**1.60 mW/g**	8.00 mW/g
Spatial Average SAR** (Whole Body)	0.08 mW/g	0.40 mW/g
Spatial Peak SAR*** (Hands/Feet/Ankle/Wrist)	4.00 mW/g	20.00 mW/g

The limit applied in this test report is shown in bold letters

Notes:

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

** The Spatial Average value of the SAR averaged over the whole body.

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

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

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.

1.7 SAR Definition

Specific Absorption Rate is defined as the time derivative (rate) of the incremental energy (dW) absorbed by(dissipated in) an incremental mass (dm) contained in a volume element (dV) of a given density (ρ).

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

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

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

where:

σ = conductivity of the tissue (S/m)
ρ = mass density of the tissue (kg/m^3)
E = rms electric field strength (V/m)

1.8 Testing laboratory

Test Site	Centre Testing International Group Co., Ltd.
Test Location	Hongwei Industrial Zone, Bao'an 70 District, Shenzhen, Guangdong, China
Telephone	+86 (0) 755 3368 3668
Fax	+86 (0) 755 3368 3385

1.9 Test Environment

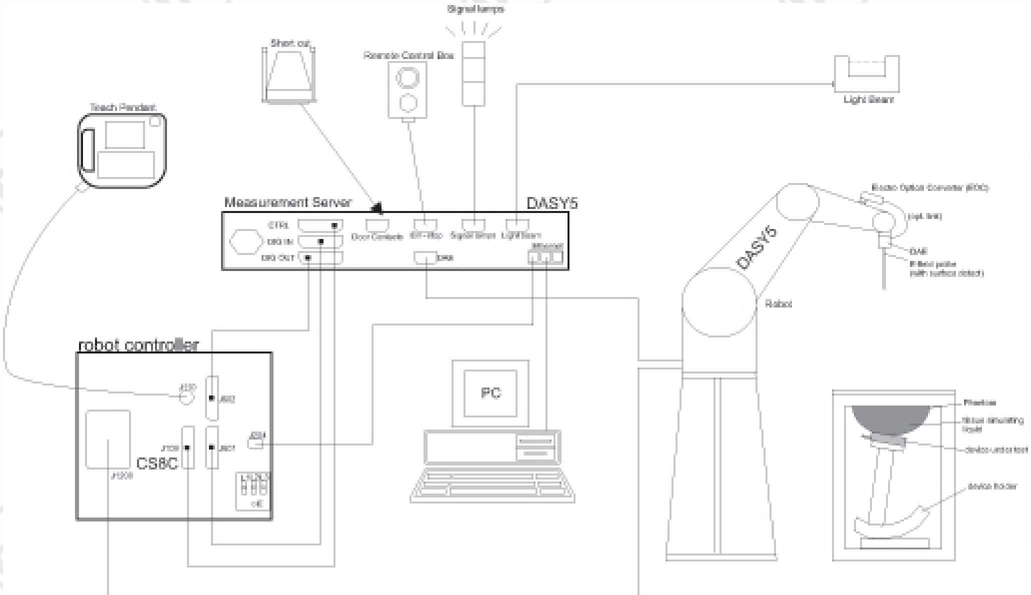
	Required	Actual
Ambient temperature:	18 – 25 °C	21.5 ± 2.0 °C
Tissue Simulating liquid:	18 – 25 °C	21.5 ± 2.0 °C
Relative humidity content:	30 – 70 %	30 – 70 %

1.10 Applicant and Manufacturer

Applicant/Client Name	Shenzhen TOMTOP Technology Co., Ltd.
Applicant Address	G-4 Zone 5/F, No.1 Exchange Square, Huanan City, Pinghu Town, Longgang Dist, Shenzhen, China.
Manufacturer	Winstars Technology Limited
Address of Manufacturer	Block 4, TaiSong Industrial Park, DaLang Street, LongHua Town, Bao'an district, Shenzhen, China

2 SAR Measurement System Description and Setup

2.1 The Measurement System Description



The DASY5 system for performing compliance tests consists of the following items:

- A standard high precision 6-axis robot (Stäubli TX/RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running Win7 profesional operating system and the DASY5 software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as warning lamps, etc.
- The phantom, the device holder and other accessories according to the targeted measurement.

2.2 Probe description

Dosimetric Probes: These probes are specially designed and calibrated for use in liquids with high permittivities. They should not be used in air, since the spherical isotropy in air is poor(±2 dB). The dosimetric probes have special calibrations in various liquids at different frequencies.

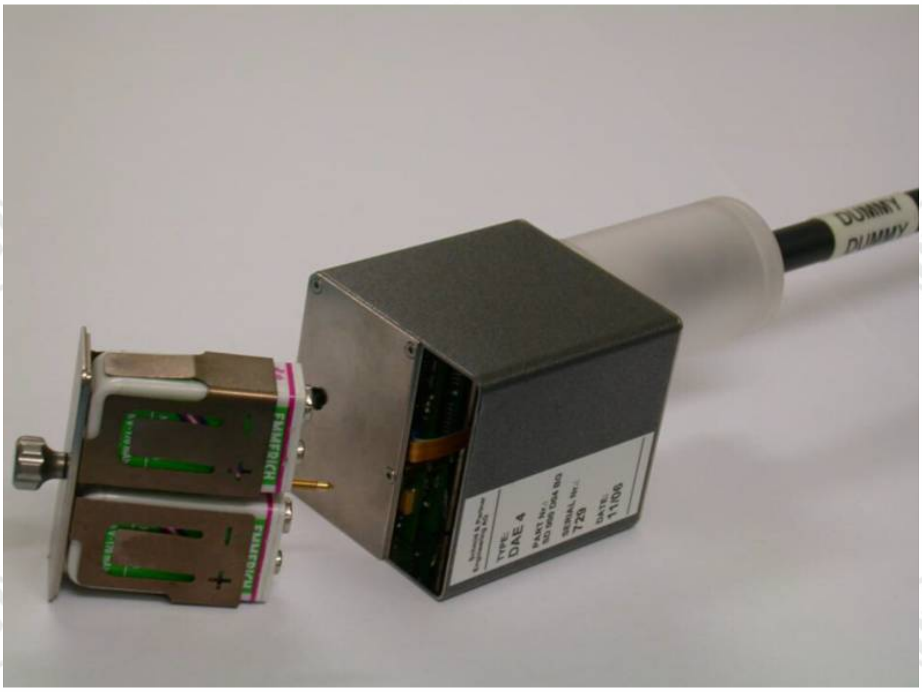
Construction	Symmetrical design with triangular core Interleaved sensors Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Calibration	ISO/IEC 17025 calibration service available.
Frequency	10 MHz to 6 GHz; Linearity: ± 0.2 dB
Probe Overall Length	337mm
Probe Body Diameter	10mm
Tip Length	9mm
Tip Diameter	2.5mm
Dynamic range	5 μW/g to 100 mW/g; Linearity: ± 0.2 dB

2.3 Data Acquisition Electronics description

The data acquisition electronics (DAE4) consist 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 with a control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information, as well as an optical uplink for commands and the clock.

The mechanical probe mounting device includes two different sensor systems for frontal and sideways probe contacts. They are used for mechanical surface detection and probe collision detection. The input impedance of the DAE4 box is 200MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.

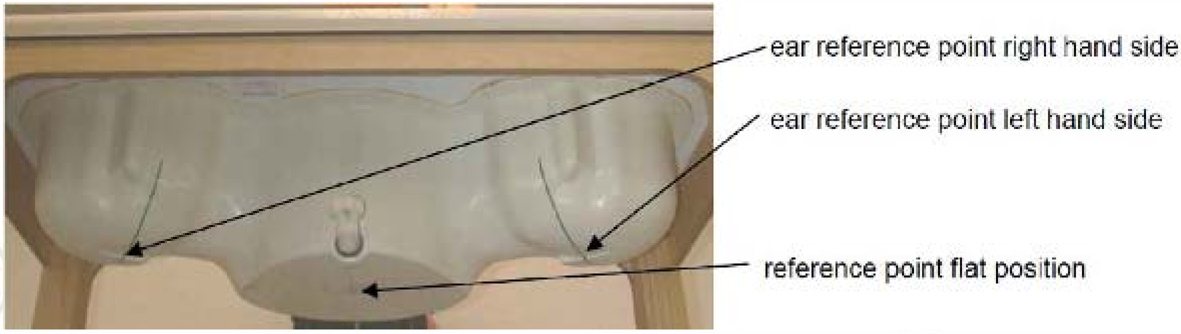
Batteries: The DAE works with either two standard 9V batteries or two 9V (actually 8.4V or 9.6 V) rechargeable batteries. Because the electronics automatically power-down unused components during braking or between measurements, the battery lifetime depends on system usage. Typical lifetimes are >20 hours for batteries and >10 hours for accus. Remove the batteries if you do not plan to use the DAE for a long period of time.



2.4 SAM Twin Phantom description

The SAM twin phantom is a fiberglass shell phantom with 2mm shell thickness (except the ear region, where shell thickness increases to 6 mm). The phantom has three measurement areas:

- ♦ Left hand
- ♦ Right hand
- ♦ Flat phantom



The phantom table for the DASY systems have the size of 100 x 50 x 85 cm (L xWx H). these tables are reinforced for mounting of the robot onto the table. For easy dislocation these tables have fork lift cut outs at the bottom.

The bottom plate contains three pairs of bolts for locking the device holder. The device holder positions are adjusted to the standard measurement positions in the three sections.

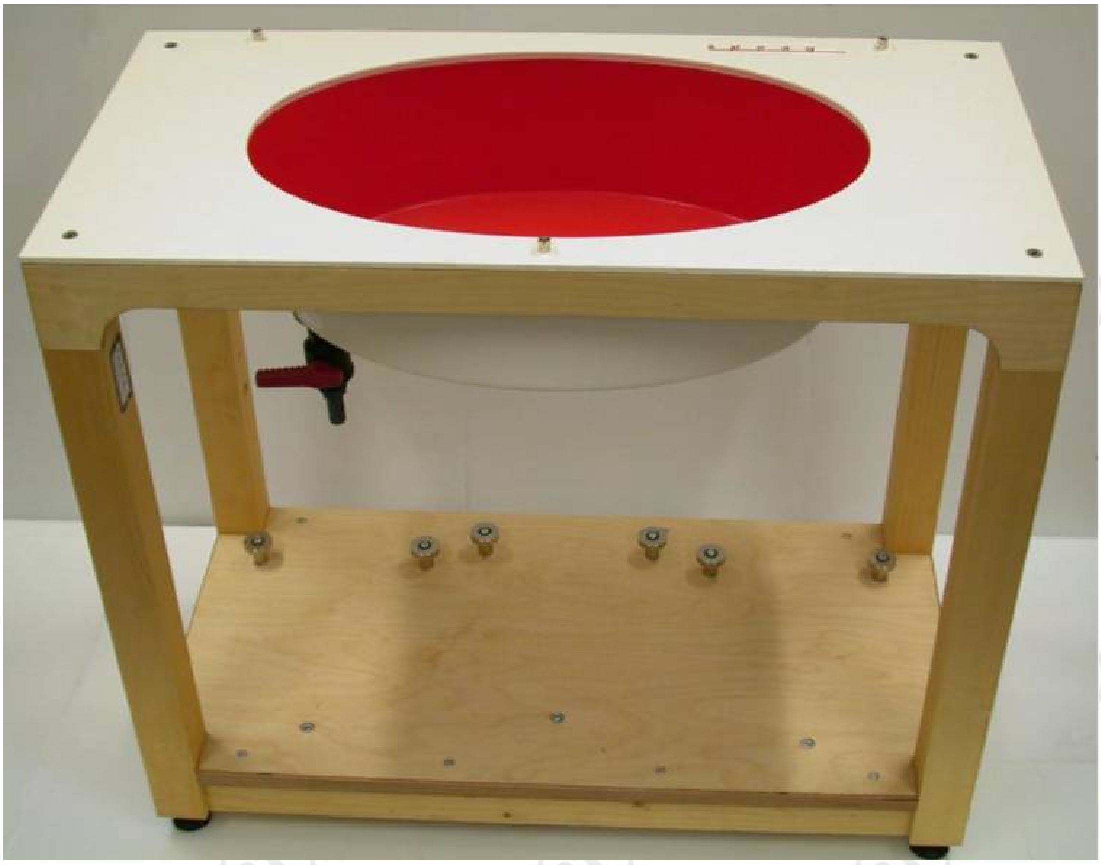
A white cover is provided to cover the phantom during off-periods to prevent water evaporation and changes in the liquid parameters.

Three reference marks are provided on the phantom counter. These reference marks are used to teach the absolute phantom position relative to the robot.

2.5 ELI4 Phantom description

The ELI4 phantom is intended for compliance testing of handheld and body mounted wireless devices in the frequency range of 30MHz to 6 GHz. ELI4 is fully compatible with the latest draft of the standard IEC 62209-2 and all known tissue simulating liquids.

ELI4 has been optimized regarding its performance and can be integrated into a SPEAG standard phantom table. A cover prevents evaporation of the liquid. Reference markings on the phantom allow installation of the complete setup, including all predefined phantom positions and measurement grids, by teaching three points



2.6 Device Holder description

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

The DASY device holder is designed to cope with the different positions given in the standard. It has two scales for device rotation (with respect to the body axis) and device inclination (with respect to the line between the ear reference points). The rotation centers for both scales is the ear reference point (ERP).Thus the device needs no repositioning when changing the angles.

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

3 SAR Test Equipment List

To simplify the identification of the test equipment and/or ancillaries which were used, the reporting of the relevant test cases only refer to the test item number as specified in the table below.

	Manufacturer	Device Type	Type(Model)	Serial number	Date of last calibration	Valid period
☒	SPEAG	E-Field Probe	EX3DV4	7328	2016-02-29	One year
☐	SPEAG	835 MHz Dipole	D835V2	4d193	2015-02-02	Three years
☐	SPEAG	1750 MHz Dipole	D1750V2	1134	2015-02-05	Three years
☐	SPEAG	1900 MHz Dipole	D1900V2	5d198	2015-02-06	Three years
☐	SPEAG	2000 MHz Dipole	D2000V2	1078	2015-02-05	Three years
☒	SPEAG	2450 MHz Dipole	D2450V2	959	2015-02-05	Three years
☐	SPEAG	2600 MHz Dipole	D2600V2	1101	2015-02-05	Three years
☒	SPEAG	5 GHz Dipole	D5GHzV2	1208	2015-02-03	Three years
☒	SPEAG	DAKS probe	DAKS-3.5	1052	2015-01-27	Three years
☒	SPEAG	Planar R140 Vector Reflectometer	DAKS-VNA R140	0200514	2015-01-27	Three years
☒	SPEAG	Data acquisition electronics	DAE4	1458	2016-02-26	One year
☒	SPEAG	Software	DASY 5	NA	NCR	NCR
☒	SPEAG	Twin Phantom	SAM V5.0	1875	NCR	NCR
☒	SPEAG	Flat Phantom	ELI V6.0	2024	NCR	NCR
☒	BALUN	Power Amplifier and directional coupler	SU319W	BLSZ1550140	NCR	NCR
☒	R & S	Universal Radio Communication Tester	CMU200	101553	2016-04-01	One year
☒	Agilent	Signal Generator	E4438C	MY45095744	2016-04-01	One year
☒	Agilent	Power Meter	E4418B	MY45104044	2015-12-01	One year
☒	Agilent	Power Meter Sensor	E9300A	MY41496140	2015-12-01	One year
☒	Agilent	Power Meter	PM2002	312901	2015-12-31	One year
☒	Agilent	Power Meter Sensor	51011A-EMC	36252	2015-12-31	One year

Note:

1) Per KDB865664D01 requirements for dipole calibration, the test laboratory has adopted three-year extended calibration interval. Each measured dipole is expected to evaluate with the following criteria at least on annual interval in Appendix C.

a) There is no physical damage on the dipole;

b) System check with specific dipole is within 10% of calibrated value;

c) The most recent return-loss result, measured at least annually, deviates by no more than 20% from the previous measurement.

d) The most recent measurement of the real or imaginary parts of the impedance, measured at least annually is within 5Ω from the previous measurement.

4 SAR Measurement Procedures

4.1 Spatial Peak SAR Evaluation

The DASY5 software includes all numerical procedures necessary to evaluate the spatial peak SAR values.The base for the evaluation is a "cube" measurement in a volume of 30mm^3 (7x7x7 points). The measured volume must include the 1 g and 10 g cubes with the highest averaged SAR values. For that purpose, the center of the measured volume is aligned to the interpolated peak SAR value of a previously performed area scan. If the 10g cube or both cubes are not entirely inside the measured volumes,the system issues a warning regarding the evaluated spatial peak values within the Postprocessing engine (SEMCAD X). This means that if the measured volume is shifted, higher values might be possible. To get the correct values you can use a finer measurement grid for the area scan. In complicated field distributions, a large grid spacing for the area scan might miss some details and give an incorrectly interpolated peak location. The entire evaluation of the spatial peak values is performed within the Postprocessing engine (SEMCAD X). The system always gives the maximum values for the 1 g and 10 g cubes.

The algorithm to find the cube with highest averaged SAR is divided into the following stages:

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

4.2 Data Storage and Evaluation

Data Storage

The DASY5 software stores the measured voltage acquired by the Data Acquisition Electronics (DAE) as raw data together with all the necessary software parameters for the data evaluation (probe calibration data, liquid parameters and communication system parameters) in measurement files with the extension .da5x. The postprocessing software evaluates the data every time the data is visualized or exported. This allows the verification and modification of the setup after completion of the measurement. For example, if a measurement has been performed with an incorrect crest factor, the parameter can be corrected afterwards and the data can be reevaluated.

To avoid unintentional parameter changes or data manipulations, the parameters in measured files are locked. In the administrator access mode of the software, the parameters can be unlocked. After changing the parameters, the measured scans can be reevaluated in the postprocessing engine.

The measured data can be visualized or exported in different units or formats, depending on the selected probe type (e.g., E-field, H-field, SAR). Some of these units are not available in certain situations or give meaningless results, e.g., a SAR-output in a lossless media will always be zero. Raw data can also be exported to perform the evaluation with other software packages.

Data Evaluation

The fields and SAR are calculated from the measured voltage (probe voltage acquired by the DAE) and the following parameters:

Probe parameters:	- Sensitivity	$norm_i$, a_{i0}, a_{i1}, a_{i2}
	- Conversion Factor	$convF_i$
	- Diode Compression Point	dcp_i
	- Probe Modulation Response Factors	a_i, b_i, c_i, d
Device parameters:	- Frequency	f
	- Crest factor	cf
Media parameters:	- Conductivity	σ
	- Relative Permittivity	ρ

This parameters are stored in the DASY5 V52 measurement file.

These parameters must be correctly set in the DASY5 V52 software setup. They are available as configuration file and can be imported into the measurement file. The values displayed in the multimeter window are assessed using the parameters of the actual system setup. In the scan visualization and export modes, the parameters stored in the measurement file are used.

The measured voltage is not proportional to the exciting. It must be first linearized.

Approximated Probe Response Linearization using Crest Factor.

This linearization method is enabled when a custom defined communication system is measured. The compensation applied is a function of the measured voltage, the detector diode compression point and the crest factor of the measured signal.

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

with V_i = linearized voltage of channel i (uV) (i = x,y,z)

U_i = measured voltage of channel i (uV) (i = x,y,z)

cf = crest factor of exciting field (DASY parameter)

dcp_i = diode compression point of channel i (uV) (Probe parameter, i = x,y,z)

Field and SAR Calculation

The primary field data for each channel are calculated using the linearized voltage:

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

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

with V_i = linearized voltage of channel i (i = x,y,z)

$Norm_i$ = sensor sensitivity of channel i (i = x,y,z)

uV/(V/m)^2 for E-field Probes

ConvF = sensitivity enhancement in solution

a_{ij} = sensor sensitivity factors for H-field probes

f = carrier frequency [GHz]

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

H_i = magnetic field strength of channel i in A/m

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

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

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

$$SAR = E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1'000}$$

with SAR = local specific absorption rate in mW/g

E_{tot} = total field strength in V/m

σ = conductivity in [mho/m] or [Siemens/m]

ρ = equivalent tissue density in g/cm^3

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

Spatial Peak SAR for 1 g and 10 g

The DASY5 software includes all numerical procedures necessary to evaluate the spatial peak SAR values.The base for the evaluation is a "cube" measurement at the points of the fine cube grid consisting of 5 x 5 x 7 points(with 8mm horizontal resolution) or 7 x 7 x 7 points(with 5mm horizontal resolution) or 8 x 8 x 7 points(with 4mm horizontal resolution)..The entire evaluation of the spatial peak values is performed within the Postprocessing engine (SEMCAD X).The system always gives the maximum values for the 1 g and 10 g cubes. The algorithm to find the cube with highest averaged SAR is divided into the following stages:

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

4.3 Data Storage and Evaluation

The DASY5 installation includes predefined files with recommended procedures for measurements and validation. All test positions (head or body-worn) are tested with the same configuration of test steps differing only in the grid definition for the different test positions.

Step 1: Power reference measurement

The Power Reference Measurement and Power Drift Measurement are for monitoring the power drift of the device under test in the batch process. The Minimum distance of probe sensors to surface determines the closest measurement point to phantom surface. By default, the Minimum distance of probe sensors to surface is 4 mm. This distance can be modified by the user, but cannot be smaller than the Distance of sensor calibration points to probe tip as defined in the probe properties. The SAR measurement was taken at a selected spatial reference point to monitor power variations during testing. This fixed location point was measured and used as a reference value.

Step 2: Area Scan

The Area Scan is used as a fast scan in two dimensions to find the area of high field values, before doing a finer measurement around the hotspot. The sophisticated interpolation routines implemented in DASY5 software can find the maximum locations even in relatively coarse grids. When an Area Scan has measured all reachable points, it computes the field maxima found in the scanned area, within a range of the global maximum. The range (in dB) is specified in the standards for compliance testing. For example, a 2 dB range is required in IEEE 1528-2003 and IEC 62209 standards, whereby 3 dB is a requirement when compliance is assessed in accordance with the ARIB standard (Japan). If only one Zoom Scan follows the Area Scan, then only the absolute maximum will be taken as reference. For cases where multiple maximums are detected, the number of Zoom Scans has to be increased accordingly.

Step 3: Zoom Scan

The Zoom Scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1 gram and 10 gram of simulated tissue. The default Zoom Scan is defined in the following table. DASY5 is also able to perform repeated zoom scans if more than 1 peak is found during area scan. When the measurement is done, the Zoom Scan evaluates the averaged SAR for 1 gram and 10 gram and displays these values next to the job's label.

Area scan and Zoom scan resolutions per FCC KDB Publication 865664 D01:

Frequency	Maximun Area Scan resolution (Δx_{Area},Δy_{Area})	Maximun Zoom Scan spatial resolution (Δx_{Zoom},Δy_{Zoom})	Maximun Zoom Scan spatial resolution			Minimum zoom scan volume (x,y,z)
			Uniform Grid	Graded Grad		
			$\Delta z_{Zoom}(n)$	$\Delta z_{Zoom}(1)$*	$\Delta z_{Zoom}(n>1)$*	
≤ 2GHz	≤ 15mm	≤ 8mm	≤ 5mm	≤ 4mm	≤1.5*$\Delta z_{Zoom}(n-1)$	≥ 30mm
2-3GHz	≤ 12mm	≤ 5mm	≤ 5mm	≤ 4mm	≤1.5*$\Delta z_{Zoom}(n-1)$	≥ 30mm
3-4GHz	≤ 12mm	≤ 5mm	≤ 4mm	≤ 3mm	≤1.5*$\Delta z_{Zoom}(n-1)$	≥ 28mm
4-5GHz	≤ 10mm	≤ 4mm	≤ 3mm	≤ 2.5mm	≤1.5*$\Delta z_{Zoom}(n-1)$	≥ 25mm
5-6GHz	≤ 10mm	≤ 4mm	≤ 2mm	≤ 2mm	≤1.5*$\Delta z_{Zoom}(n-1)$	≥ 22mm

Step 4: Power Drift Monitoring

The Power Drift Measurement measures the field at the same location as the most recent power reference measurement job within the same procedure, and with the same settings. The Power Drift Measurement gives the field difference in dB from the reading conducted within the last Power Reference Measurement. If the value changed by more than 5%, the evaluation should be retested.

5 SAR Verification Procedure

5.1 Tissue Verification

The following materials are used for producing the tissue-equivalent materials.
(Liquids used for tests are marked with☒):

Ingredients (% of weight)	**Frequency (MHz)**						
Tissue Type	**Head Tissue**						
frequency band	835	1800	2000	2300	2450	2600	5200-5800
Water	41.45	52.64	54.9	62.82	62.7	55.242	65.52
Salt (NaCl)	1.45	0.36	0.18	0.51	0.5	0.306	0.0
Sugar	56.0	0.0	0.0	0.0	0.0	0.0	0.0
HEC	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Bactericide	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Triton X-100	0.0	0.0	0.0	0.0	36.8	0.0	17.24
DGBE	0.0	47.0	44.92	36.67	0.0	44.452	0.0
Diethylenglycol monohexylether	0.0	0.0	0.0	0.0	0.0	0.0	17.24

Ingredients (% of weight)	**Body Tissue**					
frequency band	835	1750	1900	2450	2600	5200-5800
Water	52.5	69.91	69.91	73.20	64.50	76.3
Salt (NaCl)	1.40	0.13	0.13	0.04	0.02	0.0
Sugar	45.0	0.0	0.0	0.0	0.0	0.0
HEC	1.0	0.0	0.0	0.0	0.0	0.0
Bactericide	0.1	0.0	0.0	0.0	0.0	0.0
Triton X-100	0.0	0.0	0.0	0.0	0.0	10.2
DGBE	0.0	29.96	29.96	26.76	35.48	0.0
Diethylenglycol monohexylether	0.0	0.0	0.0	0.0	0.0	13.5

Salt: 99+% Pure Sodium Chloride Sugar: 98+% Pure Sucrose
Water: De-ionized, 16MΩ+ 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
Tissue simulating liquids: parameters:

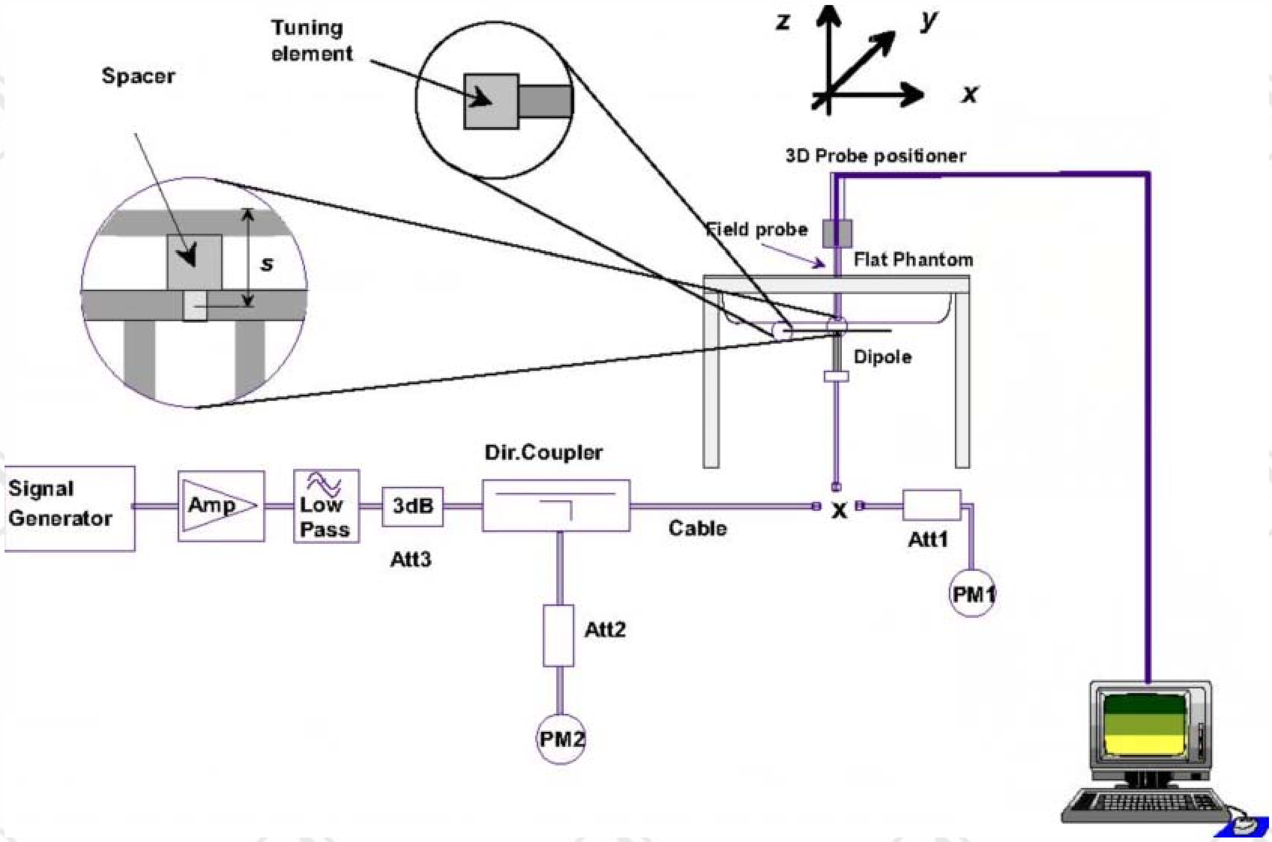
Tissue Type	Measured Frequency (MHz)	Target Tissue		Measured Tissue		Liquid Temp.	Test Date
		ε_r (+/-5%)	σ (S/m) (+/-5%)	ε_r	σ (S/m)		
2.4G Body	2410	52.80 (50.16~55.44)	1.91 (1.81~2.00)	50.97	1.853	21.30°C	2016/10/21
	2435	52.70 (50.07~55.34)	1.94 (1.84~2.04)	50.84	1.895		
	2450	52.70 (50.07~55.34)	1.95 (0.85~0.95)	50.76	1.914		

	2460	52.70 (50.07~55.34)	1.96 (0.86~0.96)	50.78	1.926		
5G Body	5200	49.00 (46.55~51.45)	5.30 (5.03~5.56)	49.68	5.289	21.54°C	2016/11/4
	5800	48.20 (45.79~50.61)	6.00 (5.70~6.30)	47.96	6.112		
ε_r= Relative permittivity, σ= Conductivity							

5.2 System check procedure

The System check is performed by using a System check dipole which is positioned parallel to the planar part of the SAM phantom at the reference point. The distance of the dipole to the SAM phantom is determined by a spacer. The dipole is connected to the signal source consisting of signal generator and amplifier via a directional coupler, N-connector cable and adaption to SMA. It is fed with a power of 100mW. To adjust this power a power meter is used. The power sensor is connected to the cable before the System check to measure the power at this point and do adjustments at the signal generator. At the outputs of the directional coupler both return loss as well as forward power are controlled during the validation to make sure that emitted power at the dipole is kept constant. This can also be checked by the power drift measurement after the test (result on plot).

System check results have to be equal or near the values determined during dipole calibration (target SAR in table above) with the relevant liquids and test system.



5.3 System check results

The system Check is performed for verifying the accuracy of the complete measurement system and performance of the software. The following table shows System check results for all frequency bands and tissue liquids used during the tests (plot(s) see annex A).

System Check (MHz)	Target SAR (1W) (+/-10%)		Measured SAR (Normalized to 1W)		Liquid Temp.	Test Date
	1-g (mW/g)	10-g (mW/g)	1-g (mW/g)	10-g (mW/g)		
D2450V2 Body	51.20 (46.08~56.32)	23.96 (21.56~26.36)	50.80	24.00	21.30°C	2016/10/21
D5200V2 Body	74.50 (67.05~81.95)	20.80 (18.72~22.88)	76.00	21.50	21.54°C	2016/11/4
D5800V2 Body	76.70 (69.03~84.37)	21.20 (19.08~23.32)	76.40	21.50	21.54°C	2016/11/4
Note: All SAR values are normalized to 1W forward power.						

6 SAR Measurement variability and uncertainty

6.1 SAR measurement variability

In accordance with published RF Exposure KDB procedure 865664 D01 SAR measurement 100 MHz to 6 GHz v01r04. These additional measurements are repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device should be returned to ambient conditions (normal room temperature) with the battery fully charged before it is re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results.

1) Repeated measurement is not required when the original highest measured SAR is < 0.80 W/kg; steps 2) through 4) do not apply.
2) When the original highest measured SAR is ≥ 0.80 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 (~ 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 and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.

6.2 SAR measurement uncertainty

Per KDB865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04,when the highest measured 1-g SAR within a frequency band is < 1.5 W/kg, the extensive SAR measurement uncertainty analysis described in IEEE Std 1528-2013 is not required in SAR reports submitted for equipment approval. The equivalent ratio (1.5/1.6) is applied to extremity and occupational exposure conditions.

7 SAR Test Configuration

For WiFi SAR testing, a communication link is set up with the testing software for WiFi mode test. During the test,at the each test frequency channel, the EUT is operated at the RF continuous emission mode. The RF signal utilized in SAR measurement has 100% duty cycle and its crest factor is 1. The test procedures in KDB 248227D01 v02r02 are applied.

Initial Test Position Procedure

For exposure condition with multiple test position, such as handsets 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 position 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 ≤ 0.4W/kg, no additional testing for the remaining test position is required. Otherwise, SAR is evaluated at the subsequent highest peak SAR position until the reported SAR result is ≤ 0.8W/kg or all test position are measured. For all positions/configurations tested using the initial test position and subsequent test positions, when the reported SAR is > 0.8 W/kg, SAR is measured for these test positions/configurations on the subsequent next highest measured output power channel(s) until the reported SAR is ≤ 1.2 W/kg or all required channels are tested.

Initial Test Configuration Procedure

An initial test configuration is determined for OFDM transmission modes according to the channel bandwidth, modulation and data rate combination(s) with the highest maximum output power specified for production units in each standalone and aggregated frequency band. SAR is measured using the highest measured maximum output power channel. For configurations with the same specified or measured maximum output power, additional transmission mode and test channel selection procedures are required (see section 5.3.2 of KDB 248227D01v02). SAR test reduction of subsequent highest output test channels is based on the reported SAR of the initial test configuration.

For next to the ear, hotspot mode and UMC mini-tablet exposure configurations where multiple test positions are required, the initial test position procedure is applied to minimize the number of test positions required for SAR measurement using the initial test configuration transmission mode. For fixed exposure conditions that do not have multiple SAR test positions, SAR is measured in the transmission mode determined by the initial test configuration.

When the reported SAR of the initial test configuration is > 0.8 W/kg, SAR measurement is required for the subsequent next highest measured output power channel(s) in the initial test configuration until the reported SAR is ≤ 1.2 W/kg or all required channels are tested.

Sub Test Configuration Procedure

SAR measurement requirements for the remaining 802.11 transmission mode configurations that have not been tested in the initial test configuration are determined separately for each standalone and aggregated frequency band, in each exposure condition, according to the maximum output power specified for production units.

When the highest reported SAR for the initial test configuration, according to the initial test position or fixed exposure position requirements, is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, SAR is not required for that subsequent test configuration.

7.1 WIFI 2.4G Test Configurations

Per KDB 248227 D01 802.11 Wi-Fi SAR v02r02,SAR Test Reduction criteria are as follows:

SAR test reduction for 802.11 Wi-Fi transmission mode configurations are considered separately for DSSS and OFDM. An initial test position is determined to reduce the number of tests required for certain exposure configurations with multiple test positions. An initial test configuration is determined for each frequency band and aggregated band according to maximum output power, channel bandwidth, wireless mode configurations and other operating parameters to streamline the measurement requirements. For 2.4 GHz DSSS, either the initial test position or DSSS procedure is applied to reduce the number of SAR tests; these are mutually exclusive. For OFDM, an initial test position is only applicable to next to the ear, UMPC mini-tablet and hotspot mode configurations, which is tested using the initial test configuration to facilitate test reduction. For other exposure conditions with a fixed test position, SAR test reduction is determined using only the initial test configuration.

The multiple test positions require SAR measurements in head, hotspot mode or UMPC mini-tablet configurations may be reduced according to the highest reported SAR determined using the *initial test position(s)* by applying the DSSS or OFDM SAR measurement procedures in the required wireless mode test configuration(s). The relative SAR levels of multiple exposure test positions can be established by area scan measurements on the highest measured output power channel to determine the initial test position. The area scans must be measured using the same SAR measurement configurations, including test channel, maximum output power, probe tip to phantom distance, scan resolution etc.

When the *reported* SAR for the *initial test position* is:

1) ≤0.4 W/kg, further SAR measurement is not required for the other test positions in that exposure configuration and wireless mode combination within the frequency band or aggregated band. DSSS and OFDM configurations are considered separately according to the required SAR procedures.
2) > 0.4 W/kg, SAR is repeated using the same wireless mode test configuration tested in the initial test position to measure the subsequent next closet/smallest test separation distance and maximum coupling test position, on the highest maximum output power channel, until the reported SAR is ≤ 0.8 W/kg or all required test positions are tested.
3) For all positions/configurations tested using the initial test position and subsequent test positions, when the reported SAR is > 0.8 W/kg, measure the SAR for these positions/configurations

on the subsequent next highest measured output power channel(s) until the reported SAR is ≤ 1.2 W/kg or all required test channels are considered.

SAR is not required for the following 2.4 GHz OFDM conditions.

1) When KDB Publication 447498 SAR test exclusion applies to the OFDM configuration.

2) When the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg.

7.2 WIFI 5G Test Configurations

1) U-NII-1 and U-NII-2A Bands

For devices that operate in only one of the U-NII-1 and U-NII-2A bands, the normally required SAR procedures for OFDM configurations are applied. For devices that operate in both U-NII bands using the same transmitter and antenna(s), SAR test reduction is determined according to the following：

1.1) When the same maximum output power is specified for both bands, begin SAR measurement in U-NII-2A band by applying the OFDM SAR requirements. If the highest reported SAR for a test configuration is ≤ 1.2 W/kg, SAR is not required for U-NII-1 band for that configuration (802.11 mode and exposure condition); otherwise, both bands are tested independently for SAR.

1.2) When different maximum output power is specified for the bands, begin SAR measurement in the band with higher specified maximum output power. The highest reported SAR for the tested configuration is adjusted by the ratio of lower to higher specified maximum output power for the two bands. When the adjusted SAR is ≤ 1.2 W/kg, SAR is not required for the band with lower maximum output power in that test configuration; otherwise, both bands are tested independently for SAR.

1.3) The two U-NII bands may be aggregated to support a 160 MHz channel on channel number 50. Without additional testing, the maximum output power for this is limited to the lower of the maximum output power certified for the two bands. When SAR measurement is required for at least one of the bands and the highest reported SAR adjusted by the ratio of specified maximum output power of aggregated to standalone band is > 1.2 W/kg, SAR is required for the 160 MHz channel. This procedure does not apply to an aggregated band with maximum output higher than the standalone band(s); the aggregated band must be tested independently for SAR. SAR is not required when the 160 MHz channel is operating at a reduced maximum power and also qualifies for SAR test exclusion.

2) U-NII-2C and U-NII-3 Bands

The frequency range covered by these bands is 380 MHz (5.47 – 5.85 GHz), which requires a minimum of at least two SAR probe calibration frequency points to support SAR measurements. when Terminal Doppler Weather Radar (TDWR) restriction applies, all channels that operate at 5.60 – 5.65 GHz must be included to apply the SAR test reduction and measurement procedures.

When the same transmitter and antenna(s) are used for U-NII-2C band and U-NII-3 band or 5.8 GHz band of §15.247, the bands may be aggregated to enable additional channels with 20, 40 or 80 MHz bandwidth to span across the band gap, as illustrated in Appendix B. The maximum output power for the additional band gap channels is limited to the lower of those certified for the bands. Unless band gap channels are permanently disabled, they must be considered for SAR testing. The frequency range covered by these bands is 380 MHz (5.47 – 5.85 GHz), which requires a minimum of at least two SAR probe calibration frequency points to support SAR measurements. To maintain SAR measurement accuracy and to facilitate test reduction, the channels in U-NII-2C band above 5.65 GHz may be grouped with the 5.8 GHz channels in U-NII-3 or §15.247 band to enable two SAR probe calibration frequency points to cover the bands, including the band gap channels. When band gap channels are supported and the bands are not aggregated for SAR testing, band gap channels must be considered independently in each band according to the normally required OFDM SAR measurement and probe calibration frequency points requirements.

3) OFDM Transmission Mode SAR Test Configuration and Channel Selection Requirements

The initial test configuration for 5 GHz OFDM transmission modes is determined by the 802.11 configuration with the highest maximum output power specified for production units, including tune-up tolerance, in each standalone and aggregated frequency band. SAR for the initial test configuration is measured using the highest maximum output power channel determined by the default power measurement procedures. When multiple configurations in a frequency band have the same specified maximum output power, the initial test configuration is determined according to the following steps applied sequentially.

3.1) The largest channel bandwidth configuration is selected among the multiple configurations with the same specified maximum output power.

3.2) If multiple configurations have the same specified maximum output power and largest channel bandwidth, the lowest order modulation among the largest channel bandwidth configurations is selected.

3.3) If multiple configurations have the same specified maximum output power, largest channel bandwidth and lowest order modulation, the lowest data rate configuration among these configurations is selected.

3.4) When multiple transmission modes (802.11a/g/n/ac) have the same specified maximum output power, largest channel bandwidth, lowest order modulation and lowest data rate, the lowest order 802.11 mode is selected; i.e., 802.11a is chosen over 802.11n then 802.11ac or 802.11g is chosen over 802.11n.

After an initial test configuration is determined, if multiple test channels have the same measured maximum output power, the channel chosen for SAR measurement is determined according to the following. These channel selection procedures apply to both the initial test configuration and subsequent test configuration(s), with respect to the default power measurement procedures or additional power measurements required for further SAR test reduction. The same procedures also apply to subsequent highest output power channel(s) selection.

3.4.1) The channel closest to mid-band frequency is selected for SAR measurement.

3.4.2) For channels with equal separation from mid-band frequency; for example, high and low channels or two mid-band channels, the higher frequency (number) channel is selected for SAR measurement.

4) SAR Test Requirements for OFDM configurations

When SAR measurement is required for 802.11 a/n/ac OFDM configurations, each standalone and frequency aggregated band is considered separately for SAR test reduction. When the same transmitter and antenna(s) are used for U-NII-1 and U-NII-2A bands, additional SAR test reduction applies. When band gap channels between U-NII-2C band and 5.8 GHz U-NII-3 or §15.247 band are supported, the highest maximum output power transmission mode configuration and maximum output power channel across the bands must be used to determine SAR test reduction, according to the initial test configuration and subsequent test configuration requirements. In applying the initial test configuration and subsequent test configuration procedures, the 802.11 transmission configuration with the highest specified maximum output power and the channel within a test configuration with the highest measured maximum output power should be clearly distinguished to apply the procedures.

8 SAR Test Results

8.1 Conducted Power Measurements

8.1.1 Conducted power of WiFi 5G

Band	Mode		Channel	Frequency (MHz)	Data Rate (Mbps)	Tune-up	Average Power (dBm)	SAR Test (Yes/No)
5.2G	802.11a SISO	Ant 0	36	5180	6	14.00	Not Required	NO
			40	5200		14.00	Not Required	NO
			44	5220		14.00	Not Required	NO
			48	5240		14.00	Not Required	NO
		Ant 1	36	5180	6	13.00	Not Required	NO
			40	5200		13.00	Not Required	NO
			44	5220		13.00	Not Required	NO
			48	5240		13.00	Not Required	NO
	802.11n HT20 SISO	Ant 0	36	5180	6.5	13.00	Not Required	NO
			40	5200		13.00	Not Required	NO
			44	5220		13.00	Not Required	NO
			48	5240		13.00	Not Required	NO
		Ant 1	36	5180	6.5	13.00	Not Required	NO
			40	5200		13.00	Not Required	NO
			44	5220		13.00	Not Required	NO
			48	5240		13.00	Not Required	NO
	802.11n HT20 MIMO		36	5180	13	17.00	15.85	NO
			40	5200		17.00	15.93	NO
			44	5220		17.00	15.86	NO
			48	5240		17.00	16.07	NO
	802.11n HT40 SISO	Ant 0	38	5190	13.5	13.00	Not Required	NO
			46	5230		13.00	Not Required	NO
		Ant 1	38	5190	13.5	13.00	Not Required	NO
			46	5230		13.00	Not Required	NO
	802.11n HT40 MIMO		38	5190	27	14.00	Not Required	NO
			46	5230		14.00	Not Required	NO

	802.11ac HT20 SISO	Ant 0	36	5180	6.5	13.00	Not Required	NO
			40	5200		13.00	Not Required	NO
			44	5220		13.00	Not Required	NO
			48	5240		13.00	Not Required	NO
		Ant 1	36	5180	6.5	13.00	Not Required	NO
			40	5200		13.00	Not Required	NO
			44	5220		13.00	Not Required	NO
			48	5240		13.00	Not Required	NO
	802.11ac HT20 MIMO		36	5180	13	17.00	15.89	Yes
			40	5200		17.00	16.05	Yes
			44	5220		17.00	16.12	Yes
			48	5240		17.00	16.36	Yes
	802.11ac HT40 SISO	Ant 0	38	5190	13.5	13.00	Not Required	NO
			46	5230		13.00	Not Required	NO
		Ant 1	38	5190	13.5	13.00	Not Required	NO
			46	5230		13.00	Not Required	NO
	802.11ac HT40 MIMO		38	5190	27	14.00	Not Required	NO
			46	5230		14.00	Not Required	NO
	802.11ac VH80 Ant 0		42	5210	29.3	12.00	Not Required	NO
	802.11ac VH80 Ant 1		42	5210		12.00	Not Required	NO
	802.11ac VH80 MIMO		42	5210	58.6	12.00	Not Required	NO

Band	Mode		Channel	Frequency (MHz)	Data Rate (Mbps)	Tune-up	Average Power (dBm)	SAR Test (Yes/No)
5.8G	802.11a SISO	Ant 0	149	5745	6	11.00	Not Required	NO
			153	5765		11.00	Not Required	NO
			157	5785		11.00	Not Required	NO
			161	5805		11.00	Not Required	NO
			165	5825		11.00	Not Required	NO
		Ant 1	149	5745	6	11.00	Not Required	NO
			153	5765		11.00	Not Required	NO
			157	5785		11.00	Not Required	NO
			161	5805		11.00	Not Required	NO
			165	5825		11.00	Not Required	NO

	802.11n HT20 SISO	Ant 0	149	5745	6.5	11.00	Not Required	NO
			153	5765		11.00	Not Required	NO
			157	5785		11.00	Not Required	NO
			161	5805		11.00	Not Required	NO
			165	5825		11.00	Not Required	NO
		Ant 1	149	5745	6.5	11.00	Not Required	NO
			153	5765		11.00	Not Required	NO
			157	5785		11.00	Not Required	NO
			161	5805		11.00	Not Required	NO
			165	5825		11.00	Not Required	NO
	802.11n HT20 MIMO		149	5745	13	12.00	Not Required	NO
			153	5765		12.00	Not Required	NO
			157	5785		12.00	Not Required	NO
			161	5805		12.00	Not Required	NO
			165	5825		12.00	Not Required	NO
	802.11n HT40 SISO	Ant 0	151	5755	13.5	11.00	Not Required	NO
			159	5795		11.00	Not Required	NO
		Ant 1	151	5755	13.5	11.00	Not Required	NO
			159	5795		11.00	Not Required	NO
	802.11n HT40 MIMO		151	5755	27	11.00	Not Required	NO
			159	5795		11.00	Not Required	NO
	802.11ac HT20 SISO	Ant 0	149	5745	6.5	11.00	Not Required	NO
			153	5765		11.00	Not Required	NO
			157	5785		11.00	Not Required	NO
			161	5805		11.00	Not Required	NO
			165	5825		11.00	Not Required	NO
		Ant 1	149	5745	6.5	11.00	Not Required	NO
			153	5765		11.00	Not Required	NO
			157	5785		11.00	Not Required	NO
			161	5805		11.00	Not Required	NO
			165	5825		11.00	Not Required	NO
	802.11ac HT20 MIMO		149	5745	13	14.00	12.13	Yes
			153	5765		14.00	12.25	Yes
			157	5785		14.00	12.46	Yes
			161	5805		14.00	12.55	Yes
			165	5825		14.00	12.98	Yes
	802.11ac HT40	Ant 0	151	5755	13.5	11.00	Not Required	NO
			159	5795		11.00	Not Required	NO

	SISO	Ant 1	151	5755	13.5	11.00	Not Required	NO
			159	5795		11.00	Not Required	NO
	802.11ac HT40 MIMO		151	5755	27	11.00	Not Required	NO
			159	5795		11.00	Not Required	NO
	802.11ac VH80 Ant 0		155	5775	29.3	11.00	Not Required	NO
	802.11ac VH80 Ant 1		155	5775		11.00	Not Required	NO
	802.11ac VH80 MIMO		155	5775	58.6	11.00	Not Required	NO

Note: An entry of “Not Required” means power measurement is not required according to the default power measurement procedures in KDB248227D01.

8.1.2 Conducted Power of WiFi 2.4G

Mode		Channel	Frequency (MHz)	Data Rate (Mbps)	Tune-up	Average Power(dBm)	SAR Test (Yes/No)
802.11b Ant 0		1	2412	1	18.00	17.35	Yes
		6	2437		18.00	16.83	Yes
		11	2462		18.00	16.89	Yes
802.11b Ant 1		1	2412	1	18.00	17.48	Yes
		6	2437		18.00	16.72	Yes
		11	2462		18.00	16.66	Yes
802.11g Ant 0		1	2412	6	17.00	Not Required	NO
		6	2437		17.00	Not Required	NO
		11	2462		17.00	Not Required	NO
802.11g Ant 1		1	2412	6	17.00	Not Required	NO
		6	2437		17.00	Not Required	NO
		11	2462		17.00	Not Required	NO
802.11n (HT20) SISO	Ant 0	1	2412	6.5	17.00	Not Required	NO
		6	2437		17.00	Not Required	NO
		11	2462		17.00	Not Required	NO
	Ant 1	1	2412	6.5	17.00	Not Required	NO
		6	2437		17.00	Not Required	NO
		11	2462		17.00	Not Required	NO
802.11n (HT20) MIMO		1	2412	13	17.00	Not Required	NO
		6	2437		17.00	Not Required	NO

		11	2462		17.00	Not Required	NO
802.11n (HT40) SISO	Ant 0	3	2422	13.5	17.00	Not Required	NO
		6	2437		17.00	Not Required	NO
		9	2452		17.00	Not Required	NO
802.11n (HT40) SISO	Ant 1	3	2422	13.5	17.00	Not Required	NO
		6	2437		17.00	Not Required	NO
		9	2452		17.00	Not Required	NO
802.11n (HT40) MIMO		3	2422	27	17.00	Not Required	NO
		6	2437		17.00	Not Required	NO
		9	2452		17.00	Not Required	NO

Note: An entry of “Not Required” means power measurement is not required according to the default power measurement procedures in KDB248227D01.

8.2 SAR test results

Notes:

1) Per KDB447498 D01v06, testing of other required channels within the operating mode of a frequency band is not required when the reported 1-g or 10-g SAR for the mid-band or highest output power channel is: ≤ 0.8 W/kg or 2.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≤ 100 MHz. When the maximum output power variation across the required test channels is > ½ dB, instead of the middle channel, the highest output power channel must be used.

2) Per KDB447498 D01v06, All measurement SAR result is scaled-up to account for tune-up tolerance is compliant.

3) Per KDB865664 D01v01r04, for each frequency band, repeated SAR measurement is required only when the measured SAR is ≥0.8W/Kg; if the deviation among the repeated measurement is ≤ 20%, and the measured SAR <1.45W/Kg, only one repeated measurement is required.

4) Per KDB865664 D02v01r02, SAR plot is only required for the highest measured SAR in each exposure configuration, wireless mode and frequency band combination; Plots are also required when the measured SAR is > 1.5 W/kg, or > 7.0 W/kg for occupational exposure. The published RF exposure KDB procedures may require additional plots; for example, to support SAR to peak location separation ratio test exclusion and/or volume scan post-processing (Refer to appendix B for details).

8.2.1 Results overview of WiFi 5G

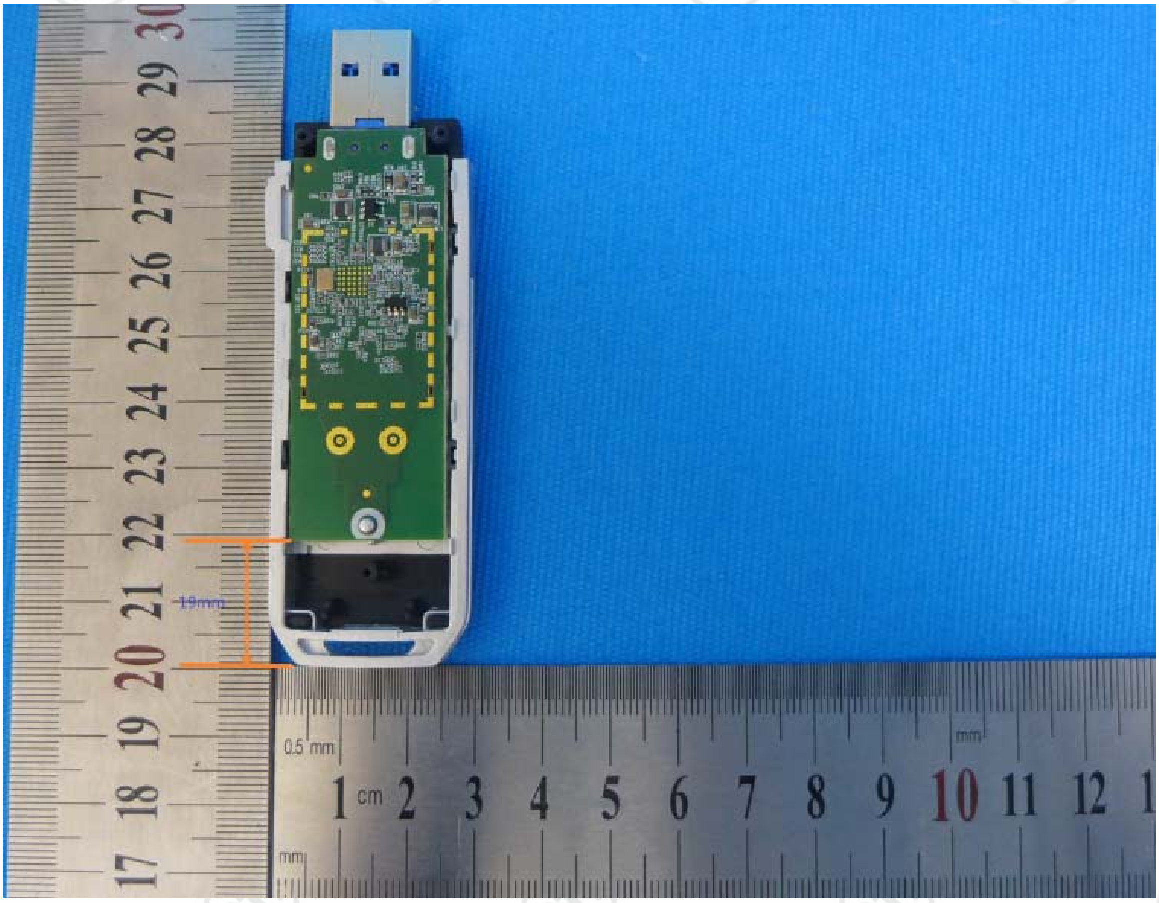
Test Position of Body With 5mm	Test channel /Freq.(MHz)	Test Mode	SAR Value (W/kg)		Power Drift (dB)	Conducted Power (dBm)	Tune-up power (dBm)	Scaled SAR_{1-g} (W/kg)	Liquid Temp.
			1-g	10-g					
5.2G (U-NII-1 Band)									
Front Side	48/5240	802.11 ac HT20 MIMO	0.066	0.022	0.120	16.36	17.00	0.077	21.54°C
Back Side	48/5240	802.11 ac HT20 MIMO	0.130	0.029	0.040	16.36	17.00	0.151	21.54°C
Left Side	48/5240	802.11 ac HT20 MIMO	0.077	0.027	-0.170	16.36	17.00	0.089	21.54°C
Right Side	48/5240	802.11 ac HT20 MIMO	0.052	0.016	-0.010	16.36	17.00	0.060	21.54°C
5.8G (U-NII-3 Band)									
Front Side	165/5825	802.11 ac HT20 MIMO	0.099	0.029	0.150	12.98	14.00	0.125	21.54°C
Back Side	165/5825	802.11 ac HT20 MIMO	0.126	0.026	-0.040	12.98	14.00	0.159	21.54°C
Left Side	165/5825	802.11 ac HT20 MIMO	0.069	0.023	-0.140	12.98	14.00	0.088	21.54°C
Right Side	165/5825	802.11 ac HT20 MIMO	0.077	0.025	0.180	12.98	14.00	0.097	21.54°C

8.2.2 Results overview of WiFi 2.4G

Test Position of Body With 5mm	Test channel /Freq.(MHz)	Test Mode	SAR Value (W/kg)		Power Drift (dB)	Conducted Power (dBm)	Tune-up power (dBm)	Scaled SAR_{1-g} (W/kg)	Liquid Temp.
			1-g	10-g					
Ant 0									
Front Side	1/2412	802.11b	0.157	0.066	-0.100	17.35	18.00	0.182	21.30°C
Back Side	1/2412	802.11b	0.445	0.181	0.100	17.35	18.00	0.517	21.30°C
Left Side	1/2412	802.11b	0.029	0.014	0.170	17.35	18.00	0.034	21.30°C
Right Side	1/2412	802.11b	0.105	0.038	-0.020	17.35	18.00	0.122	21.30°C
Back Side	11/2462	802.11b	0.183	0.074	-0.050	16.89	18.00	0.236	21.30°C
Back Side	6/2437	802.11b	0.254	0.107	-0.120	16.83	18.00	0.333	21.30°C
Ant 1									
Front Side	1/2412	802.11b	0.098	0.040	0.120	17.48	18.00	0.110	21.30°C
Back Side	1/2412	802.11b	0.350	0.144	0.080	17.48	18.00	0.395	21.30°C
Left Side	1/2412	802.11b	0.070	0.024	0.110	17.48	18.00	0.079	21.30°C
Right Side	1/2412	802.11b	0.015	0.00698	0.130	17.48	18.00	0.017	21.30°C
Back Side	11/2462	802.11b	0.133	0.050	0.030	16.66	18.00	0.181	21.30°C
Back Side	6/2437	802.11b	0.155	0.063	-0.030	16.72	18.00	0.208	21.30°C

8.3 Multiple Transmitter Information

The location of the antennas inside DC29 is shown as below picture:



Note: Per KDB 447498 D02, if the antenna is within 1cm from the tip of the dongle (the end without the USB connector), the tip of the dongle should also be tested at 5 mm perpendicular to the phantom. the antenna of DC29 to the tip of the dongle is more than 1cm, so the tip side is not required to be tested.

8.4 Stand-alone SAR

Per FCC KDB 447498D01:

1) The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:

[(max. power of channel, including tune-up tolerance, mW) / (min. test separation distance, mm)] · [√f(GHz)] ≤ 3.0 for 1-g SAR and ≤ 7.5 for 10-g extremity SAR, where

• f(GHz) is the RF channel transmit frequency in GHz

• Power and distance are rounded to the nearest mW and mm before calculation

• The result is rounded to one decimal place for comparison

When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

Mode	Position	P_{max} (dBm)	P_{max} (mW)	Distance (mm)	F (GHz)	Calculation Result	SAR test exclusion Threshold	SAR test exclusion
WiFi 2.4G	Body	18.00	63.10	5.00	2.450	19.75	3.00	NO
WiFi 5.2G	Body	17.00	50.12	5.00	5.200	22.86	3.00	NO
WiFi 5.8G	Body	14.00	25.12	5.00	5.800	12.10	3.00	NO

8.5 Simultaneous Transmission Conlcusion

The WiFi 2.4G and WiFi 5G of device can"t transmit simultaneously therefore simultaneous transmission SAR is not required per KDB 447498 D01v06.

Annex A: Appendix A: SAR System performance Check Plots

(Please See Appendix A)

Annex B: Appendix B: SAR Measurement results Plots

(Please See Appendix B)

Annex C: Appendix C: Calibration reports

(Please See Appendix C)

Annex D: Appendix D: Photo documentation

(Please See Appendix D)

——END OF REPORT——

Appendix A:SAR System performance Check Plots
Table of contents
System Performance Check-D2450-Body
System Performance Check-D5200-Body
System Performance Check-D5800-Body

Date/Time: 10/21/2016 8:40:23 AM

Test Laboratory: CTI SAR Lab

Systemcheck 2450-Body

DUT: Dipole 2450 MHz D2450V2; Type: D2450V2; Serial: D2450V2 - SN:959

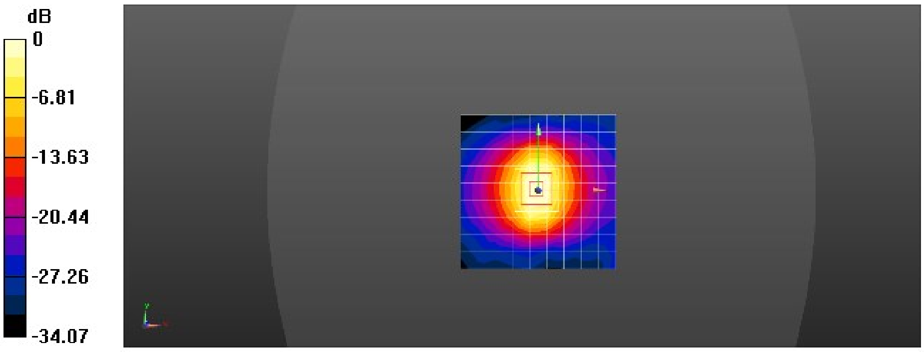
Communication System: UID 0, CW (0); Communication System Band: D2450 (2450.0 MHz); Frequency: 2450 MHz;Duty Cycle: 1:1
Medium parameters used: f = 2450 MHz; σ = 1.914 S/m; ε_r = 50.764; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY Configuration:

- Probe: EX3DV4 - SN7328; ConvF(7.45, 7.45, 7.45); Calibrated: 2/19/2016;
- Sensor-Surface: 2mm (Mechanical Surface Detection), z = 1.0, 31.0
- Electronics: DAE4 Sn1458; Calibrated: 2/26/2016
- Phantom: ELI v6.0; Type: QDOVA003AA; Serial: 2024
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/d=10mm,Pin=100mW/Area Scan (10x10x1): Measurement grid: dx=12mm, dy=12mm
Maximum value of SAR (measured) = 5.70 W/kg

Configuration/d=10mm,Pin=100mW/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 55.30 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 10.1 W/kg
SAR(1 g) = 5.08 W/kg; SAR(10 g) = 2.4 W/kg
Maximum value of SAR (measured) = 7.62 W/kg



0 dB = 5.70 W/kg = 7.56 dBW/kg

Date/Time: 11/4/2016 8:39:28 AM

Test Laboratory: CTI SAR Lab

Systemcheck 5200-Body-2

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1208

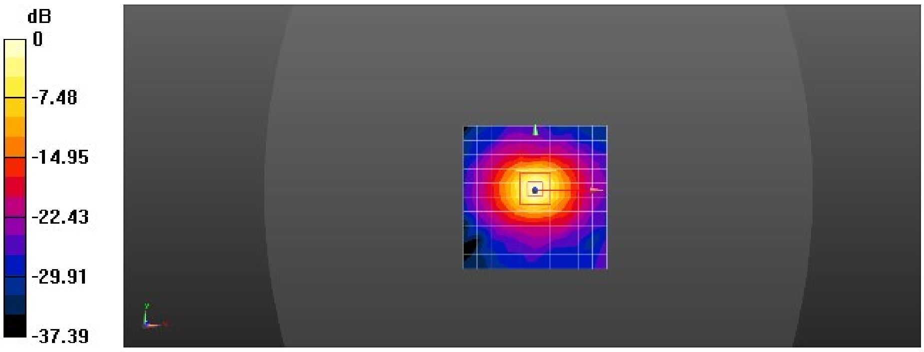
Communication System: UID 0, CW (0); Communication System Band: D5GHz (5000.0 - 6000.0 MHz); Frequency: 5200 MHz;Duty Cycle: 1:1
Medium parameters used: f = 5200 MHz; σ = 5.289 S/m; ε_r = 49.677; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY Configuration:

- Probe: EX3DV4 - SN7328; ConvF(4.38, 4.38, 4.38); Calibrated: 2/19/2016;
- Sensor-Surface: 2mm (Mechanical Surface Detection), z = 1.0, 31.0
- Electronics: DAE4 Sn1458; Calibrated: 2/26/2016
- Phantom: ELI v6.0; Type: QDOVA003AA; Serial: 2024
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/d=10mm,Pin=100mW/Area Scan (11x11x1): Measurement grid: dx=10mm, dy=10mm
Maximum value of SAR (measured) = 12.7 W/kg

Configuration/d=10mm,Pin=100mW/Zoom Scan (8x8x16)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 42.33 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 29.1 W/kg
SAR(1 g) = 7.6 W/kg; SAR(10 g) = 2.15 W/kg
Maximum value of SAR (measured) = 15.3 W/kg



0 dB = 12.7 W/kg = 11.02 dBW/kg

Date/Time: 11/4/2016 9:25:00 AM

Test Laboratory: CTI SAR Lab

Systemcheck 5800-Body-2

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1208

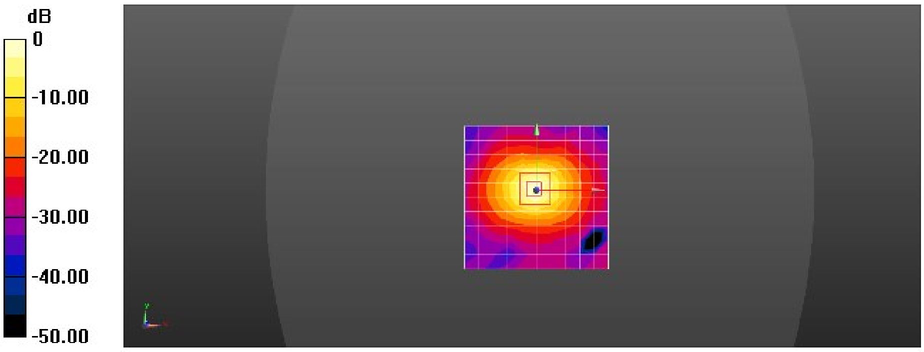
Communication System: UID 0, CW (0); Communication System Band: D5GHz (5000.0 - 6000.0 MHz); Frequency: 5800 MHz;Duty Cycle: 1:1
Medium parameters used: f = 5800 MHz; σ = 6.112 S/m; ε_r = 47.964; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY Configuration:

- Probe: EX3DV4 - SN7328; ConvF(3.72, 3.72, 3.72); Calibrated: 2/19/2016;
- Sensor-Surface: 2mm (Mechanical Surface Detection), z = 1.0, 31.0
- Electronics: DAE4 Sn1458; Calibrated: 2/26/2016
- Phantom: ELI v6.0; Type: QDOVA003AA; Serial: 2024
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/d=10mm,Pin=50mW/Area Scan (11x11x1): Measurement grid: dx=10mm, dy=10mm
Maximum value of SAR (measured) = 13.1 W/kg

Configuration/d=10mm,Pin=50mW/Zoom Scan (8x8x16)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 38.91 V/m; Power Drift = -0.08 dB
Peak SAR (extrapolated) = 30.9 W/kg
SAR(1 g) = 7.64 W/kg; SAR(10 g) = 2.15 W/kg
Maximum value of SAR (measured) = 16.1 W/kg



0 dB = 13.1 W/kg = 11.17 dBW/kg

Appendix B:SAR Measurement results Plots

Table of contents
WIFI 2.4G-Body
WIFI 5G-Body

Date/Time: 10/21/2016 10:17:03 AM

Test Laboratory: CTI SAR Lab

DC29 WiFi 802.11b 1CH Back Side with Ant0 5mm

DUT: Wireless 802.11AC Dual band USB Adapter; Type: DC29; Serial: WS1604180562

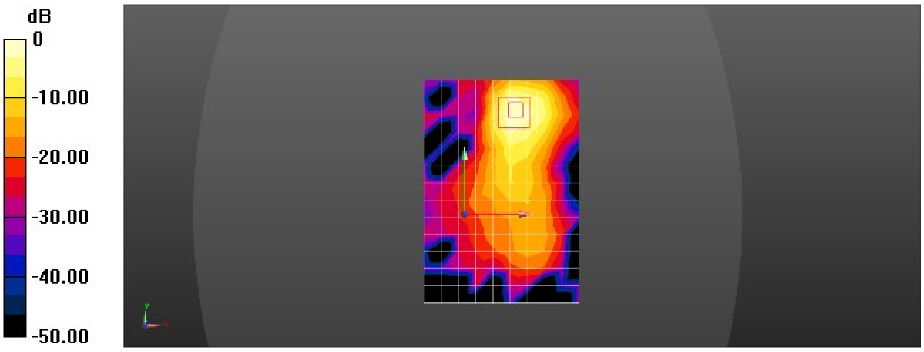
Communication System: UID 0, WiFi 802.11 a/b/g/n/ac (0); Communication System Band: WiFi; Frequency: 2412 MHz;Duty Cycle: 1:1
Medium parameters used: f = 2412 MHz; σ = 1.877 S/m; ε_r = 50.942; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY Configuration:

- Probe: EX3DV4 - SN7328; ConvF(7.45, 7.45, 7.45); Calibrated: 2/19/2016;
- Sensor-Surface: 2mm (Mechanical Surface Detection), z = 1.0, 31.0
- Electronics: DAE4 Sn1458; Calibrated: 2/26/2016
- Phantom: ELI v6.0; Type: QDOVA003AA; Serial: 2024
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/WiFi/Area Scan (10x14x1): Measurement grid: dx=12mm, dy=12mm
Maximum value of SAR (measured) = 0.478 W/kg

Configuration/WiFi/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 0.9760 V/m; Power Drift = 0.10 dB
Peak SAR (extrapolated) = 1.04 W/kg
SAR(1 g) = 0.445 W/kg; SAR(10 g) = 0.181 W/kg
Maximum value of SAR (measured) = 0.668 W/kg



0 dB = 0.478 W/kg = -3.20 dBW/kg

Date/Time: 10/21/2016 2:19:18 PM

Test Laboratory: CTI SAR Lab

DC29 WiFi 802.11b 1CH Back Side with Ant1 5mm

DUT: Wireless 802.11AC Dual band USB Adapter; Type: DC29; Serial: WS1604180562

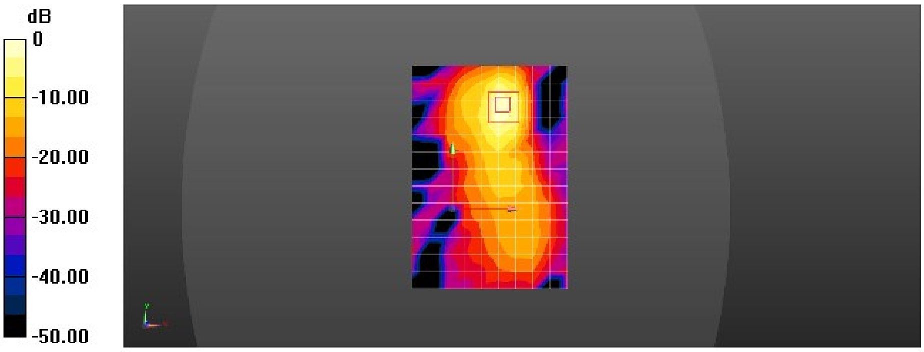
Communication System: UID 0, WiFi 802.11 a/b/g/n/ac (0); Communication System Band: WiFi; Frequency: 2412 MHz;Duty Cycle: 1:1
Medium parameters used: f = 2412 MHz; σ = 1.877 S/m; ε_r = 50.942; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY Configuration:

- Probe: EX3DV4 - SN7328; ConvF(7.45, 7.45, 7.45); Calibrated: 2/19/2016;
- Sensor-Surface: 2mm (Mechanical Surface Detection), z = 1.0, 31.0
- Electronics: DAE4 Sn1458; Calibrated: 2/26/2016
- Phantom: ELI v6.0; Type: QDOVA003AA; Serial: 2024
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/WiFi/Area Scan (10x14x1): Measurement grid: dx=12mm, dy=12mm
Maximum value of SAR (measured) = 0.470 W/kg

Configuration/WiFi/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 0.9160 V/m; Power Drift = 0.08 dB
Peak SAR (extrapolated) = 0.680 W/kg
SAR(1 g) = 0.350 W/kg; SAR(10 g) = 0.144 W/kg
Maximum value of SAR (measured) = 0.484 W/kg



0 dB = 0.470 W/kg = -3.28 dBW/kg

Date/Time: 11/4/2016 3:39:58 PM

Test Laboratory: CTI SAR Lab

DC29 WiFi 802.11ac 20M 48CH Back Side with MIMO 5mm

DUT: Wireless 802.11AC Dual band USB Adapter; Type: DC29; Serial: WS1604180562

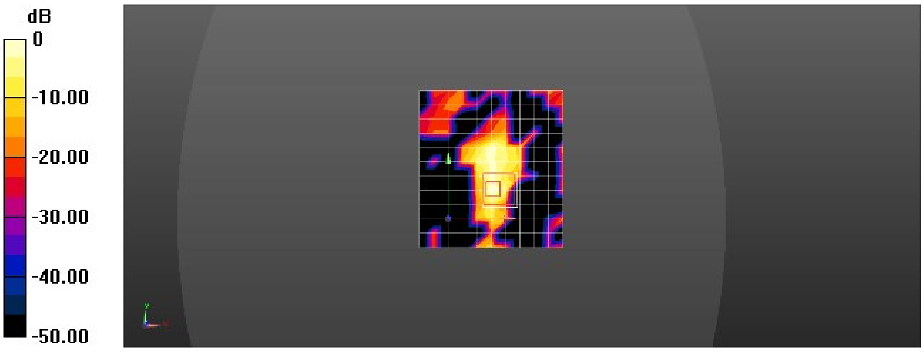
Communication System: UID 0, WiFi 802.11 a/b/g/n/ac (0); Communication System Band: WiFi 5.2G; Frequency: 5240 MHz;Duty Cycle: 1:1
Medium parameters used: f = 5240 MHz; σ = 5.19 S/m; ε_r = 49.613; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY Configuration:

- Probe: EX3DV4 - SN7328; ConvF(4.38, 4.38, 4.38); Calibrated: 2/19/2016;
- Sensor-Surface: 2mm (Mechanical Surface Detection), z = 1.0, 31.0
- Electronics: DAE4 Sn1458; Calibrated: 2/26/2016
- Phantom: ELI v6.0; Type: QDOVA003AA; Serial: 2024
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/WiFi/Area Scan (11x12x1): Measurement grid: dx=10mm, dy=10mm
Maximum value of SAR (measured) = 0.254 W/kg

Configuration/WiFi/Zoom Scan (7x7x16)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 0.1780 V/m; Power Drift = 0.04 dB
Peak SAR (extrapolated) = 0.488 W/kg
SAR(1 g) = 0.130 W/kg; SAR(10 g) = 0.029 W/kg
Maximum value of SAR (measured) = 0.280 W/kg



0 dB = 0.254 W/kg = -5.95 dBW/kg

Date/Time: 11/4/2016 8:32:38 PM

Test Laboratory: CTI SAR Lab

DC29 WiFi 802.11ac 20M 165CH Back Side with MIMO 5mm

DUT: Wireless 802.11AC Dual band USB Adapter; Type: DC29; Serial: WS1604180562

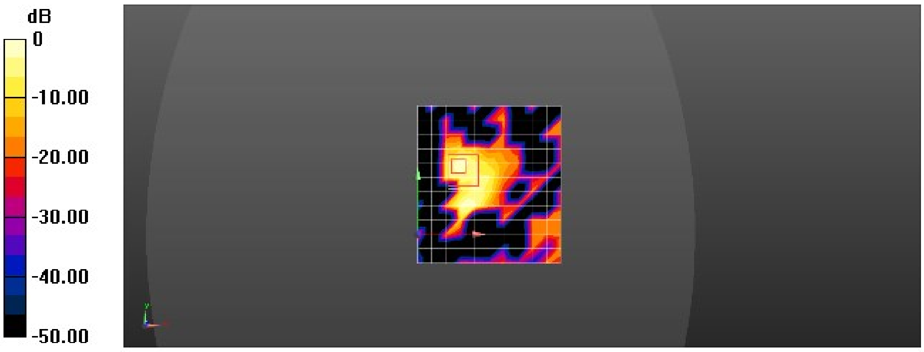
Communication System: UID 0, WiFi 802.11 a/b/g/n/ac (0); Communication System Band: WiFi 5.8G; Frequency: 5825 MHz;Duty Cycle: 1:1
Medium parameters used: f = 5825 MHz; σ = 6.093 S/m; ε_r = 48.221; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY Configuration:

- Probe: EX3DV4 - SN7328; ConvF(3.72, 3.72, 3.72); Calibrated: 2/19/2016;
- Sensor-Surface: 2mm (Mechanical Surface Detection), z = 1.0, 31.0
- Electronics: DAE4 Sn1458; Calibrated: 2/26/2016
- Phantom: ELI v6.0; Type: QDOVA003AA; Serial: 2024
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/WiFi/Area Scan (11x12x1): Measurement grid: dx=10mm, dy=10mm
Maximum value of SAR (measured) = 0.337 W/kg

Configuration/WiFi/Zoom Scan (7x7x16)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 1.135 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 0.564 W/kg
SAR(1 g) = 0.126 W/kg; SAR(10 g) = 0.026 W/kg
Maximum value of SAR (measured) = 0.308 W/kg



0 dB = 0.337 W/kg = -4.72 dBW/kg

Appendix C: Calibration reports

Table of contents
Probe EX3DV4 SN:7328
DAE4 SN:1458
Dipole D2450V2 SN:959
Dipole D5GV2 SN:1208

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

S **Schweizerischer Kalibrierdienst**
C **Service suisse d'étalonnage**
S **Servizio svizzero di taratura**
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client **CTI cert (Auden)**

Certificate No: EX3-7328_Feb16

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:7328
Calibration procedure(s)	QA CAL-01.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6 Calibration procedure for dosimetric E-field probes
Calibration date:	February 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 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter E4419B	GB41293874	01-Apr-15 (No. 217-02128)	Mar-16
Power sensor E4412A	MY41498087	01-Apr-15 (No. 217-02128)	Mar-16
Reference 3 dB Attenuator	SN: S5054 (3c)	01-Apr-15 (No. 217-02129)	Mar-16
Reference 20 dB Attenuator	SN: S5277 (20x)	01-Apr-15 (No. 217-02132)	Mar-16
Reference 30 dB Attenuator	SN: S5129 (30b)	01-Apr-15 (No. 217-02133)	Mar-16
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
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-13)	In house check: Apr-16
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

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

Issued: February 20, 2016

Glossary:

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,y,z
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization φ	φ rotation around probe axis
Polarization ϑ	ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis
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:

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"

Methods Applied and Interpretation of Parameters:

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

Probe EX3DV4

SN:7328

Manufactured: December 11, 2014
Calibrated: February 19, 2016

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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7328

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)[A]	0.40	0.43	0.47	± 10.1 %
DCP (mV)[B]	103.6	97.6	98.5	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB$\sqrt{\mu V}$	C	D dB	VR mV	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	172.3	±3.3 %
		Y	0.0	0.0	1.0		198.6	
		Z	0.0	0.0	1.0		182.2	

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 E^2-field uncertainty inside TSL (see Pages 5 and 6).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7328

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)
835	41.5	0.90	10.17	10.17	10.17	0.38	1.04	± 12.0 %
1750	40.1	1.37	8.52	8.52	8.52	0.46	0.80	± 12.0 %
1900	40.0	1.40	8.16	8.16	8.16	0.44	0.84	± 12.0 %
2000	40.0	1.40	8.19	8.19	8.19	0.43	0.80	± 12.0 %
2450	39.2	1.80	7.39	7.39	7.39	0.38	0.88	± 12.0 %
2600	39.0	1.96	7.23	7.23	7.23	0.50	0.80	± 12.0 %
5200	36.0	4.66	5.22	5.22	5.22	0.40	1.80	± 13.1 %
5300	35.9	4.76	5.02	5.02	5.02	0.40	1.80	± 13.1 %
5500	35.6	4.96	4.61	4.61	4.61	0.45	1.80	± 13.1 %
5600	35.5	5.07	4.29	4.29	4.29	0.50	1.80	± 13.1 %
5800	35.3	5.27	4.39	4.39	4.39	0.50	1.80	± 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.

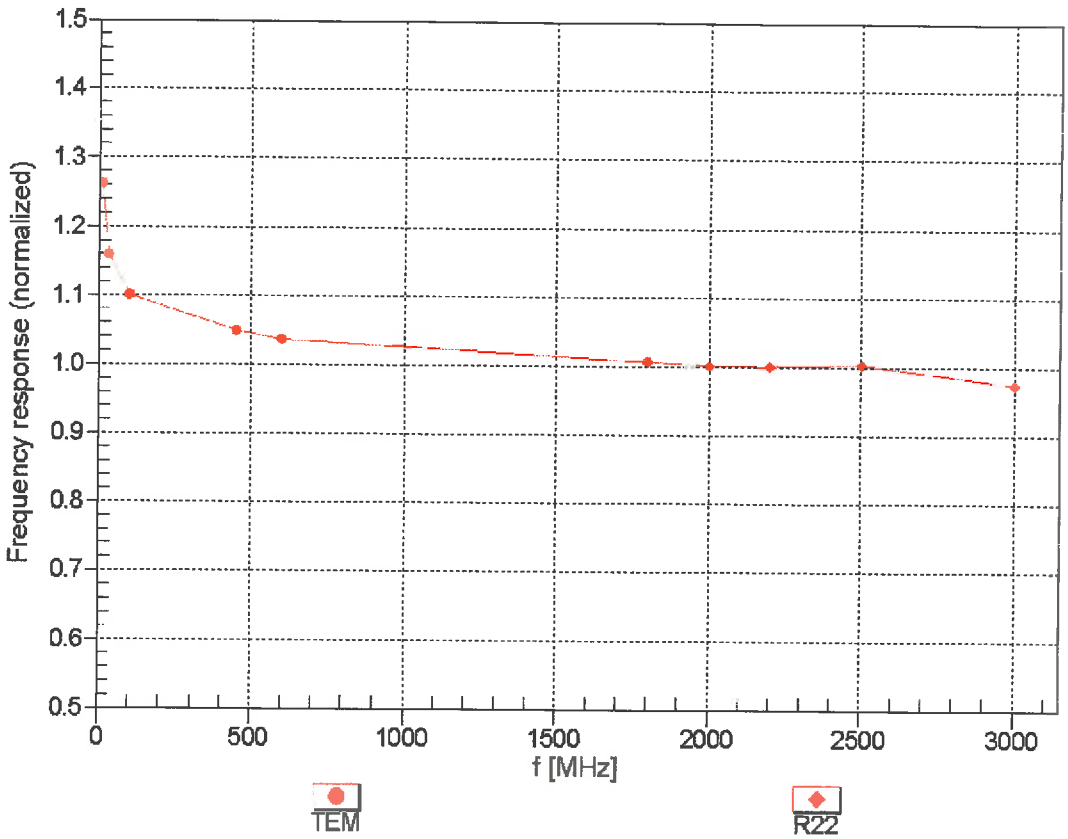
DASY/EASY - Parameters of Probe: EX3DV4 - SN:7328

Calibration Parameter Determined in Body Tissue Simulating Media

f (MHz) [C]	Relative Permittivity [F]	Conductivity (S/m) [F]	ConvF X	ConvF Y	ConvF Z	Alpha [G]	Depth [G] (mm)	Unc (k=2)
835	55.2	0.97	9.67	9.67	9.67	0.31	1.19	± 12.0 %
1750	53.4	1.49	8.10	8.10	8.10	0.49	0.80	± 12.0 %
1900	53.3	1.52	7.80	7.80	7.80	0.43	0.80	± 12.0 %
2000	53.3	1.52	7.92	7.92	7.92	0.43	0.82	± 12.0 %
2450	52.7	1.95	7.45	7.45	7.45	0.41	0.86	± 12.0 %
2600	52.5	2.16	7.13	7.13	7.13	0.32	0.95	± 12.0 %
5200	49.0	5.30	4.38	4.38	4.38	0.50	1.90	± 13.1 %
5300	48.9	5.42	4.22	4.22	4.22	0.50	1.90	± 13.1 %
5500	48.6	5.65	3.77	3.77	3.77	0.55	1.90	± 13.1 %
5600	48.5	5.77	3.54	3.54	3.54	0.60	1.90	± 13.1 %
5800	48.2	6.00	3.72	3.72	3.72	0.60	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.

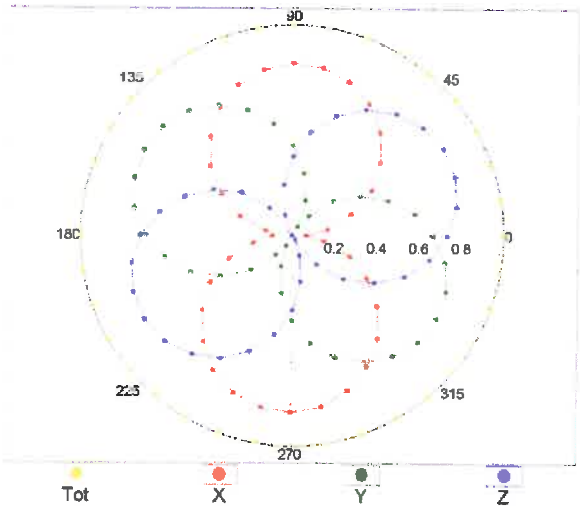
Frequency Response of E-Field
(TEM-Cell:ifi110 EXX, Waveguide: R22)



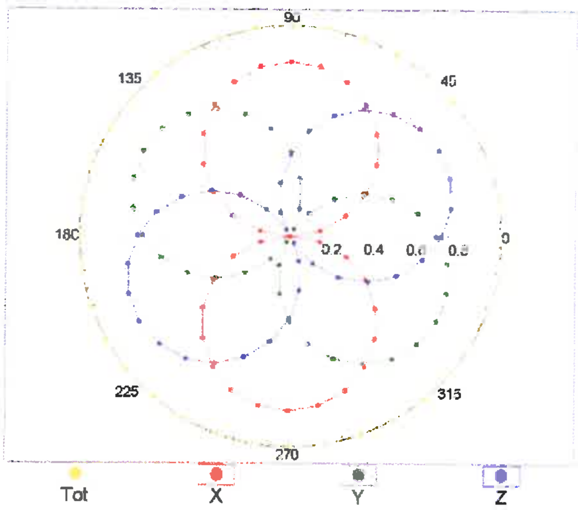
Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)

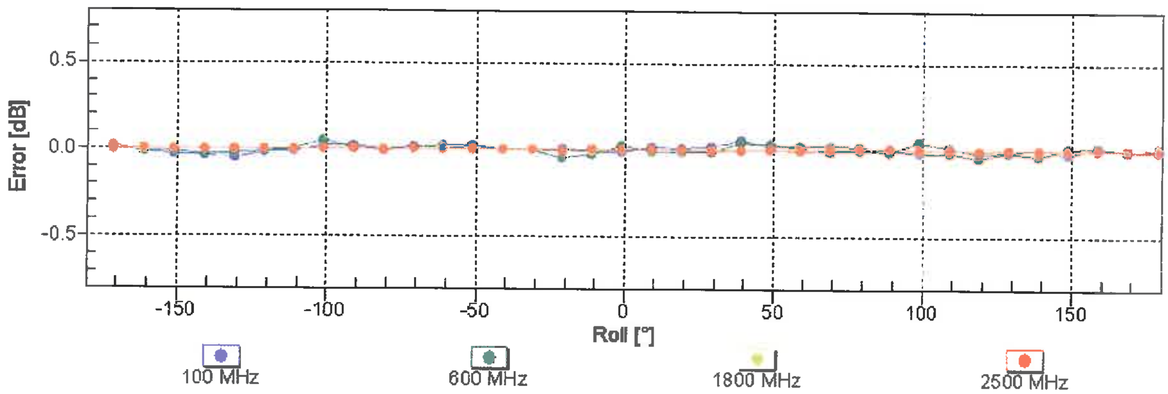
Receiving Pattern (φ), ϑ = 0°

f=600 MHz,TEM



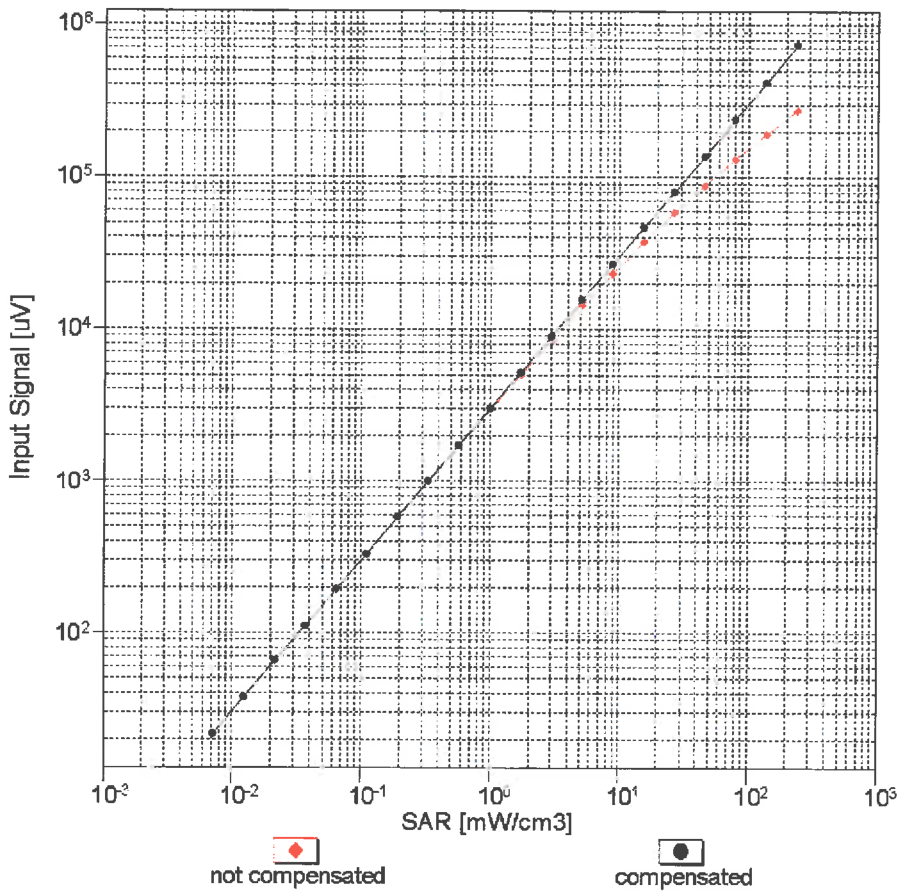
f=1800 MHz,R22

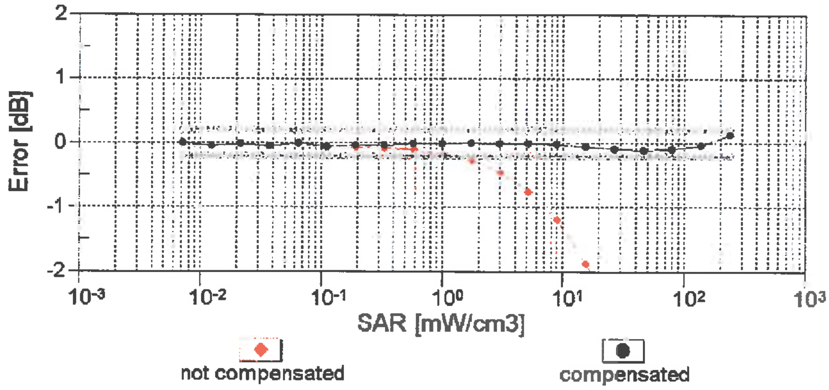




Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

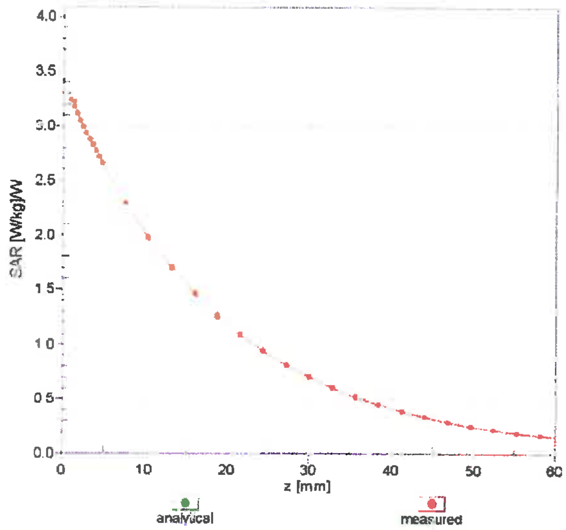
Dynamic Range f(SAR_{head})
(TEM cell , f_{eval}= 1900 MHz)

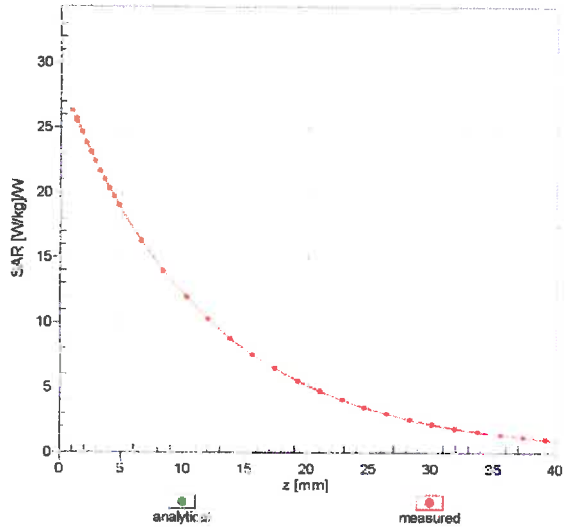




Uncertainty of Linearity Assessment: ± 0.6% (k=2)

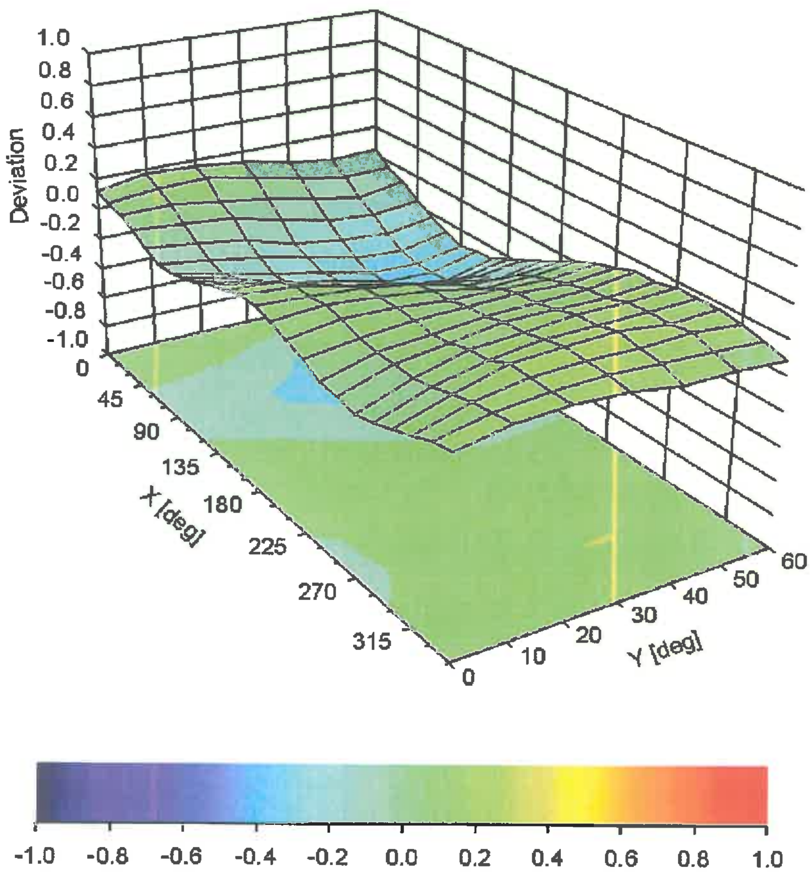
Conversion Factor Assessment





Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz



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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7328

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	118.7
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

Schmid & Partner Engineering AG

s p e a g

Zeughausstrasse 43, 8004 Zurich, Switzerland
Phone +41 44 245 9700, Fax +41 44 245 9779
info@speag.com, http://www.speag.com

1458

IMPORTANT NOTICE

USAGE OF THE DAE 4

The DAE unit is a delicate, high precision instrument and requires careful treatment by the user. There are no serviceable parts inside the DAE. Special attention shall be given to the following points:

Battery Exchange: The battery cover of the DAE4 unit is closed using a screw, over tightening the screw may cause the threads inside the DAE to wear out.

Shipping of the DAE: Before shipping the DAE to SPEAG for calibration, remove the batteries and pack the DAE in an antistatic bag. This antistatic bag shall then be packed into a larger box or container which protects the DAE from impacts during transportation. The package shall be marked to indicate that a fragile instrument is inside.

E-Stop Failures: Touch detection may be malfunctioning due to broken magnets in the E-stop. Rough handling of the E-stop may lead to damage of these magnets. Touch and collision errors are often caused by dust and dirt accumulated in the E-stop. To prevent E-stop failure, the customer shall always mount the probe to the DAE carefully and keep the DAE unit in a non-dusty environment if not used for measurements.

Repair: Minor repairs are performed at no extra cost during the annual calibration. However, SPEAG reserves the right to charge for any repair especially if rough unprofessional handling caused the defect.

DASY Configuration Files: Since the exact values of the DAE input resistances, as measured during the calibration procedure of a DAE unit, are not used by the DASY software, a nominal value of 200 MOhm is given in the corresponding configuration file.

Important Note:
Warranty and calibration is void if the DAE unit is disassembled partly or fully by the Customer.

Important Note:
Never attempt to grease or oil the E-stop assembly. Cleaning and readjusting of the E-stop assembly is allowed by certified SPEAG personnel only and is part of the annual calibration procedure.

Important Note:
To prevent damage of the DAE probe connector pins, use great care when installing the probe to the DAE. Carefully connect the probe with the connector notch oriented in the mating position. Avoid any rotational movement of the probe body versus the DAE while turning the locking nut of the connector. The same care shall be used when disconnecting the probe from the DAE.

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

S **Schweizerischer Kalibrierdienst**
C **Service suisse d'étalonnage**
S **Servizio svizzero di taratura**
S **Swiss Calibration Service**

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client **CTI cert (Auden)**

Certificate No: DAE4-1458_Feb16

CALIBRATION CERTIFICATE

Object	DAE4 - SD 000 D04 BM - SN: 1458
Calibration procedure(s)	QA CAL-06.v29 Calibration procedure for the data acquisition electronics (DAE)
Calibration date:	February 26, 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
Keithley Multimeter Type 2001	SN: 0810278	09-Sep-15 (No:17153)	Sep-16

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Auto DAE Calibration Unit	SE UWS 053 AA 1001	05-Jan-16 (in house check)	In house check: Jan-17
Calibrator Box V2.1	SE UMS 006 AA 1002	05-Jan-16 (in house check)	In house check: Jan-17

	Name	Function	Signature
Calibrated by:	R.Mayoraz	Technician	R. Mayoraz
Approved by:	Fin Bomholt	Deputy Technical Manager	i.V. B. Bomholt

Issued: February 26, 2016

Glossary

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

Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle*: The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
  - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
  - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
  - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
  - *Input Offset Measurement*: Output voltage and statistical results over a large number of zero voltage measurements.
  - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
  - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
  - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
  - *Power consumption:* Typical value for information. Supply currents in various operating modes.

DC Voltage Measurement

A/D - Converter Resolution nominal

High Range:	1LSB =	6.1μV ,	full range =	-100...+300 mV
Low Range:	1LSB =	61nV ,	full range =	-1.......+3mV

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

Calibration Factors	X	Y	Z
High Range	404.357 ± 0.02% (k=2)	404.348 ± 0.02% (k=2)	404.579 ± 0.02% (k=2)
Low Range	3.99060 ± 1.50% (k=2)	3.95834 ± 1.50% (k=2)	3.96178 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	334.0 ° ± 1 °

Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	200029.05	-2.61	-0.00
Channel X	+ Input	20002.74	-1.16	-0.01
Channel X	- Input	-20003.37	1.85	-0.01
Channel Y	+ Input	200037.70	0.70	0.00
Channel Y	+ Input	20003.11	-0.75	-0.00
Channel Y	- Input	-20007.07	-1.69	0.01
Channel Z	+ Input	200029.13	-7.99	-0.00
Channel Z	+ Input	20002.60	-1.22	-0.01
Channel Z	- Input	-20007.23	-1.82	0.01

Low Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	2000.10	-0.38	-0.02
Channel X	+ Input	200.81	0.25	0.13
Channel X	- Input	-198.85	0.63	-0.32
Channel Y	+ Input	2000.25	-0.15	-0.01
Channel Y	+ Input	199.69	-0.83	-0.41
Channel Y	- Input	-199.69	-0.21	0.10
Channel Z	+ Input	1999.84	-0.55	-0.03
Channel Z	+ Input	198.93	-1.60	-0.80
Channel Z	- Input	-201.41	-1.78	0.89

2. Common mode sensitivity

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

	Common mode Input Voltage (mV)	High Range Average Reading (μV)	Low Range Average Reading (μV)
Channel X	200	20.68	18.72
	- 200	-18.32	-19.98
Channel Y	200	-4.77	-4.88
	- 200	3.81	3.30
Channel Z	200	-1.97	-1.91
	- 200	-0.55	-0.32

3. Channel separation

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

	Input Voltage (mV)	Channel X (μV)	Channel Y (μV)	Channel Z (μV)
Channel X	200	-	0.20	-5.28
Channel Y	200	8.61	-	2.12
Channel Z	200	9.96	5.87	-

4. AD-Converter Values with inputs shorted

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

	High Range (LSB)	Low Range (LSB)
Channel X	16323	15393
Channel Y	15751	15672
Channel Z	16844	15985

5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec
Input 10MΩ

	Average (μV)	min. Offset (μV)	max. Offset (μV)	Std. Deviation (μV)
Channel X	0.27	-1.78	1.84	0.64
Channel Y	0.93	-1.29	2.12	0.55
Channel Z	-1.08	-2.94	0.61	0.76

6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

7. Input Resistance (Typical values for information)

	Zeroing (kOhm)	Measuring (MOhm)
Channel X	200	200
Channel Y	200	200
Channel Z	200	200

8. Low Battery Alarm Voltage (Typical values for information)

Typical values	Alarm Level (VDC)
Supply (+ Vcc)	+7.9
Supply (- Vcc)	-7.6

9. Power Consumption (Typical values for information)

Typical values	Switched off (mA)	Stand by (mA)	Transmitting (mA)
Supply (+ Vcc)	+0.01	+6	+14
Supply (- Vcc)	–0.01	-8	-9

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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
Servizio svizzero di taratura
S Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client Dgieie (Vitec)

Certificate No: D2450V2-959_Feb15

CALIBRATION CERTIFICATE

Object	D2450V2 - SN:959
Calibration procedure(s)	QA CAL-05.v9 Calibration procedure for dipole validation kits above 700 MHz
Calibration date:	February 05, 2015

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	US37292783	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	MY41092317	07-Oct-14 (No. 217-02021)	Oct-15
Reference 20 dB Attenuator	SN: 5058 (20k)	03-Apr-14 (No. 217-01918)	Apr-15
Type-N mismatch combination	SN: 5047.2 / 06327	03-Apr-14 (No. 217-01921)	Apr-15
Reference Probe ES3DV3	SN: 3205	30-Dec-14 (No. ES3-3205_Dec14)	Dec-15
DAE4	SN: 601	18-Aug-14 (No. DAE4-601_Aug14)	Aug-15

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-13)	In house check: Oct-16
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

	Name	Function	Signature
Calibrated by:	Israe Elnaouq	Laboratory Technician	Israe Elnaouq
Approved by:	Katja Pokovic	Technical Manager	

Issued: February 6, 2015

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

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) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

d) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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	2450 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	39.3 ± 6 %	1.88 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.7 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**53.7 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.31 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**25.0 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	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	51.6 ± 6 %	2.03 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	13.1 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**51.2 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.00 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**23.7 W/kg ± 16.5 % (k=2)**

Appendix (Additional assessments outside the scope of SCS0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	54.2 Ω + 0.5 jΩ
Return Loss	- 27.9 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	51.9 Ω + 5.1 jΩ
Return Loss	- 25.4 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.158 ns

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

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	August 05, 2014

DASY5 Validation Report for Head TSL

Date: 04.02.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:959

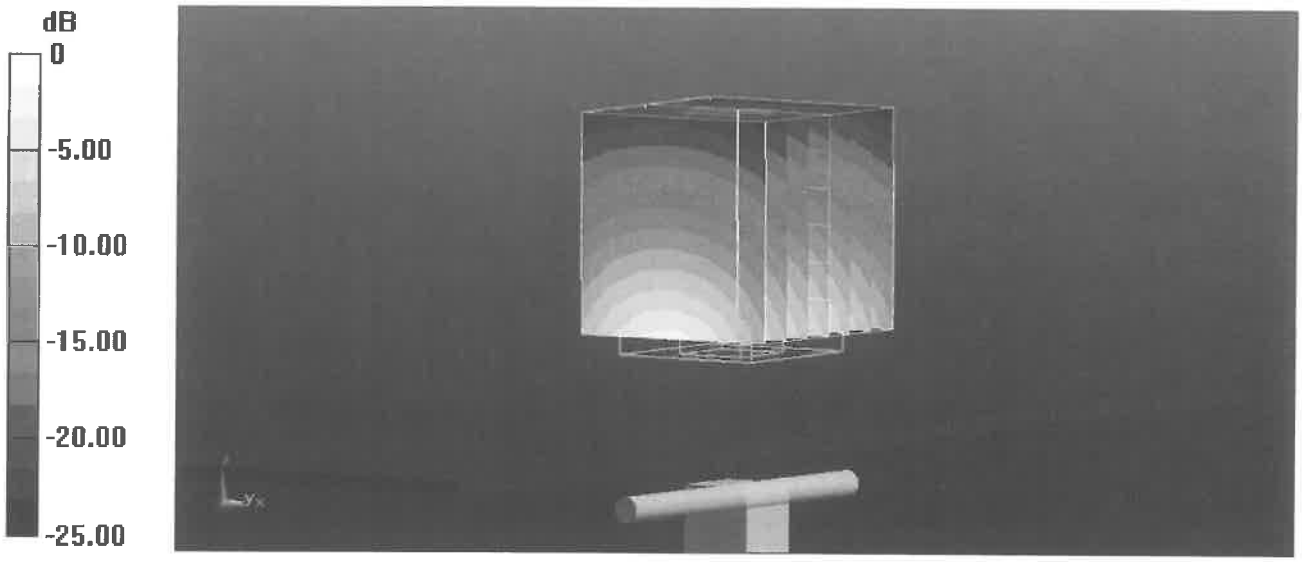
Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 1.88 S/m; ε_r = 39.3; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.54, 4.54, 4.54); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

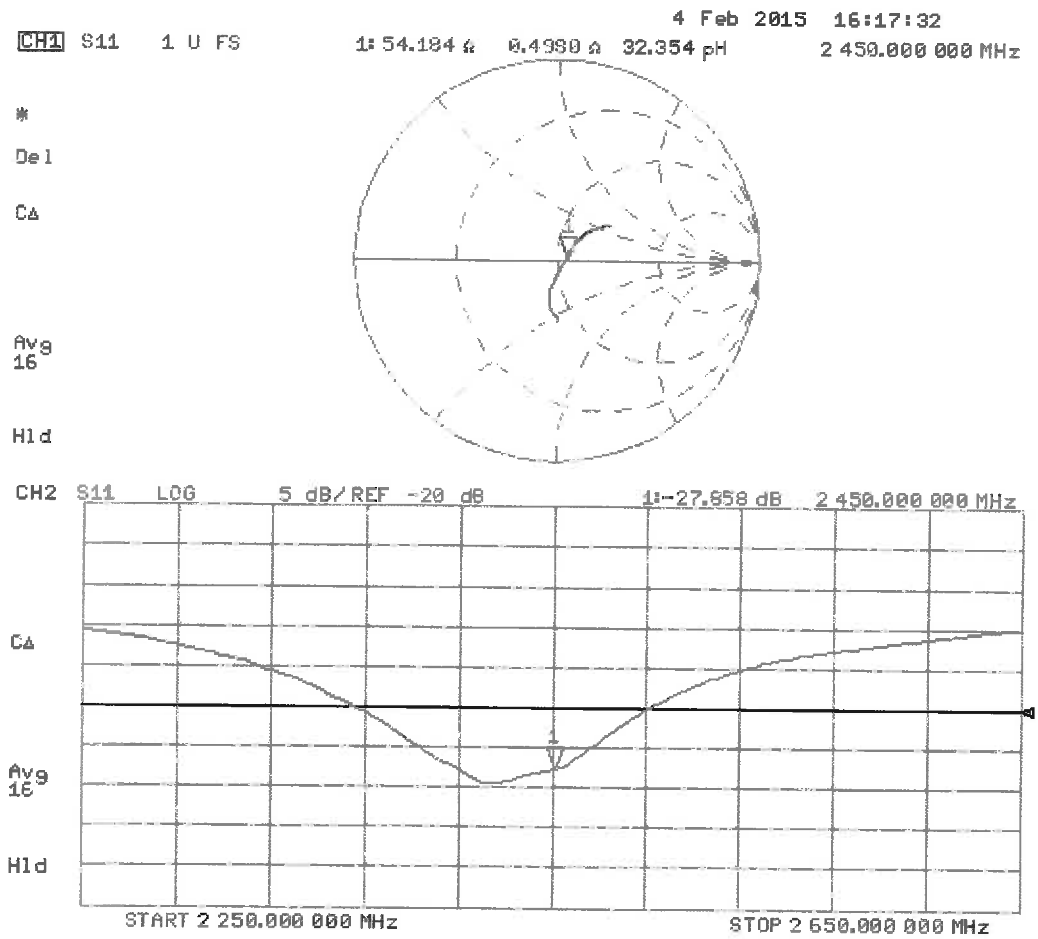
Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 101.6 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 28.6 W/kg
SAR(1 g) = 13.7 W/kg; SAR(10 g) = 6.31 W/kg
Maximum value of SAR (measured) = 18.1 W/kg



0 dB = 18.1 W/kg = 12.58 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 05.02.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:959

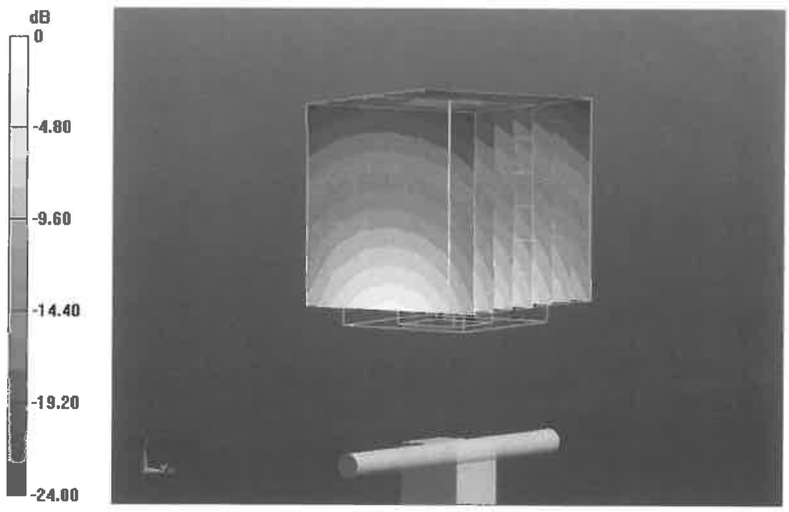
Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 2.03 S/m; ε_r = 51.6; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.32, 4.32, 4.32); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

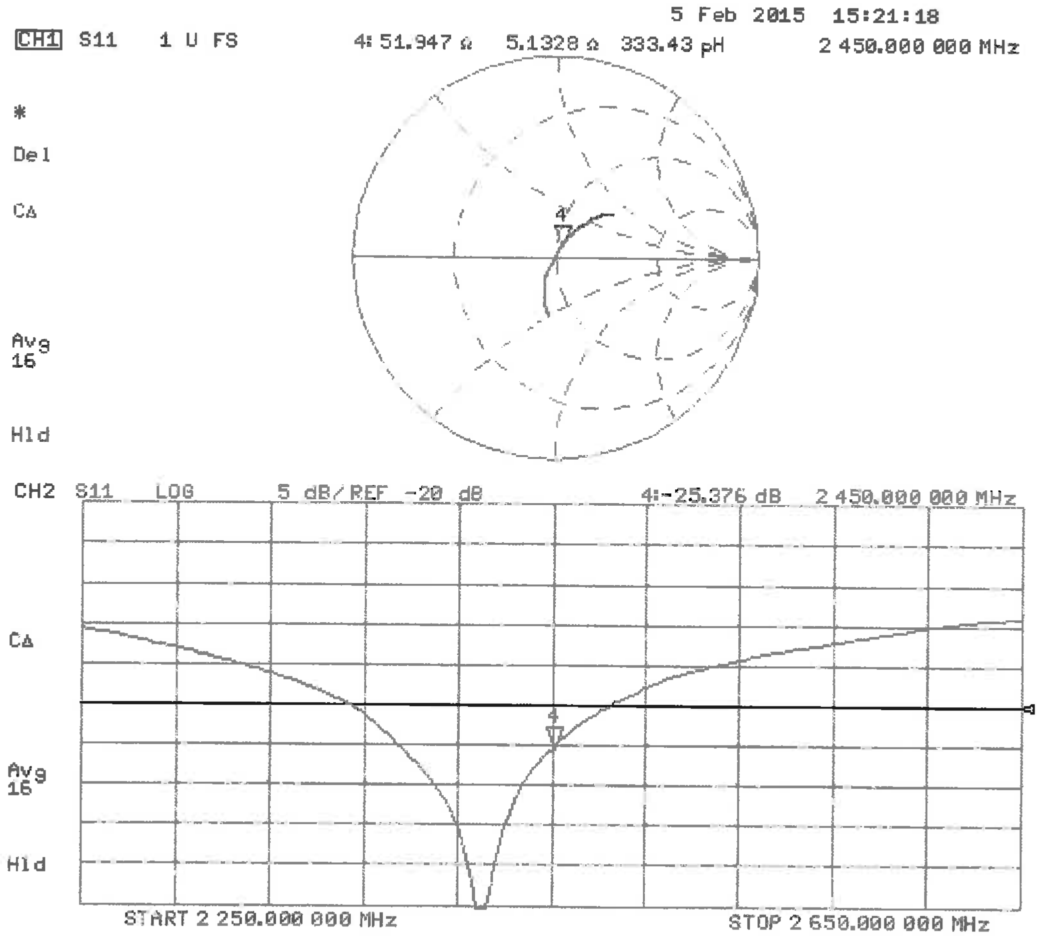
Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 95.40 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 27.4 W/kg
SAR(1 g) = 13.1 W/kg; SAR(10 g) = 6 W/kg
Maximum value of SAR (measured) = 17.3 W/kg

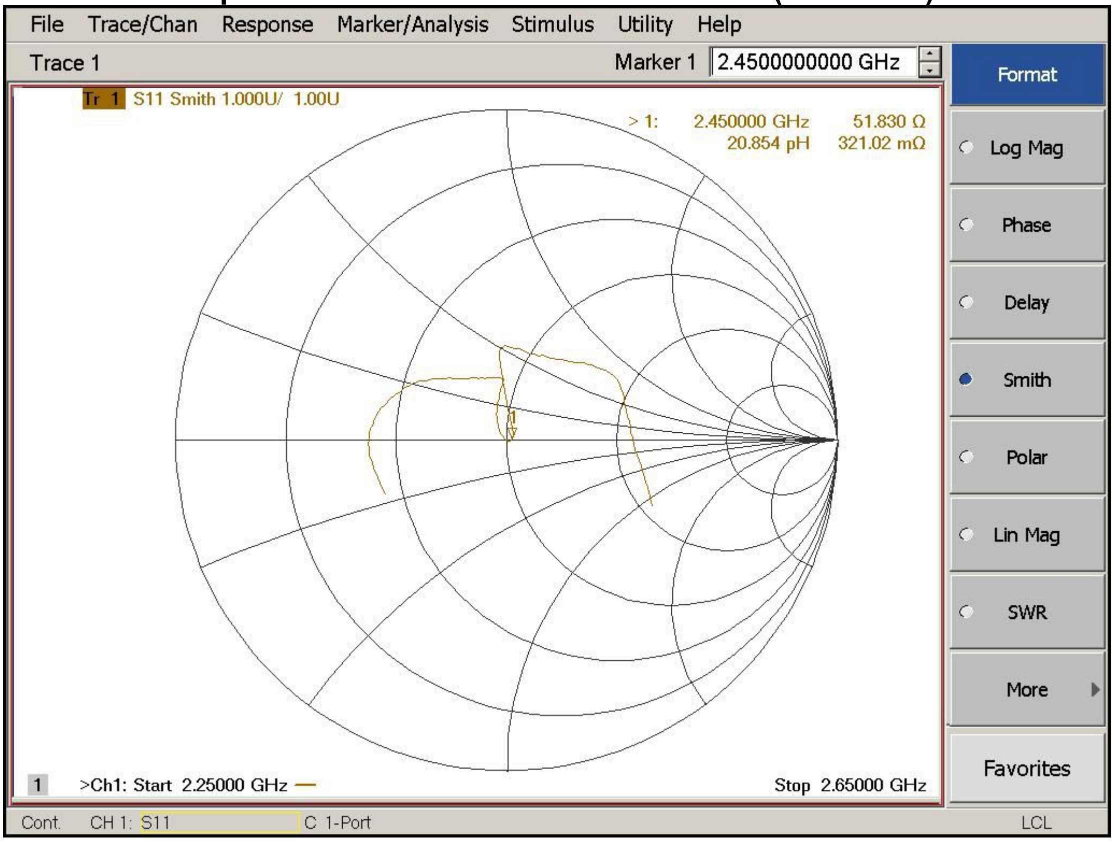


0 dB = 17.3 W/kg = 12.38 dBW/kg

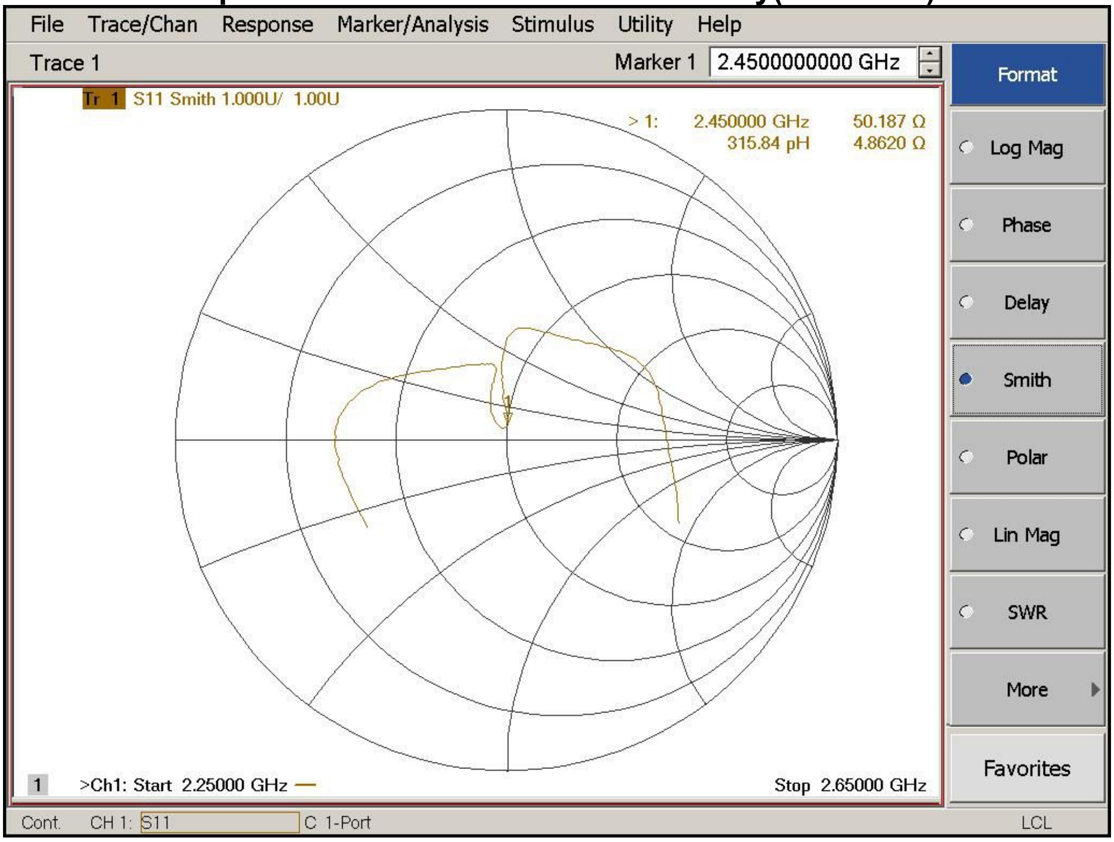
Impedance Measurement Plot for Body TSL



Impedance and Return Loss Test-Head(2016.2.19)



Impedance and Return Loss Test-Body(2016.2.19)



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

S	**Schweizerischer Kalibrierdienst**
C	**Service suisse d'étalonnage**
	Servizio svizzero di taratura
S	**Swiss Calibration Service**

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client **Dgieie (Vitec)**

Certificate No: D5GHzV2-1208_Feb15

CALIBRATION CERTIFICATE

Object	D5GHzV2 - SN:1208
Calibration procedure(s)	QA CAL-22.v2 Calibration procedure for dipole validation kits between 3-6 GHz
Calibration date:	February 03, 2015

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	US37292783	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	MY41092317	07-Oct-14 (No. 217-02021)	Oct-15
Reference 20 dB Attenuator	SN: 5058 (20k)	03-Apr-14 (No. 217-01918)	Apr-15
Type-N mismatch combination	SN: 5047.2 / 06327	03-Apr-14 (No. 217-01921)	Apr-15
Reference Probe EX3DV4	SN: 3503	30-Dec-14 (No. EX3-3503_Dec14)	Dec-15
DAE4	SN: 601	18-Aug-14 (No. DAE4-601_Aug14)	Aug-15

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-13)	In house check: Oct-16
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

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

Issued: February 9, 2015

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

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) 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
b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"
c) 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

Additional Documentation:

d) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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 V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5200 MHz ± 1 MHz 5300 MHz ± 1 MHz 5500 MHz ± 1 MHz 5600 MHz ± 1 MHz 5800 MHz ± 1 MHz	

Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	36.0	4.66 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.3 ± 6 %	4.56 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.83 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**78.4 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.23 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.3 W/kg ± 19.5 % (k=2)**

Head TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.76 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.1 ± 6 %	4.66 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5300 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.35 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**83.5 W / kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.39 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.9 W/kg ± 19.5 % (k=2)**

Head TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.6	4.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.9 ± 6 %	4.86 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5500 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.24 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**82.4 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.34 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.4 W/kg ± 19.5 % (k=2)**

Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.7 ± 6 %	4.97 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.31 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**83.1 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.35 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.5 W/kg ± 19.5 % (k=2)**

Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.4 ± 6 %	5.18 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.92 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**79.2 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.25 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.5 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	49.0	5.30 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	49.4 ± 6 %	5.42 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5200 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.43 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**74.5 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.07 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**20.8 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.42 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	49.2 ± 6 %	5.55 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5300 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.55 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**75.6 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.10 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**21.1 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.6	5.65 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.9 ± 6 %	5.82 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5500 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	8.02 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**80.4 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.22 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**22.3 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.7 ± 6 %	5.96 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.85 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**78.7 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.16 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**21.7 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.2	6.00 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.4 ± 6 %	6.25 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5800 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.65 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**76.7 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.10 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**21.0 W/kg ± 19.5 % (k=2)**

Appendix (Additional assessments outside the scope of SCS0108)

Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	48.4 Ω - 6.5 jΩ
Return Loss	- 23.3 dB

Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	51.3 Ω - 1.2 jΩ
Return Loss	- 35.1 dB

Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	48.7 Ω + 2.3 jΩ
Return Loss	- 31.3 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	51.9 Ω - 0.1 jΩ
Return Loss	- 34.5 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	55.4 Ω + 5.3 jΩ
Return Loss	- 22.9 dB

Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	48.1 Ω - 5.1 jΩ
Return Loss	- 25.2 dB

Antenna Parameters with Body TSL at 5300 MHz

Impedance, transformed to feed point	50.9 Ω + 0.0 jΩ
Return Loss	- 41.0 dB

Antenna Parameters with Body TSL at 5500 MHz

Impedance, transformed to feed point	48.6 Ω + 3.5 jΩ
Return Loss	- 28.4 dB

Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	52.1 Ω + 1.5 jΩ
Return Loss	- 32.1 dB

Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	55.8 Ω + 6.3 jΩ
Return Loss	- 21.8 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.190 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 14, 2014

DASY5 Validation Report for Head TSL

Date: 03.02.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN:1208

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; σ = 4.56 S/m; ε_r = 36.3; ρ = 1000 kg/m^3 , Medium parameters used: f = 5300 MHz; σ = 4.66 S/m; ε_r = 36.1; ρ = 1000 kg/m^3 , Medium parameters used: f = 5500 MHz; σ = 4.86 S/m; ε_r = 35.9; ρ = 1000 kg/m^3 , Medium parameters used: f = 5600 MHz; σ = 4.97 S/m; ε_r = 35.7; ρ = 1000 kg/m^3 , Medium parameters used: f = 5800 MHz; σ = 5.18 S/m; ε_r = 35.4; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.51, 5.51, 5.51); Calibrated: 30.12.2014, ConvF(5.21, 5.21, 5.21); Calibrated: 30.12.2014, ConvF(5.12, 5.12, 5.12); Calibrated: 30.12.2014, ConvF(4.92, 4.92, 4.92); Calibrated: 30.12.2014, ConvF(4.9, 4.9, 4.9); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

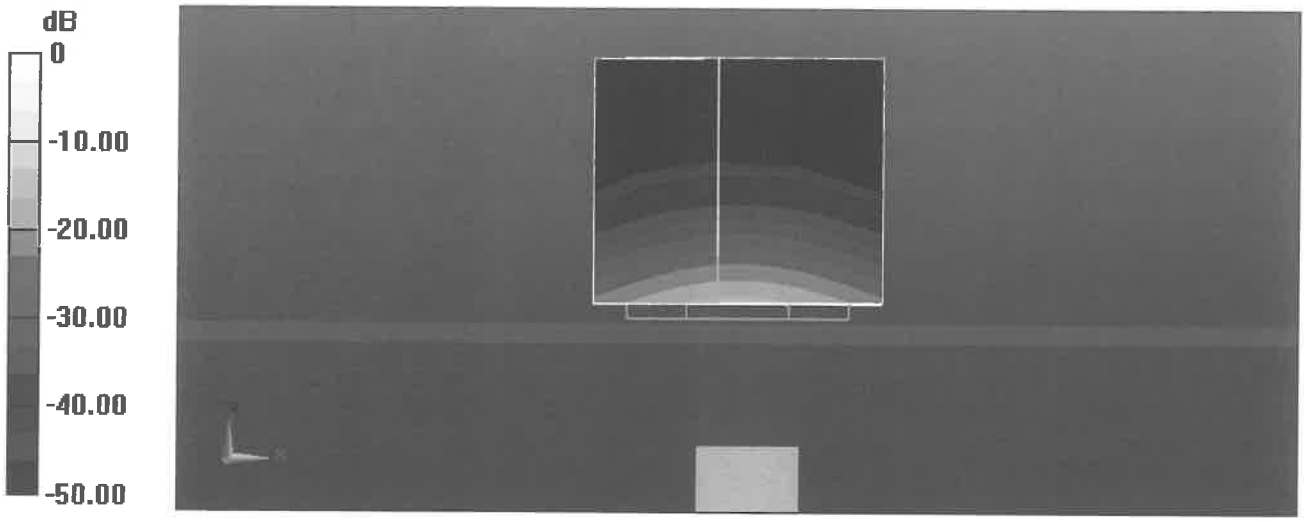
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 64.69 V/m; Power Drift = 0.05 dB
Peak SAR (extrapolated) = 28.8 W/kg
SAR(1 g) = 7.83 W/kg; SAR(10 g) = 2.23 W/kg
Maximum value of SAR (measured) = 18.1 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.76 V/m; Power Drift = 0.05 dB
Peak SAR (extrapolated) = 31.7 W/kg
SAR(1 g) = 8.35 W/kg; SAR(10 g) = 2.39 W/kg
Maximum value of SAR (measured) = 19.3 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 64.62 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 32.7 W/kg
SAR(1 g) = 8.24 W/kg; SAR(10 g) = 2.34 W/kg
Maximum value of SAR (measured) = 19.5 W/kg

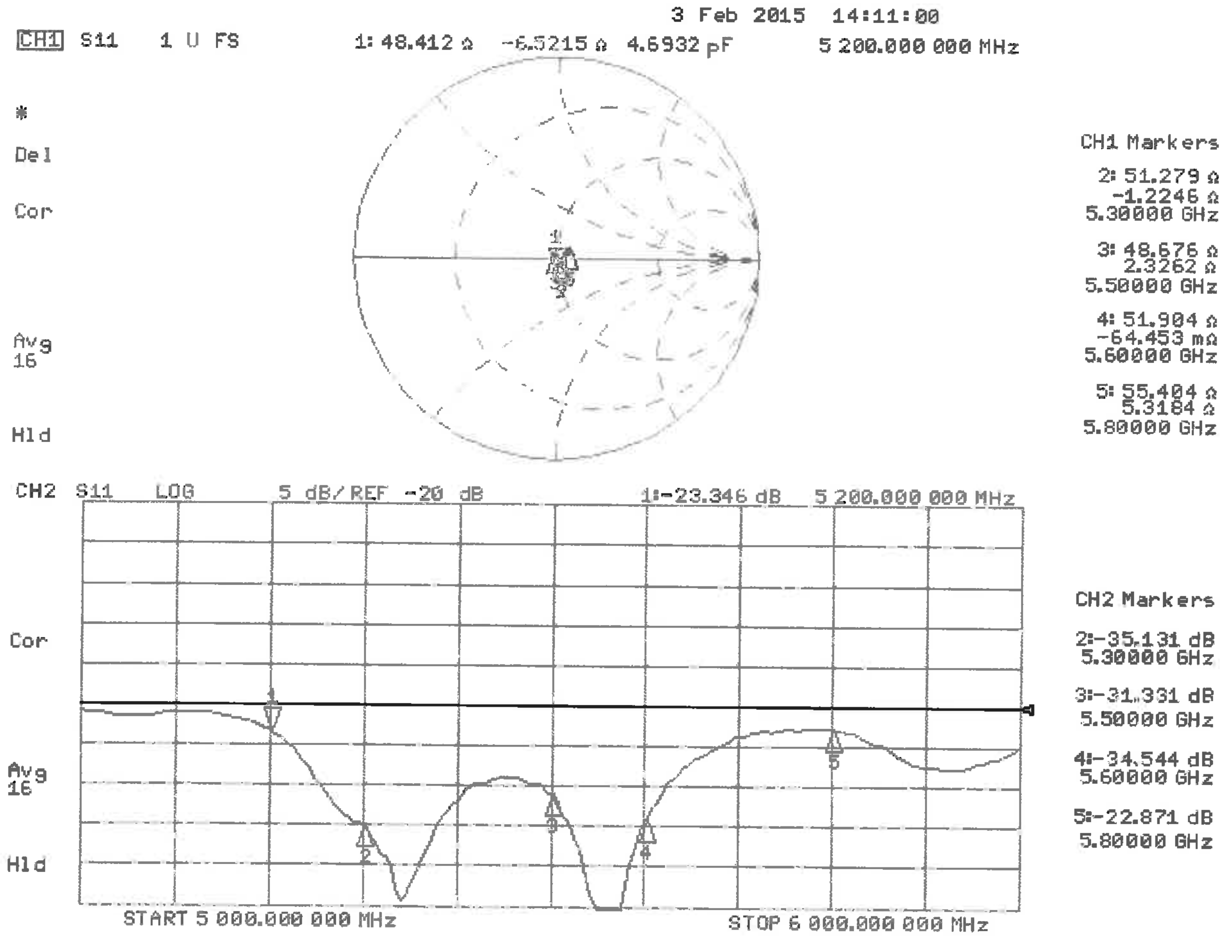
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 64.57 V/m; Power Drift = 0.04 dB
Peak SAR (extrapolated) = 33.2 W/kg
SAR(1 g) = 8.31 W/kg; SAR(10 g) = 2.35 W/kg
Maximum value of SAR (measured) = 19.9 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 61.67 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 33.1 W/kg
SAR(1 g) = 7.92 W/kg; SAR(10 g) = 2.25 W/kg



0 dB = 18.1 W/kg = 12.58 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 02.02.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN:1208

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; σ = 5.42 S/m; ε_r = 49.4; ρ = 1000 kg/m^3 , Medium parameters used: f = 5300 MHz; σ = 5.55 S/m; ε_r = 49.2; ρ = 1000 kg/m^3 , Medium parameters used: f = 5500 MHz; σ = 5.82 S/m; ε_r = 48.9; ρ = 1000 kg/m^3 , Medium parameters used: f = 5600 MHz; σ = 5.96 S/m; ε_r = 48.7; ρ = 1000 kg/m^3 , Medium parameters used: f = 5800 MHz; σ = 6.25 S/m; ε_r = 48.4; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(4.95, 4.95, 4.95); Calibrated: 30.12.2014, ConvF(4.78, 4.78, 4.78); Calibrated: 30.12.2014, ConvF(4.45, 4.45, 4.45); Calibrated: 30.12.2014, ConvF(4.35, 4.35, 4.35); Calibrated: 30.12.2014, ConvF(4.32, 4.32, 4.32); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

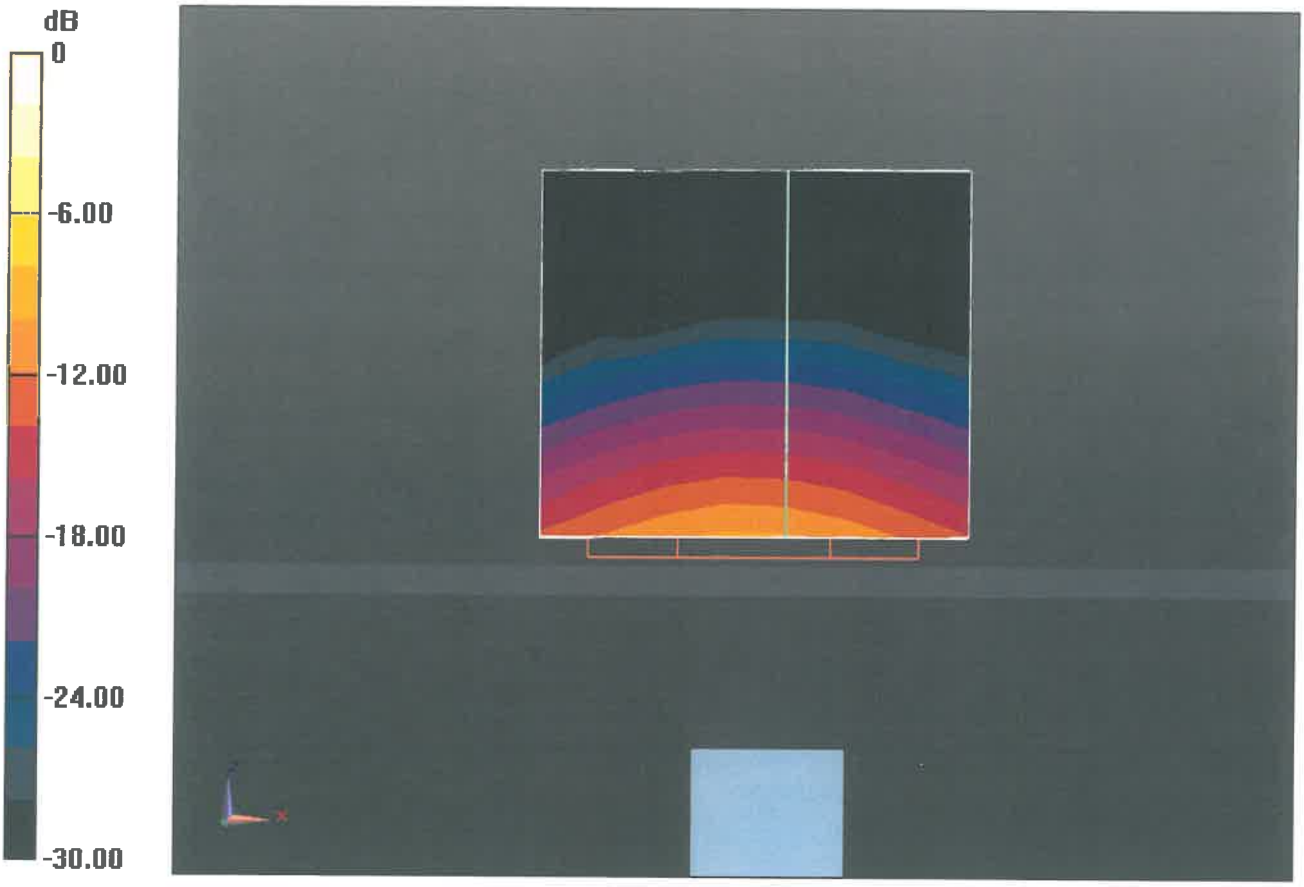
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 59.42 V/m; Power Drift = -0.05 dB
Peak SAR (extrapolated) = 29.4 W/kg
SAR(1 g) = 7.43 W/kg; SAR(10 g) = 2.07 W/kg
Maximum value of SAR (measured) = 17.1 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 58.38 V/m; Power Drift = 0.04 dB
Peak SAR (extrapolated) = 30.5 W/kg
SAR(1 g) = 7.55 W/kg; SAR(10 g) = 2.1 W/kg
Maximum value of SAR (measured) = 17.5 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 59.21 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 34.3 W/kg
SAR(1 g) = 8.02 W/kg; SAR(10 g) = 2.22 W/kg
Maximum value of SAR (measured) = 18.9 W/kg

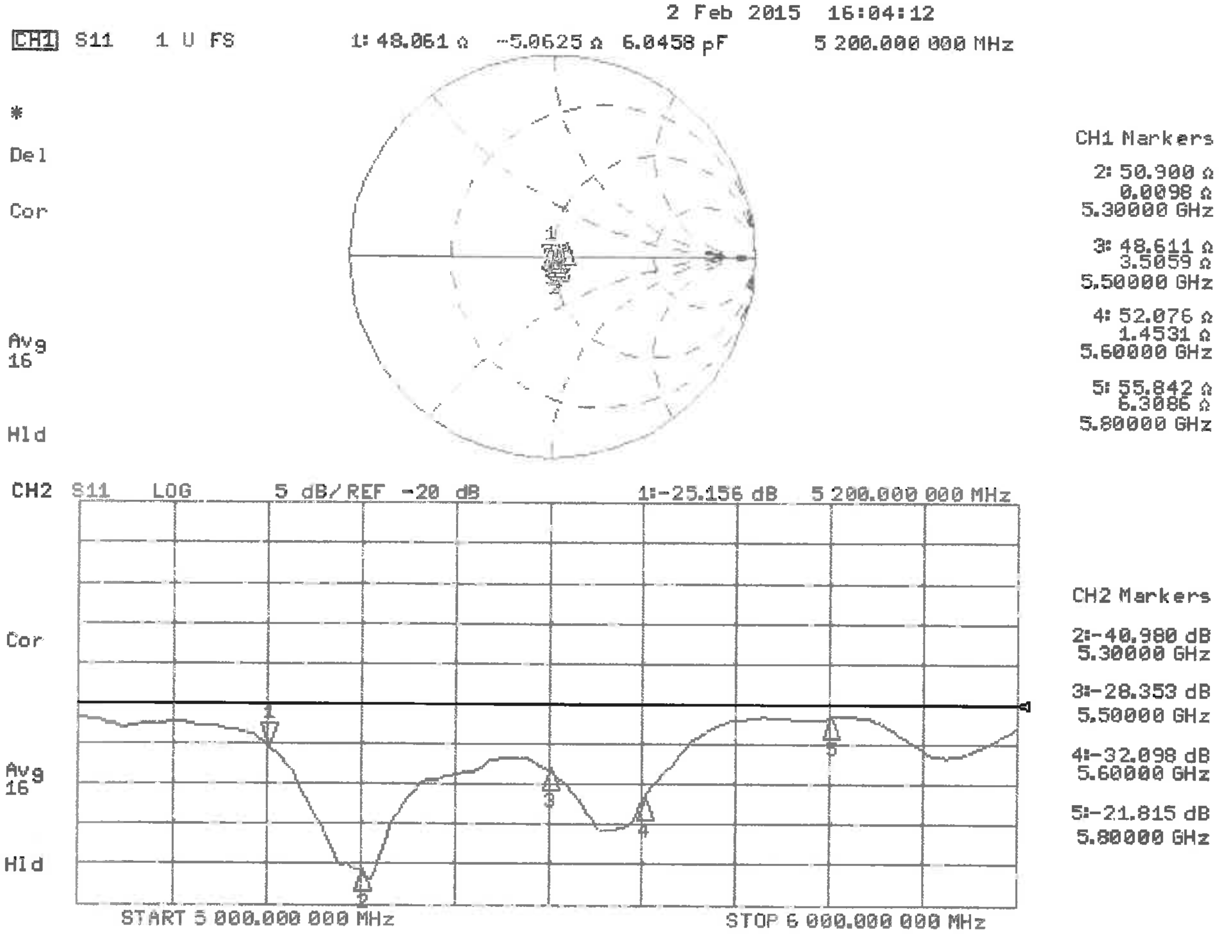
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 57.80 V/m; Power Drift = 0.05 dB
Peak SAR (extrapolated) = 35.1 W/kg
SAR(1 g) = 7.85 W/kg; SAR(10 g) = 2.16 W/kg
Maximum value of SAR (measured) = 18.8 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 55.95 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 35.9 W/kg
SAR(1 g) = 7.65 W/kg; SAR(10 g) = 2.1 W/kg
Maximum value of SAR (measured) = 18.6 W/kg

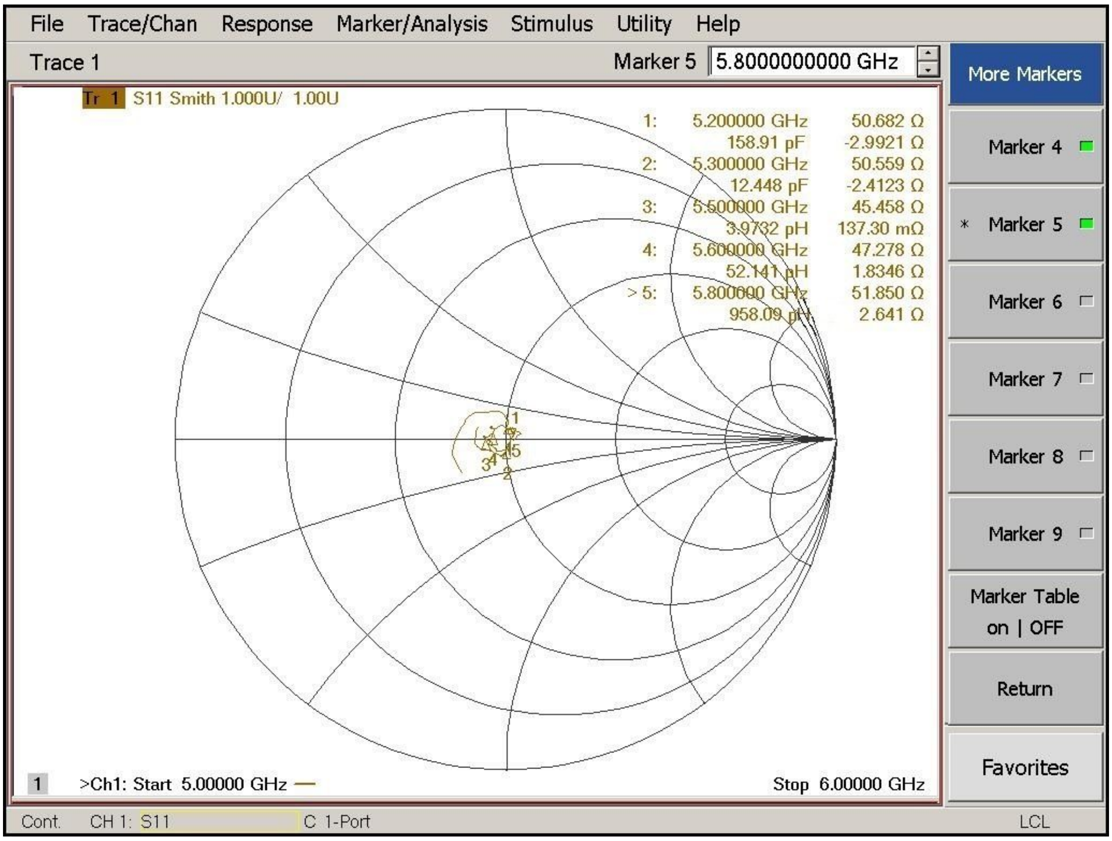


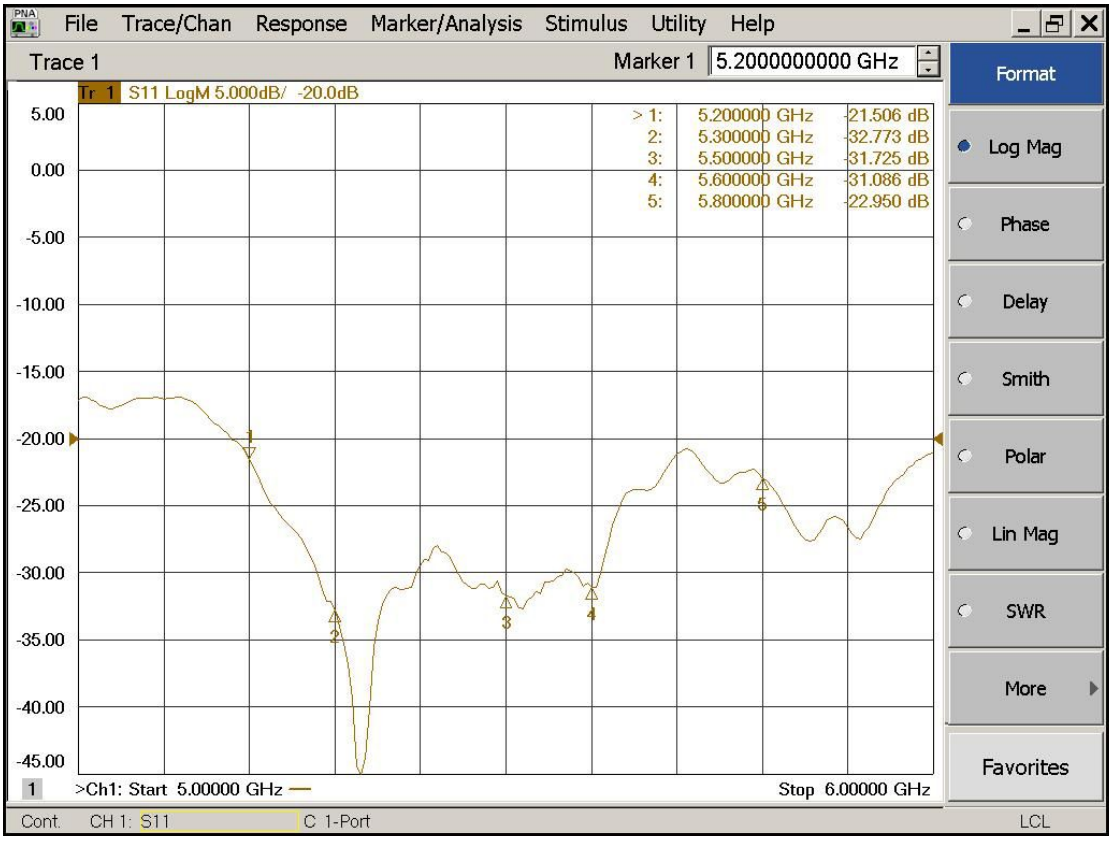
0 dB = 17.1 W/kg = 12.33 dBW/kg

Impedance Measurement Plot for Body TSL

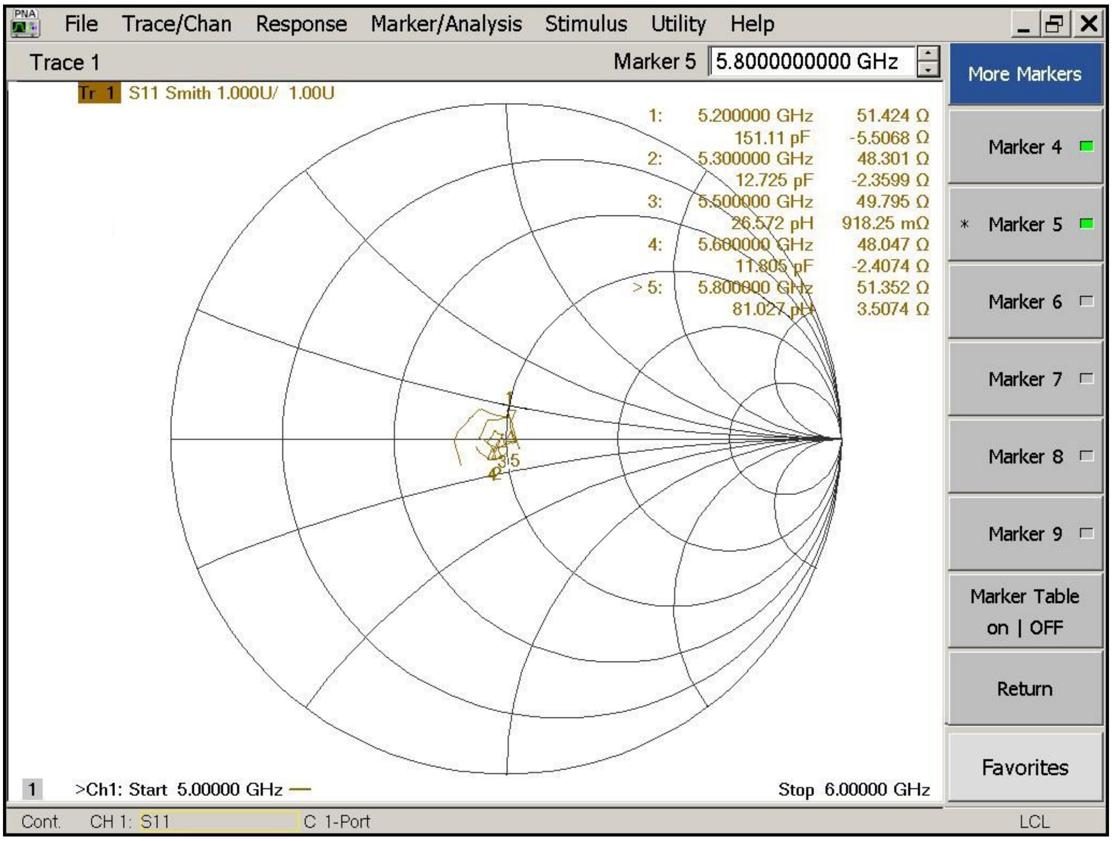


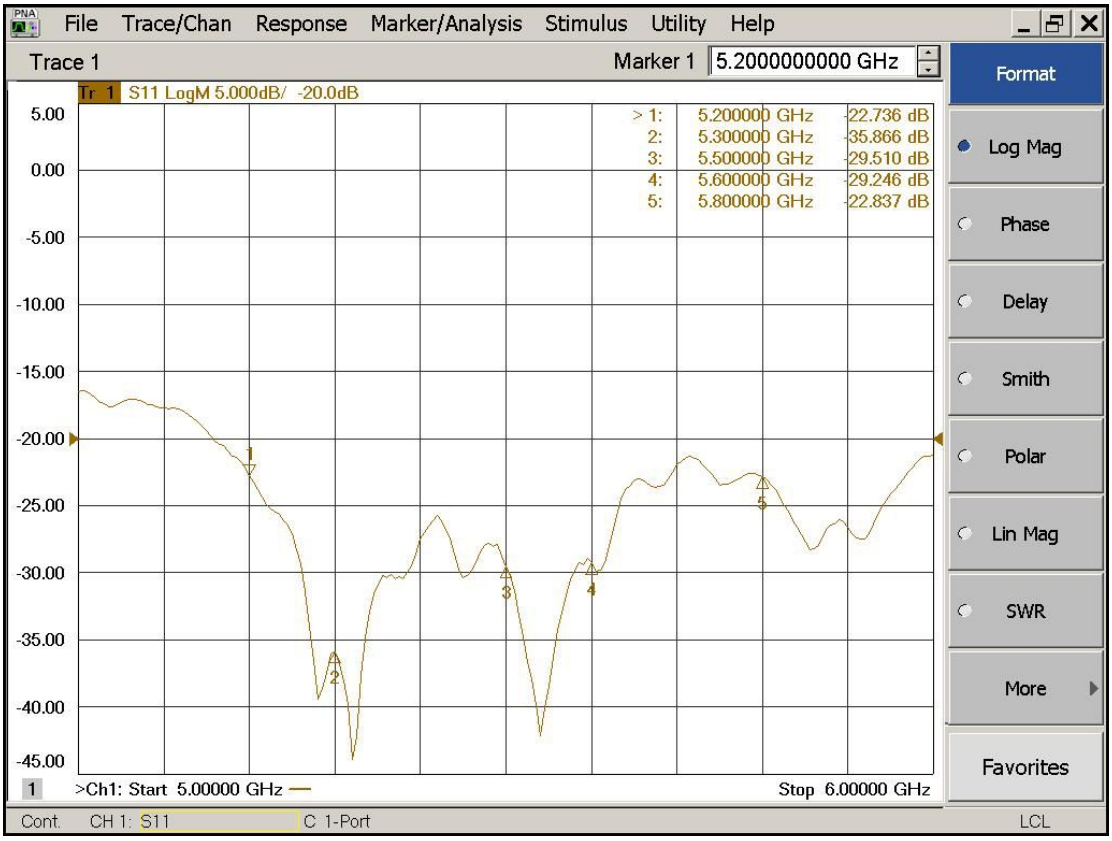
Impedance and Return Loss Test-Head (2016.2.21)





Impedance and Return Loss Test-Body (2016.2.21)





Appendix D: Photo documentation

Photo 1: Measurement System DASY5 SAR	Photo 2: Front Side 5mm
	
Photo 3: Back Side 5mm	Photo 4: Left Side 5mm
	

Photo 5: Right Side 5mm	NA
	NA