FCC SAR TEST REPORT

For

HYUNDAI CORPORATION

Smart Phone

Model No.: E553

FCC ID: RQQHLT-E553TA

Prepared For	:	HYUNDAI CORPORATION
Address	:	25,Yulgok-ro 2-Gil, Jongno-gu, Seoul, South Korea
Prepared By	:	Shenzhen Anbotek Compliance Laboratory Limited
Address	:	1/F., Building 1, SEC Industrial Park, No.0409 Qianhai Road, Nanshan District, Shenzhen, Guangdong, China Tel: (86) 755-26066544 Fax: (86) 755-26014772
Report Number	:	R0219050002W
Date of Test	:	May.05, 2019 - May.10, 2019
Date of Report	:	May.21, 2019

Contents

TEST REPORT

Applicant	:	HYUNDAI CORPORATION
Manufacturer	:	Shenzhen Tinno Mobile Technology Corp.
Product Name	:	Smart Phone
Model No.	:	E553
Trade Mark	:	HYUNDAI
Rating(s)	:	DC 3.85V

Test Standard(s) : **IEEE Std 1528:2013; FCC 47 CFR Part 2 (2.1093:2013); ANSI/IEEE C95.1:2005; KDB 865664 D01,KDB 865664 D02, KDB 447498 D01, KDB248227 D01, KDB941225 D01,KDB648474 D04**

The device described above is tested by Shenzhen Anbotek Compliance Laboratory Limited to determine the maximum emission levels emanating from the device and the severe levels of the device can endure and its performance criterion. The measurement results are contained in this test report and Shenzhen Anbotek Compliance Laboratory Limited is assumed full of responsibility for the accuracy and completeness of these measurements. Also, this report shows that the EUT (Equipment Under Test) is technically compliant with the FCC requirements.

This report applies to above tested sample only and shall not be reproduced in part without written approval of Shenzhen Anbotek Compliance Laboratory Limited.

Date of Test: May.05, 2019 - May.10, 2019

Prepared By: Winkey Wang

(Tested Engineer / Winkey Wang)

Reviewer: Bobby Wang

(Project Manager / Bobby Wang)

Approved & Authorized Signer: Tom Chen

(Manager / Tom Chen)

Version

Version No.	Date	Description
01	May.21, 2019	Original

1. Statement of Compliance

The maximum results of Specific Absorption Rate (SAR) found during testing are as follows.

<Highest SAR Summary>

Frequency Band	Highest Reported 1g-SAR(W/Kg)		SAR Test Limit (W/Kg)
	Head	Body (10mm)	
GSM 850	0.31	0.47	1.6
GSM1900	0.33	0.78	
WCDMA Band V	0.32	0.53	
WCDMA Band II	0.34	0.82	
WLAN2.4G	0.28	0.16	
Simultaneous Reported SAR	0.98		
Test Result	PASS		

This device is in compliance with Specific Absorption Rate (SAR) for general population/uncontrolled exposure limits (1.6 W/kg) specified in FCC 47 CFR part 2 (2.1093) and ANSI/IEEE C95.1-2005, and had been tested in accordance with the measurement methods and procedures specified in IEEE 1528-2013

2. General Information

2.1. Client Information

Applicant:	HYUNDAI CORPORATION
Address of Applicant:	25,Yulgok-ro 2-Gil, Jongno-gu, Seoul, South Korea
Manufacture:	Shenzhen Tinno Mobile Technology Corp.
Address of Manufacture:	MMAA

2.2. Testing Laboratory Information

Test Site:	Shenzhen Anbotek Compliance Laboratory Limited
Address:	1/F., Building 1, SEC Industrial Park, No.0409 Qianhai Road, Nanshan District, Shenzhen, Guangdong, China

2.3. Description of Equipment Under Test (EUT)

Equipment	Smart Phone
Brand Name	HYUNDAI
Model Name	E553
Tx Frequency	GSM850: 824.2 MHz ~ 848.6 MHz GSM1900: 1850.2 MHz ~ 1909.8 MHz WCDMA Band V: 826.4 MHz ~ 846.6 MHz WCDMA Band II: 1852.4 MHz ~ 1907.6 MHz WLAN2.4GHz: 2412 MHz ~ 2462 MHz BT: 2402 MHz ~ 2480 MHz
Type of Modulation	GSM,GPRS,EGPRS(Not support 8PSK for EGPRS) RMC,AMR 12.2Kbps,HSDPA,HSUPA BPSK,QPSK,16QAM,64QAM GFSK,8DPSK,π/4DQPSK
Hardware version	K210AG V0.20
Software version	V1.0
Category of device	Portable device

Remark:

1. The above DUT's information was declared by manufacturer. Please refer to the specifications or user's manual for more detailed description.
2. This EUT owns two SIM cards, after we perform the pretest for these two SIM cards; we found the SIM 1 is the worst case, so its result is recorded in this report.

2.4. Device Category and SAR Limits

This device belongs to portable device category because its radiating structure is allowed to be used within 20 centimeters of the body of the user. Limit for General Population/Uncontrolled exposure should be applied for this device, it is 1.6 W/kg as averaged over any 1 gram of tissue.

2.5. Applied Standard

The Specific Absorption Rate (SAR) testing specification, method, and procedure for this device is in accordance with the following standards:

- FCC 47 CFR Part 2 (2.1093:2013)
- ANSI/IEEE C95.1:2005
- IEEE Std 1528:2013
- KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04
- KDB 865664 D02 RF Exposure Reporting v01r02
- KDB 447498 D01 General RF Exposure Guidance v06
- KDB 248227 D01 802 11 Wi-Fi SAR v02r02
- KDB 941225 D01 3G SAR Procedures v03r01
- KDB 648474 D04 Handset SAR v01r03

2.6. Environment of Test Site

Items	Required	Actual
Temperature (℃)	18-25	22~23
Humidity (%RH)	30-70	55~65

2.7. Test Configuration

The device was controlled by using a base station emulator. Communication between the device and the emulator was established by air link. The distance between the EUT and the antenna of the emulator is larger than 50 cm and the output power radiated from the emulator antenna is at least 30 dB smaller than the output power of EUT. The EUT was set from the emulator to radiate maximum output power during all tests. For WLAN SAR testing, WLAN engineering testing software installed on the EUT can provide continuous transmitting RF signal.

3. Specific Absorption Rate (SAR)

3.1. Introduction

SAR is related to the rate at which energy is absorbed per unit mass in an object exposed to a radio field. The SAR distribution in a biological body is complicated and is usually carried out by experimental techniques or numerical modeling. The standard recommends limits for two tiers of groups, occupational/controlled and general population/uncontrolled, based on a person's awareness and ability to exercise control over his or her exposure. In general, occupational/controlled exposure limits are higher than the limits for general population/uncontrolled.

3.2. SAR Definition

The SAR definition is 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).The equation description is as below:

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

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

SAR measurement can be either related to the temperature elevation in tissue by

$$\mathbf{SAR} = \mathbf{C}\left(\frac{\boldsymbol{\delta}\mathbf{T}}{\boldsymbol{\delta}\mathbf{t}}\right)$$

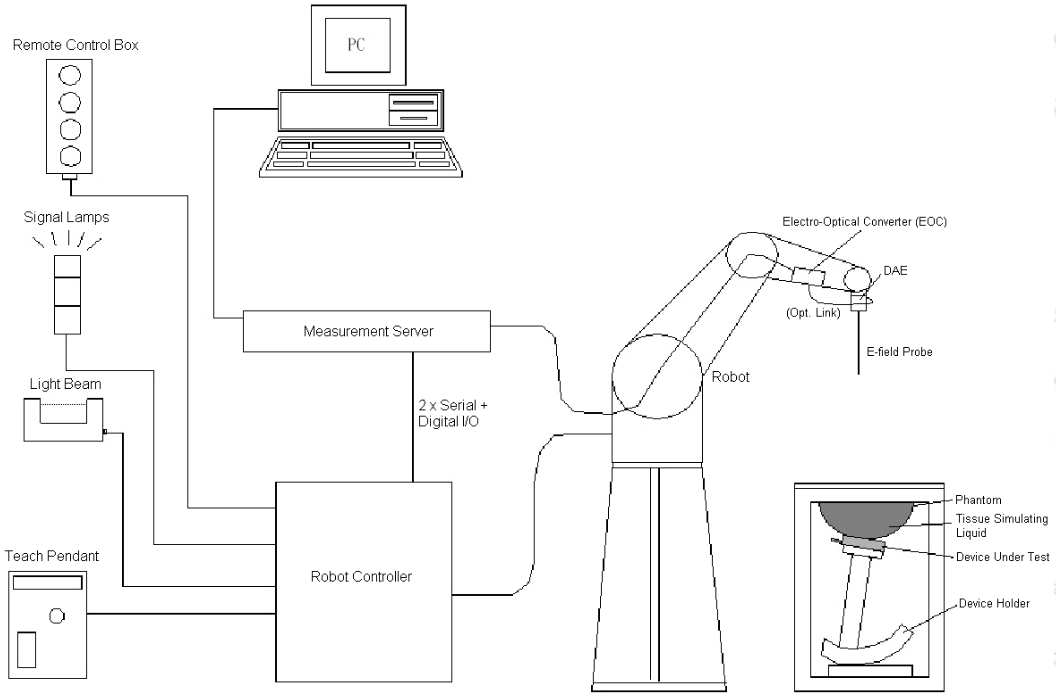
Where: C is the specific head capacity, δT is the temperature rise and δtisthe exposure duration, or related to the electrical field in the tissue by

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

Where: σ is the conductivity of the tissue, ρ is the mass density of the tissue and E is the RMS electrical field strength.

However for evaluating SAR of low power transmitter, electrical field measurement is typically applied.

4. SAR Measurement System



DASY System Configurations

The DASY system for performance compliance tests is illustrated above graphically. This system consists of the following items:

- A standard high precision 6-axis robot with controller, a teach pendant and software
- A data acquisition electronic (DAE) attached to the robot arm extension
- A dosimetric probe equipped with an optical surface detector system
- The electro-optical converter (EOC) performs the conversion between optical and electrical signals
- A measurement server performs the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- A probe alignment unit which improves the accuracy of the probe positioning
- A computer operating Windows XP
- DASY software
- Remove control with teach pendant and additional circuitry for robot safety such as warming lamps, etc.
- The SAM twin phantom
- A device holder
- Tissue simulating liquid
- Dipole for evaluating the proper functioning of the system

components are described in details in the following sub-sections.

4.1. E-Field Probe

The SAR measurement is conducted with the dosimetric probe (manufactured by SPEAG).The probe is specially designed and calibrated for use in liquid with high permittivity. The dosimetric probe has special calibration in liquid at different frequency. This probe has a built in optical surface detection system to prevent from collision with phantom.

➢ **E-Field Probe Specification**

<EX3DV4 Probe>

Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Frequency	10 MHz to 6 GHz; Linearity: ± 0.2 dB
Directivity	± 0.3 dB in HSL (rotation around probe axis) ± 0.5 dB in tissue material (rotation normal to probe axis)
Dynamic Range	10 µW/g to 100 mW/g; Linearity: ± 0.2 dB (noise: typically < 1 µW/g)
Dimensions	Overall length: 330 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Typical distance from probe tip to dipole centers: 1 mm

Photo of EX3DV4

➢ **E-Field Probe Calibration**

Each probe needs to be calibrated according to a dosimetric assessment procedure with accuracy better than ± 10%. The spherical isotropy shall be evaluated and within ± 0.25dB. The sensitivity parameters (NormX, NormY, and NormZ), the diode compression parameter (DCP) and the conversion factor (ConvF) of the probe are tested. The calibration data can be referred to appendix C of this report.

4.2. Data Acquisition Electronics (DAE)

The data acquisition electronics (DAE) consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the 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 input impedance of the DAE is 200MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80dB.

Photo of DAE

4.3. Robot

The SPEAG DASY system uses the high precision robots (DASY5: TX60XL) type from Stäubli SA (France). For the 6-axis controller system, the robot controller version (DASY5: CS8c) from Stäubli is used. The Stäublirobot series have many features that are important for our application:

- High precision (repeatability ±0.035 mm)
- High reliability (industrial design)
- Jerk-free straight movements
- Low ELF interference (the closed metallic construction shields against motor control fields)

Photo of DASY5

4.4. Measurement Server

The measurement server is based on a PC/104 CPU board with CPU (DASY5: 400 MHz, Intel Celeron), chip disk (DASY5: 128 MB), RAM (DASY5: 128 MB). The necessary circuits for communication with the DAE electronic box, as well as the 16 bit AD converter system for optical detection and digital I/O interface are contained on the DASY I/O board, which is directly connected to the PC/104 bus of the CPU board.

The measurement server performs all the real-time data evaluation for field measurements and surface detection, controls robot movements and handles safety operations.

Photo of Server for DASY5

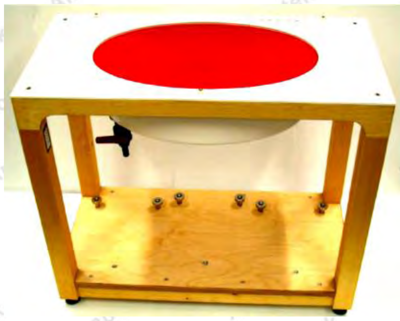
4.5. Phantom

<SAM Twin Phantom>

Shell Thickness	2 ± 0.2 mm; Center ear point: 6 ± 0.2 mm	 **Photo of SAM Phantom**
Filling Volume	Approx. 25 liters	
Dimensions	Length: 1000 mm; Width: 500 mm; Height: adjustable feet	
Measurement Areas	Left Hand, Right Hand, Flat Phantom	

The bottom plate contains three pair 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 tap the phantom during off-periods to prevent water evaporation and changes in the liquid parameters. On the phantom top, three reference markers are provided to identify the phantom position with respect to the robot.

<ELI4 Phantom>

Shell Thickness	2 ± 0.2 mm (sagging: <1%)	 **Photo of ELI4 Phantom**
Filling Volume	Approx. 30 liters	
Dimensions	Major ellipse axis: 600 mm Minor axis:400 mm	

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

4.6. Device Holder

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 5 mm 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 different positions given in the standard. It has two scales for the device rotation (with respect to the body axis) and the device inclination (with respect to the line between the ear reference points). The rotation center 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.

Device Holder

4.7. Data Storage and Evaluation

- Data Storage

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

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

- Data Evaluation

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

Probe parameters:	- Sensitivity	$Norm_i$, a_{i0}, a_{i1}, a_{i2}
	- Conversion factor	$ConvF_i$
	- Diode compression point	dcp_i
Device parameters:	- Frequency	f
	- Crest factor	cf
Media parameters:	- Conductivity	σ
	- Density	ρ

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

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

The formula for each channel can be given as:

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

with V_i= compensated signal of channel i, (i = x, y, z)
U_i = input signal of channel i, (i = x, y, z)
cf = crest factor of exciting field (DASY parameter)
dcp_i = diode compression point (DASY parameter)

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

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

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

with V_i = compensated signal of channel i,(i = x, y, z)
$Norm_i$= sensor sensitivity of channel i, (i = x, y, z), μV/(V/m)^2 for E-field Probes
ConvF= sensitivity enhancement in solution
a_{ij}= sensor sensitivity factors for H-field probes
f = carrier frequency [GHz]
E_i= electric field strength of channel i in V/m
H_i= magnetic field strength of channel i in A/m

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

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

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

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

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

5. Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	835MHz System Validation Kit	D835V2	4d154	Jun 16,2018	Jun 15,2021
SPEAG	1900MHz System Validation Kit	D1900V2	5d175	Jun 15,2018	Jun 14,2021
SPEAG	2450MHz System Validation Kit	D2450V2	910	Jun 15,2018	Jun 14,2021
Rohde & Schwarz	UNIVERSAL RADIO COMMUNICATION TESTER	CMW500	1201.0002K50-1 04209-JC	May.22, 2018	May. 21, 2019
SPEAG	Data Acquisition Electronics	DAE4	387	Sep 6,2018	Sep 5,2019
SPEAG	Dosimetric E-Field Probe	EX3DV4	7396	May 12,2018	May 11,2019
Agilent	ENA Series Network Analyzer	E5071C	MY46317418	May.23, 2018	May. 22, 2019
SPEAG	DAK	DAK-3.5	1226	NCR	NCR
SPEAG	SAM Twin Phantom	QD000P40CD	1802	NCR	NCR
SPEAG	ELI Phantom	QDOVA004AA	2058	NCR	NCR
AR	Amplifier	ZHL-42W	QA1118004	NCR	NCR
Agilent	Power Meter	N1914A	MY50001102	Oct. 28, 2018	Oct. 27, 2019
Agilent	Power Sensor	N8481H	MY51240001	Oct. 29, 2018	Oct. 28, 2019
R&S	Spectrum Analyzer	N9020A	MY51170037	May.23, 2018	May. 22, 2019
Agilent	Signal Generation	N5182A	MY48180656	May.23, 2018	May. 22, 2019
Worken	Directional Coupler	0110A05601O-10	COM5BNW1A2	May.23, 2018	May. 22, 2019

Note:

1. The calibration certificate of DASY can be referred to appendix C of this report.
2. The dipole calibration interval can be extended to 3 years with justification. The dipoles are also not physically damaged, or repaired during the interval.
3. The Insertion Loss calibration of Dual Directional Coupler and Attenuator were characterized via the network analyzer and compensated during system check.
4. The dielectric probe kit was calibrated via the network analyzer, with the specified procedure (calibrated in pure water) and calibration kit (standard) short circuit, before the dielectric measurement. The specific procedure and calibration kit are provided by Agilent.
5. In system check we need to monitor the level on the power meter, and adjust the power amplifier level to have precise power level to the dipole; the measured SAR will be normalized to 1W input power according to the ratio of 1W to the input power to the dipole. For system check, the calibration of the power amplifier is deemed not critically required for correct measurement; the power meter is critical and we do have calibration for it

6. Tissue Simulating Liquids

For the measurement of the field distribution inside the SAM phantom with DASY, the phantom must be filled with around 25 liters of homogeneous body tissue simulating liquid. For head SAR testing, the liquid height from the ear reference point (ERP) of the phantom to the liquid top surface is larger than 15 cm, which is shown in Fig. 6.1. For body SAR testing, the liquid height from the center of the flat phantom to the liquid top surface is larger than 15 cm, which is shown as followed:

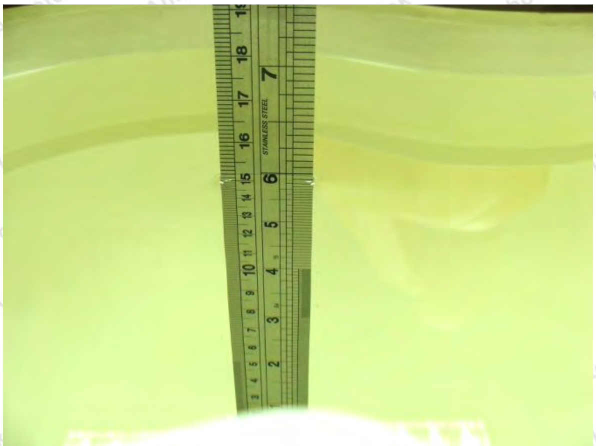


Photo of Liquid Height for Head SAR

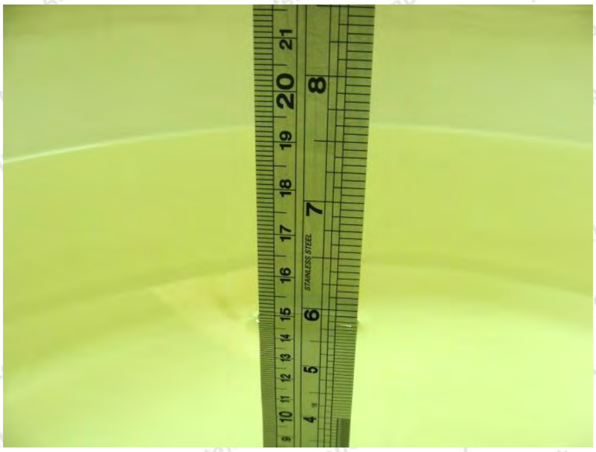


Photo of Liquid Height for Body SAR

The following table gives the recipes for tissue simulating liquid.

Frequency (MHz)	Water (%)	Sugar (%)	Cellulose (%)	Salt (%)	Preventol (%)	DGBE (%)	Conductivity (σ)	Permittivity (εr)
For Head								
900	40.3	57.9	0.2	1.4	0.2	0	0.97	41.5
1750	55.2	0	0	0.3	0	44.5	1.37	40.1
1800,1900,2000	55.2	0	0	0.3	0	44.5	1.40	40.0
2450	55.0	0	0	0	0	45.0	1.80	39.2
For Body								
900	50.8	48.2	0	0.9	0.1	0	0.97	55.2
1750	70.2	0	0	0.4	0	29.4	1.49	53.4
1800,1900,2000	70.2	0	0	0.4	0	29.4	1.52	53.3
2450	68.6	0	0	0	0	31.4	1.95	52.7

The following table shows the measuring results for simulating liquid.

Tissue Type	Measured Frequency (MHz)	Target Tissue		Measured Tissue				Liquid Temp.	Test Data
		ε_r	σ	ε_r	Dev. (%)	σ	Dev. (%)		
835H	850	41.5	0.90	41.62	0.24	0.92	2.22	22.1℃	2019-05-5
1900H	1900	40.0	1.40	40.05	0.12	1.42	1.43	22.2℃	2019-05-7
2450H	2450	39.2	1.80	39.11	-0.23	1.79	-0.56	22.1℃	2019-05-9
835B	850	55.2	0.97	55.15	-0.13	0.96	-1.03	22.0℃	2019-05-6
1900B	1900	53.3	1.52	53.13	-0.32	1.53	0.66	22.1℃	2019-05-8
2450B	2450	52.7	1.95	52.52	-0.34	1.94	-0.51	22.1℃	2019-05-10

7. System Verification Procedures

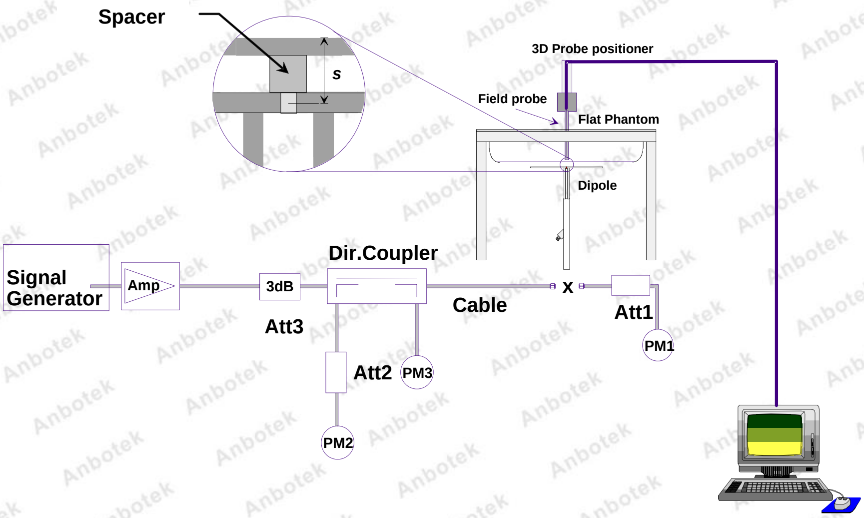
Each DASY system is equipped with one or more system validation kits. These units, together with the predefined measurement procedures within the DASY software, enable the user to conduct the system performance check and system validation. System validation kit includes a dipole, tripod holder to fix it underneath the flat phantom and a corresponding distance holder.

➢ Purpose of System Performance check

The system performance check verifies that the system operates within its specifications. System and operator errors can be detected and corrected. It is recommended that the system performance check be performed prior to any usage of the system in order to guarantee reproducible results. The system performance check uses normal SAR measurements in a simplified setup with a well characterized source. This setup was selected to give a high sensitivity to all parameters that might fail or vary over time. The system check does not intend to replace the calibration of the components, but indicates situations where the system uncertainty is exceeded due to drift or failure.

➢ System Setup

In the simplified setup for system evaluation, the EUT is replaced by a calibrated dipole and the power source is replaced by a continuous wave that comes from a signal generator. The calibrated dipole must be placed beneath the flat phantom section of the SAM twin phantom with the correct distance holder. The distance holder should touch the phantom surface with a light pressure at the reference marking and be oriented parallel to the long side of the phantom. The equipment setup is shown below:



System Setup for System Evaluation

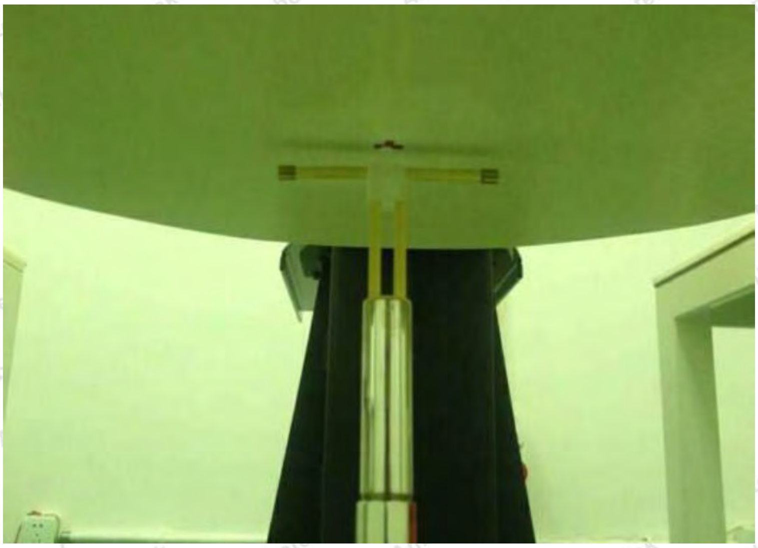


Photo of Dipole Setup

➢ **Validation Results**

Comparing to the original SAR value provided by SPEAG, the verification data should be within its specification of 10 %. The table below shows the target SAR and measured SAR after normalized to 1W input power. It indicates that the system performance check can meet the variation criterion and the plots can be referred to Appendix A of this report.

Date	Frequency (MHz)	Liquid Type	Power fed onto reference dipole (mW)	Targeted SAR (W/kg)	Measured SAR (W/kg)	Normalized SAR (W/kg)	Deviation (%)
2019-05-5	850	Head	250	9.24	2.34	9.36	1.30
2019-05-7	1900	Head	250	40.4	9.62	38.48	-4.75
2019-05-9	2450	Head	250	52.4	12.4	49.60	-5.34
2019-05-6	850	Body	250	9.57	2.47	9.88	3.24
2019-05-8	1900	Body	250	40.1	10.3	41.20	2.74
2019-05-10	2450	Body	250	51.8	12.5	50.00	-3.47

Target and Measurement SAR after Normalized

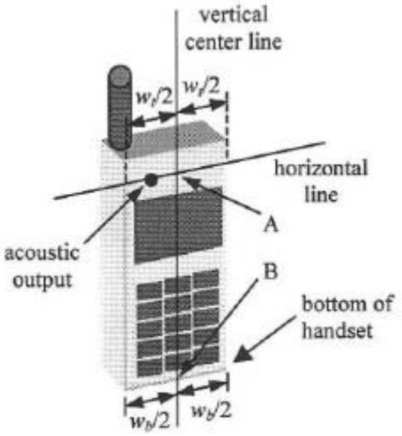
8. EUT Testing Position

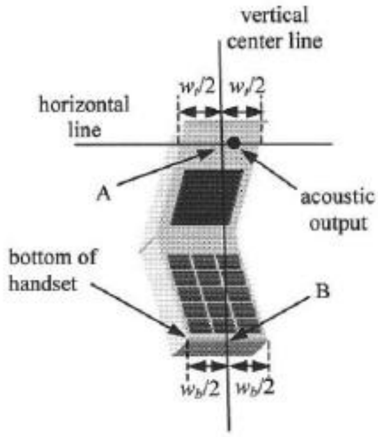
8.1. Define two imaginary lines on the handset

(a) The vertical centerline passes through two points on the front side of the handset - the midpoint of the width w_t of the handset at the level of the acoustic output, and the midpoint of the width w_b of the bottom of the handset.

(b) The horizontal line is perpendicular to the vertical centerline and passes through the center of the acoustic output. The horizontal line is also tangential to the face of the handset at point A.

(c) The two lines intersect at point A. Note that for many handsets, point A coincides with the center of the acoustic output; however, the acoustic output may be located elsewhere on the horizontal line. Also note that the vertical centerline is not necessarily parallel to the front face of the handset, especially for clamshell handsets, handsets with flip covers, and other irregularly shaped handsets.



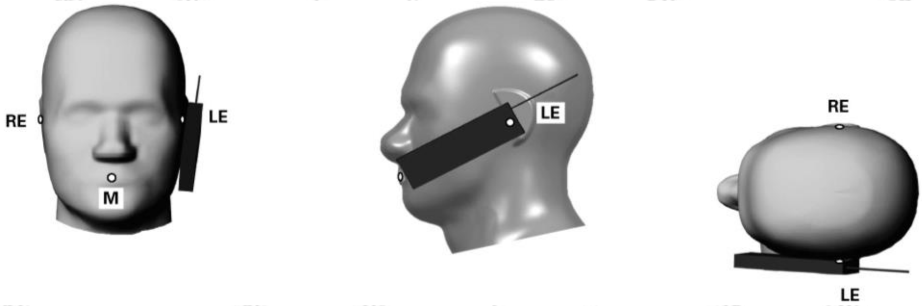


Handset Vertical and Horizontal Reference Lines

8.2. Position for Cheek/Touch

(a) To position the device with the vertical center line of the body of the device and the horizontal line crossing the center piece in a plane parallel to the sagittal plane of the phantom. While maintaining the device in this plane, align the vertical center line with the reference plane containing the three ear and mouth reference point (M: Mouth, RE: Right Ear, and LE: Left Ear) and align the center of the ear piece with the line RE-LE.

(b) To move the device towards the phantom with the ear piece aligned with the line LE-RE until the phone touched the ear. While maintaining the device in the reference plane and maintaining the phone contact with the ear, move the bottom of the phone until any point on the front side is in contact with the cheek of the phantom or until contact with the ear is lost.

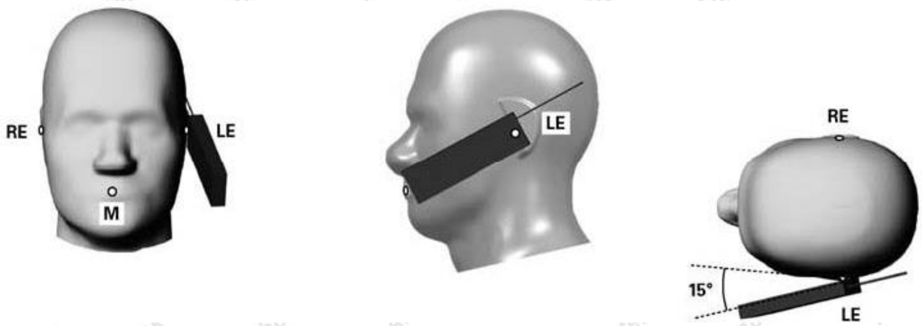


Cheek Position

8.3. Position for Ear / 15°Tilt

(a) To position the device in the "cheek" position described above.

(b) While maintaining the device the reference plane described above and pivoting against the ear, moves it outward away from the mouth by an angle of 15 degrees or until contact with the ear is lost.

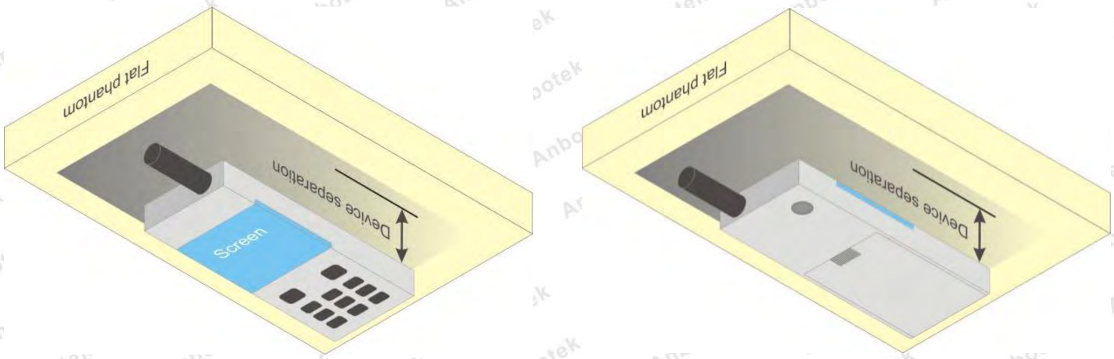


Tilt Position

8.4. Body Worn Position

Body-worn operating configurations are tested with the belt-clips and holsters attached to the device and positioned against a flat phantom in a normal use configuration. Per KDB 648474 D04, body-worn accessory exposure is typically related to voice mode operations when handsets are carried in body-worn accessories. The body-worn accessory procedures in FCC KDB 447498 D01 should be used to test for body-worn accessory SAR compliance, without a headset connected to it. This enables the test results for such configuration to be compatible with that required for hotspot mode when the body-worn accessory test separation distance is greater than or equal to that required for hotspot mode, when applicable. When the reported SAR for body-worn accessory, measured without a headset connected to the handset is < 1.2 W/kg, the highest reported SAR configuration for that wireless mode and frequency band should be repeated for that body-worn accessory with a handset attached to the handset.

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



Body Worn Position

8.5. Wireless Router (Hotspot)

Some battery-operated handsets have the capability to transmit and receive user through simultaneous transmission of WIFI simultaneously with a separate licensed transmitter. The FCC has provided guidance in FCC KDB Publication941225 D06 where SAR test considerations for handsets (L x W ≥ 9 cm x 5 cm) are based on a composite test separation distance of 10mm from the front, back and edges of the device containing transmitting antennas within 2.5cm of their edges, determined form general mixed use conditions for this type of devices. Since the hotspot SAR results may overlap with the body-worn accessory SAR requirements, the more conservative configurations can be considered, thus excluding some body-worn accessory SAR tests.

When the user enables the personal wireless router functions for the handset, actual operations include simultaneous transmission of both the WIFI transmitter and another licensed transmitter. Both transmitters often do not transmit at the same transmitting frequency and thus cannot be evaluated for SAR under actual use conditions due to the limitations of the SAR assessment probes. Therefore, SAR must be evaluated for each frequency transmission and mode separately and spatially summed with the WIFI transmitter according to FCC KDB Publication 447498 D01 publication procedures. The “Portable Hotspot” feature on the handset was NOT activated during SAR assessments, to ensure the SAR measurements were evaluated for a single transmission frequency RF signal at a time.

9. Measurement Procedures

The measurement procedures are as follows:

(a) Use base station simulator (if applicable) or engineering software to transmit RF power continuously (continuous Tx) in the middle channel.
(b) Keep EUT to radiate maximum output power or 100% duty factor (if applicable)
(c) Measure output power through RF cable and power meter.
(d) Place the EUT in the positions as setup photos demonstrates.
(e) Set scan area, grid size and other setting on the DASY software.
(f) Measure SAR transmitting at the middle channel for all applicable exposure positions.
(g) Identify the exposure position and device configuration resulting the highest SAR
(h) Measure SAR at the lowest and highest channels atthe worst exposure position and device configuration.

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

(a) Power reference measurement
(b) Area scan
(c) Zoom scan
(d) Power drift measurement

9.1. Spatial Peak SAR Evaluation

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

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

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

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

9.2. Power Reference Measurement

The Power Reference Measurement and Power Drift Measurements 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. This distance cannot be smaller than the distance of sensor calibration points to probe tip as defined in the probe properties.

9.3. Area Scan Procedures

The area scan is used as a fast scan in two dimensions to find the area of high field values, before doing a fine measurement around the hot spot. The sophisticated interpolation routines implemented in DASY software can find the maximum found in the scanned area, within a range of the global maximum. The range (in dB0 is specified in the standards for compliance testing. For example, a 2 dB range is required in IEEE standard 1528 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.

Area scan parameters extracted from FCC KDB 865664 D01 SAR measurement 100 MHz to 6 GHz.

	≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	5 ± 1 mm	½·δ·ln(2) ± 0.5 mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location	30° ± 1°	20° ± 1°
Maximum area scan spatial resolution: Δx_{Area}, Δy_{Area}	≤ 2 GHz: ≤ 15 mm 2 – 3 GHz: ≤ 12 mm	3 – 4 GHz: ≤ 12 mm 4 – 6 GHz: ≤ 10 mm
	When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be ≤ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	

9.4. Zoom Scan Procedures

Zoom scans are used assess the peak spatial SAR values within a cubic averaging volume containing 1 gram and 10gram of simulated tissue. The zoom scan measures points (refer to table below) within a cube shoes base faces are centered on the maxima found in a preceding area scan job within the same procedure. 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.

Zoom scan parameters extracted from FCC KDB 865664 D01 SAR measurement 100 MHz to 6 GHz.

			≤ 3 GHz	> 3 GHz
Maximum zoom scan spatial resolution: Δx_{Zoom}, Δy_{Zoom}			≤ 2 GHz: ≤ 8 mm 2 – 3 GHz: ≤ 5 mm*	3 – 4 GHz: ≤ 5 mm* 4 – 6 GHz: ≤ 4 mm*
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{Zoom}(n)$		≤ 5 mm	3 – 4 GHz: ≤ 4 mm 4 – 5 GHz: ≤ 3 mm 5 – 6 GHz: ≤ 2 mm
	graded grid	$\Delta z_{Zoom}(1)$: between 1st two points closest to phantom surface	≤ 4 mm	3 – 4 GHz: ≤ 3 mm 4 – 5 GHz: ≤ 2.5 mm 5 – 6 GHz: ≤ 2 mm
		$\Delta z_{Zoom}(n>1)$: between subsequent points	≤ $1.5 \cdot \Delta z_{Zoom}(n-1)$	
Minimum zoom scan volume	x, y, z		≥ 30 mm	3 – 4 GHz: ≥ 28 mm 4 – 5 GHz: ≥ 25 mm 5 – 6 GHz: ≥ 22 mm

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

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

9.5. Volume Scan Procedures

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

9.6. Power Drift Monitoring

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

10. Conducted Power

<GSM Conducted power>

Band GSM850	Burst Average Power (dBm)				Frame-Average Power (dBm)		
TX Channel	Tune-up power	128	190	251	128	190	251
Frequency (MHz)		824.2	836.6	848.6	824.2	836.6	848.6
GSM (GMSK, 1 Tx slot)	32.5	32.12	32.25	32.17	23.09	23.22	23.14
GPRS (GMSK, 1 Tx slot)	32.5	32.25	32.30	32.27	23.22	23.27	23.24
GPRS (GMSK, 2 Tx slots)	31.0	30.71	30.75	30.69	24.69	24.73	24.67
GPRS (GMSK, 3 Tx slots)	29.0	28.48	28.42	28.41	24.22	24.16	24.15
GPRS (GMSK, 4 Tx slots)	28.5	27.82	28.03	27.92	24.81	25.02	24.91
EGPRS (GMSK, 1 Tx slot)	32.5	32.23	32.32	32.25	23.20	23.29	23.22
EGPRS (GMSK, 2 Tx slots)	31.0	30.72	30.78	30.70	24.70	24.76	24.68
EGPRS (GMSK, 3 Tx slots)	29.0	28.45	28.45	28.42	24.19	24.19	24.16
EGPRS (GMSK, 4 Tx slots)	28.5	27.83	28.01	27.89	24.82	25.00	24.88
Band GSM1900	Burst Average Power (dBm)				Frame-Average Power (dBm)		
TX Channel	Tune-up power	512	661	810	512	661	810
Frequency (MHz)		1850.2	1880.0	1909.8	1850.2	1880.0	1909.8
GSM (GMSK, 1 Tx slot)	30.5	30.08	30.32	30.37	21.05	21.29	21.34
GPRS (GMSK, 1 Tx slot)	30.5	30.17	30.31	30.45	21.14	21.28	21.42
GPRS (GMSK, 2 Tx slots)	28.5	27.51	27.79	27.86	21.49	21.77	21.84
GPRS (GMSK, 3 Tx slots)	27.0	26.42	26.56	26.65	22.16	22.30	22.39
GPRS (GMSK, 4 Tx slots)	26.5	25.77	25.93	25.97	22.76	22.92	22.96
EGPRS (GMSK, 1 Tx slot)	30.5	30.19	30.28	30.41	21.16	21.25	21.38
EGPRS (GMSK, 2 Tx slots)	28.5	27.48	27.75	27.88	21.46	21.73	21.86
EGPRS (GMSK, 3 Tx slots)	27.0	26.45	26.57	26.67	22.19	22.31	22.41
EGPRS (GMSK, 4 Tx slots)	26.5	25.72	25.92	25.95	22.71	22.91	22.94

Remark: The frame-averaged power is linearly scaled the maximum burst averaged power over 8 time slots.
The calculated method are shown as below:
Frame-averaged power = Maximum burst averaged power (1 Tx Slot) – 9.03 dB
Frame-averaged power = Maximum burst averaged power (2 Tx Slots) – 6.02 dB
Frame-averaged power = Maximum burst averaged power (3 Tx Slots) - 4.26 dB
Frame-averaged power = Maximum burst averaged power (4 Tx Slots) – 3.01 dB

Note:

1. Per KDB 447498 D01, the maximum output power channel is used for SAR testing and for further SAR test reduction
2. For Head SAR testing, GSM should be evaluated, therefore the EUT was set in GSM Voice for GSM850and GSM1900 due to its highest frame-average power.
3. For Hotspot mode SAR testing, GPRS and EDGE should be evaluated, therefore the EUT was set in GPRS 4 Tx slots for GSM850and GSM1900 due to its highest frame-average power.

<WCDMA Conducted Power>

The following tests were conducted according to the test requirements outlines in 3GPP TS 34.121 specification. A summary of these settings are illustrated below:

HSDPA Setup Configuration:

a. The EUT was connected to Base Station Agilent E5515C referred to the Setup Configuration.

b. The RF path losses were compensated into the measurements.

c. A call was established between EUT and Base Station with following setting:

 i. Set Gain Factors (β_c and β_d) and parameters were set according to each

 ii. Specific sub-test in the following table, C10.1.4, quoted from the TS 34.121

 iii. Set RMC 12.2Kbps + HSDPA mode.

 iv. Set Cell Power = -86 dBm

 v. Set HS-DSCH Configuration Type to FRC (H-set 1, QPSK)

 vi. Select HSDPA Uplink Parameters

 vii. Set Delta ACK, Delta NACK and Delta CQI = 8

 viii. Set Ack-Nack Repetition Factor to 3

 ix. Set CQI Feedback Cycle (k) to 4 ms

 x. Set CQI Repetition Factor to 2

 xi. Power Ctrl Mode = All Up bits

d. The transmitted maximum output power was recorded.

Table C.10.1.4: β values for transmitter characteristics tests with HS-DPCCH

Sub-test	β_c	β_d	β_d (SF)	β_c/β_d	β_{HS} (Note1, Note 2)	CM (dB) (Note 3)	MPR (dB) (Note 3)
1	2/15	15/15	64	2/15	4/15	0.0	0.0
2	12/15 (Note 4)	15/15 (Note 4)	64	12/15 (Note 4)	24/15	1.0	0.0
3	15/15	8/15	64	15/8	30/15	1.5	0.5
4	15/15	4/15	64	15/4	30/15	1.5	0.5

Note 1: Δ_{ACK}, Δ_{NACK} and Δ_{CQI} = 30/15 with β_{hs} = 30/15 * β_c.

Note 2: For the HS-DPCCH power mask requirement test in clause 5.2C, 5.7A, and the Error Vector Magnitude (EVM) with HS-DPCCH test in clause 5.13.1A, and HSDPA EVM with phase discontinuity in clause 5.13.1AA, Δ_{ACK} and Δ_{NACK} = 30/15 with β_{hs} = 30/15 * β_c, and Δ_{CQI} = 24/15 with β_{hs} = 24/15 * β_c.

Note 3: CM = 1 for β_c/β_d =12/15, β_{hs}/β_c=24/15. For all other combinations of DPDCH, DPCCH and HS-DPCCH the MPR is based on the relative CM difference. This is applicable for only UEs that support HSDPA in release 6 and later releases.

Note 4: For subtest 2 the β_c/β_d ratio of 12/15 for the TFC during the measurement period (TF1, TF0) is achieved by setting the signalled gain factors for the reference TFC (TF1, TF1) to β_c = 11/15 and β_d = 15/15.

Setup Configuration

HSUPA Setup Configuration:

a. The EUT was connected to Base Station Agilent E5515C referred to the Setup Configuration.

b. The RF path losses were compensated into the measurements.

c. A call was established between EUT and Base Station with following setting * :

i. Call Configs = 5.2B, 5.9B, 5.10B, and 5.13.2B with QPSK

ii. Set the Gain Factors (β_c and β_d) and parameters (AG Index) were set according to each specific sub-test in the following table, C11.1.3, quoted from the TS 34.121

iii. Set Cell Power = -86 dBm

iv. Set Channel Type = 12.2k + HSPA

v. Set UE Target Power

vi. Power Ctrl Mode= Alternating bits

vii. Set and observe the E-TFCI

viii. Confirm that E-TFCI is equal to the target E-TFCI of 75 for sub-test 1, and other subtest's E-TFCI

d. The transmitted maximum output power was recorded.

Table C.11.1.3: β values for transmitter characteristics tests with HS-DPCCH and E-DCH

Sub-test	β_c	β_d	β_d (SF)	β_c/β_d	β_{HS} (Note1)	β_{ec}	β_{ed} (Note 5) (Note 6)	β_{ed} (SF)	β_{ed} (Codes)	CM (dB) (Note 2)	MPR (dB) (Note 2)	AG Index (Note 6)	E-TFCI
1	11/15 (Note 3)	15/15 (Note 3)	64	11/15 (Note 3)	22/15	209/225	1309/225	4	1	1.0	0.0	20	75
2	6/15	15/15	64	6/15	12/15	12/15	94/75	4	1	3.0	2.0	12	67
3	15/15	9/15	64	15/9	30/15	30/15	β_{ed}1: 47/15 β_{ed}2: 47/15	4 4	2	2.0	1.0	15	92
4	2/15	15/15	64	2/15	4/15	2/15	56/75	4	1	3.0	2.0	17	71
5	15/15 (Note 4)	15/15 (Note 4)	64	15/15 (Note 4)	30/15	24/15	134/15	4	1	1.0	0.0	21	81

Note 1: Δ_{ACK}, Δ_{NACK} and Δ_{CQI} = 30/15 with β_{hs} = 30/15 * β_c .

Note 2: CM = 1 for β_c/β_d =12/15, β_{hs}/β_c=24/15. For all other combinations of DPDCH, DPCCH, HS- DPCCH, E-DPDCH and E-DPCCH the MPR is based on the relative CM difference.

Note 3: For subtest 1 the β_c/β_d ratio of 11/15 for the TFC during the measurement period (TF1, TF0) is achieved by setting the signalled gain factors for the reference TFC (TF1, TF1) to β_c = 10/15 and β_d = 15/15.

Note 4: For subtest 5 the β_c/β_d ratio of 15/15 for the TFC during the measurement period (TF1, TF0) is achieved by setting the signalled gain factors for the reference TFC (TF1, TF1) to β_c = 14/15 and β_d = 15/15.

Note 5: In case of testing by UE using E-DPDCH Physical Layer category 1, Sub-test 3 is omitted according to TS25.306 Table 5.1g.

Note 6: β_{ed} can not be set directly, it is set by Absolute Grant Value.

Setup Configuration

<WCDMA Conducted Power>

WCDMA	Band II (dBm)				Band V (dBm)			
TX Channel	Tune-up power	9262	9400	9538	Tune-up power	4132	4183	4233
Frequency (MHz)		1852.4	1880.0	1907.6		826.4	836.6	846.6
RMC 12.2Kbps	23.0	22.71	22.82	22.97	23.0	22.71	22.81	22.32
HSDPA Subtest-1	23.0	22.25	22.32	21.91	23.0	22.06	22.47	22.41
HSDPA Subtest-2	23.0	22.38	21.75	22.18	23.0	22.05	21.41	22.33
HSDPA Subtest-3	23.0	22.2	21.63	22.43	23.0	22.16	21.42	22.58
HSDPA Subtest-4	23.0	21.35	21.95	21.12	23.0	21.1	21.58	21.37
HSUPA Subtest-1	22.0	20.11	21.51	20.23	22.0	20.63	21.13	20.02
HSUPA Subtest-2	21.0	20.26	20.49	20.18	21.0	20.22	20.16	20.3
HSUPA Subtest-3	22.0	21.06	21.56	21.19	22.0	21.21	21.28	21.56
HSUPA Subtest-4	21.0	20.07	20.48	20.21	21.0	20.36	20.05	20.23
HSUPA Subtest-5	22.0	20.26	21.51	20.1	21.5	19.88	21.27	20.11

General Note

1. Per KDB 941225 D01 v02, RMC 12.2kbps setting is used to evaluate SAR. If AMR 12.2kbps power is < 0.25dB higher than RMC 12.2kbps, SAR tests with AMR 12.2kbps can be excluded.
2. By design, AMR and HSDPA/HSUPA RF power will not be larger than RMC 12.2kbps, detailed information is included in Tune-up Procure exhibit.
3. It is expected by the manufacturer that MPR for some HSDPA/HSUPA subtests may differ from the specification of 3GPP, according to the chipset implementation in this model. The implementation and expected deviation are detailed in tune-up procedure exhibit.

<WLAN 2.4GHz Conducted Power>

Mode	Channel	Frequency (MHz)	Conducted Output Power(dBm)	Conducted Avg. Power(dBm)	Tune-up Power (dBm)	Test Rate Data
802.11b	1	2412	17.05	14.54	16.0	1 Mbps
	6	2437	18.01	15.37	16.0	1 Mbps
	11	2462	18.16	15.48	16.0	1 Mbps
802.11g	1	2412	17.13	13.42	15.0	6 Mbps
	6	2437	18.25	14.26	15.0	6 Mbps
	11	2462	18.53	14.49	15.0	6 Mbps
802.11n(20MHz)	1	2412	18.01	13.73	15.0	MCS0
	6	2437	19.13	14.56	15.0	MCS0
	11	2462	19.58	14.91	15.0	MCS0

Note:

1. Per KDB 447498 D01, the 1-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, 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

Mode	Frequency (GHz)	Tune-up Power (dBm)	Max. Power (mW)	Test distance (mm)	Result	exclusion thresholds for 1-g SAR
802.11b	2450	16.0	39.81	5	12.46	3.0
802.11b	2450	16.0	39.81	10	6.23	3.0

2. Base on the result of note1, RF exposure evaluation of 802.11 b mode is required.
3. Per KDB 248227 D01, choose the highest output power channel to test SAR and determine further SAR exclusion.
4. Per KDB 248227 D01, In the 2.4 GHz band, separate SAR procedures are applied to DSSS and OFDM configurations to simplify DSSS test requirements. 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.

<Bluetooth Conducted Power>

Mode	Channel	Frequency (MHz)	Conducted Power (dBm)	Tune-up power(dBm)
BLE-GFSK	00	2402	-19.06	-18.0
	19	2440	-18.56	-18.0
	39	2480	-19.30	-18.0
GFSK	00	2402	2.18	3.0
	39	2441	2.22	3.0
	78	2480	2.02	3.0
8DPSK	00	2402	1.62	3.0
	39	2441	2.05	3.0
	78	2480	1.79	3.0
π/4DQPSK	00	2402	1.71	3.0
	39	2441	2.18	3.0
	78	2480	1.95	3.0

Note:

Per KDB 447498 D01v05r02, 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

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

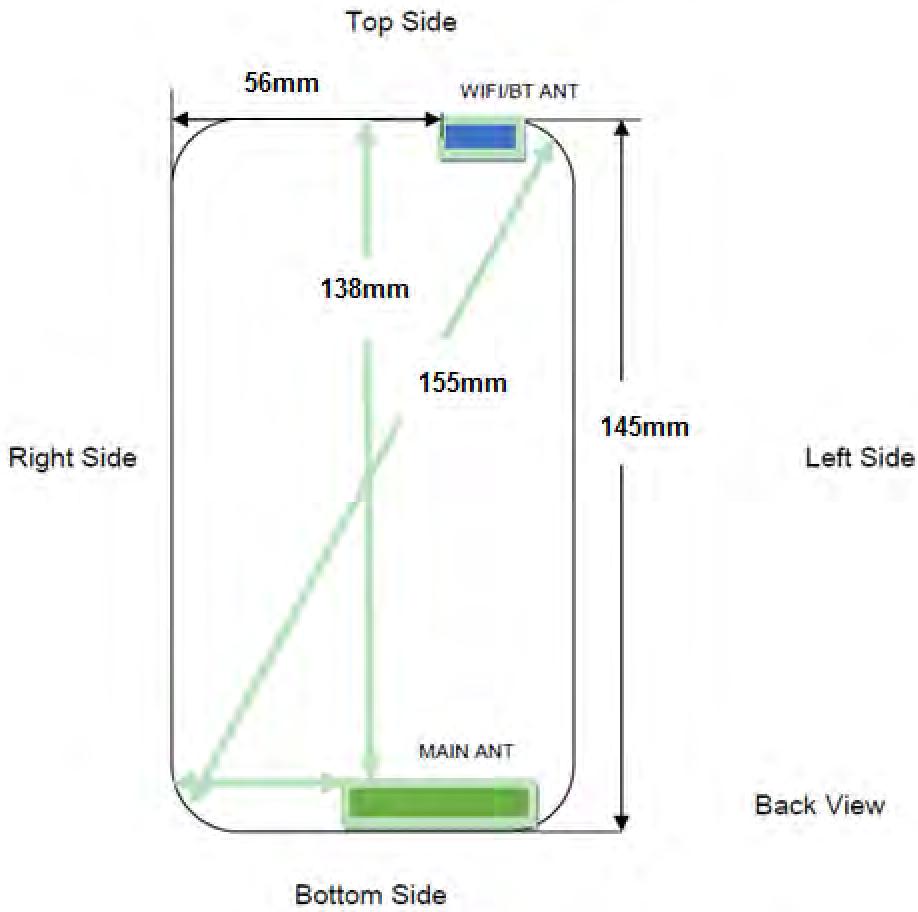
Power and distance are rounded to the nearest mW and mm before calculation

The result is rounded to one decimal place for comparison

Bluetooth Max Power (dBm)	Separation Distance (mm)	Frequency (GHz)	exclusion thresholds
3.0	0	2.44	0.625

Per KDB 447498 D01, when the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion. The test exclusion threshold is 0.625 which is<= 3, SAR testing is not required.

11. Antenna Location



Distance of The Antenna to the EUT surface and edge						
Antennas	**Front**	**Back**	**Top Side**	**Bottom Side**	**Left Side**	**Right Side**
WWAN	<25mm	<25mm	>25mm	<25mm	<25mm	<25mm
BT&WLAN	<25mm	<25mm	<25mm	>25mm	<25mm	>25mm

Positions for SAR tests; Hotspot mode						
Antennas	**Front**	**Back**	**Top Side**	**Bottom Side**	**Left Side**	**Right Side**
WWAN	Yes	Yes	No	Yes	Yes	Yes
BT&WLAN	Yes	Yes	Yes	No	Yes	No

General Note: Referring to KDB 941225 D06, When the overall device length and width are ≥9cm*5cm, the test distance is 10mm, SAR must be measured for all sides and surfaces with a transmitting antenna located with 25mm from that surface or edge.

12.SAR Test Results Summary

General Note:

1. Per KDB 447498 D01v05r01, the reported SAR is the measured SAR value adjusted for maximum tune-up tolerance.

   Scaling Factor = tune-up limit power (mW) / EUT RF power (mW), where tune-up limit is the maximum rated power among all production units.

   Reported SAR(W/kg)= Measured SAR(W/kg) Scaling Factor*
2. Per KDB 447498 D01v05r01, for each exposure position, if the highest output channel reported SAR≤0.8W/kg, other channels SAR testing are not necessary

12.1. Head SAR Results

<GSM>

Plot No.	Band	Mode	Test Position	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Scaling Factor	Power Drift (dB)	Measured SAR_{1g} (W/kg)	Reported SAR_{1g} (W/kg)
#1	GSM850	GSM Voice	Left Cheek	190	836.60	32.25	32.5	1.06	-0.07	0.294	**0.31**
	GSM850	GSM Voice	Left Tilted	190	836.60	32.25	32.5	1.06	0.06	0.225	0.24
	GSM850	GSM Voice	Right Cheek	190	836.60	32.25	32.5	1.06	-0.10	0.277	0.29
	GSM850	GSM Voice	Right Tilted	190	836.60	32.25	32.5	1.06	0.05	0.221	0.23
#2	GSM1900	GSM Voice	Left Cheek	661	1880.00	30.32	30.5	1.04	0.10	0.317	**0.33**
	GSM1900	GSM Voice	Left Tilted	661	1880.00	30.32	30.5	1.04	-0.15	0.235	0.24
	GSM1900	GSM Voice	Right Cheek	661	1880.00	30.32	30.5	1.04	-0.18	0.292	0.30
	GSM1900	GSM Voice	Right Tilted	661	1880.00	30.32	30.5	1.04	-0.12	0.223	0.23

<WCDMA>

Plot No.	Band	Mode	Test Position	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Scaling Factor	Power Drift (dB)	Measured SAR_{1g} (W/kg)	Reported SAR_{1g} (W/kg)
#3	WCDMA Band V	RMC 12.2K	Left Cheek	4182	836.40	22.81	23.0	1.04	0.02	0.310	**0.32**
	WCDMA Band V	RMC 12.2K	Left Tilted	4182	836.40	22.81	23.0	1.04	0.07	0.256	0.27
	WCDMA Band V	RMC 12.2K	Right Cheek	4182	836.40	22.81	23.0	1.04	0.05	0.295	0.31
	WCDMA Band V	RMC 12.2K	Right Tilted	4182	836.40	22.81	23.0	1.04	0.10	0.238	0.25
#4	WCDMA Band II	RMC 12.2K	Left Cheek	9400	1880	22.82	23.0	1.04	-0.17	0.330	**0.34**
	WCDMA Band II	RMC 12.2K	Left Tilted	9400	1880	22.82	23.0	1.04	0.08	0.266	0.28
	WCDMA Band II	RMC 12.2K	Right Cheek	9400	1880	22.82	23.0	1.04	0.04	0.309	0.32
	WCDMA Band II	RMC 12.2K	Right Tilted	9400	1880	22.82	23.0	1.04	0.02	0.241	0.25

<WLAN 2.4GHz>

Plot No.	Band	Mode	Test Position	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Scaling Factor	D.C Factor	Power Drift (dB)	Measured SAR_{1g} (W/kg)	Reported SAR_{1g} (W/kg)
#5	WLAN2.4GHz	802.11b	Left Cheek	11	2462	15.48	16.0	1.13	99.87 %	-0.07	0.247	**0.28**
	WLAN2.4GHz	802.11b	Left Tilted	11	2462	15.48	16.0	1.13	99.87 %	0.07	0.210	0.24
	WLAN2.4GHz	802.11b	Right Cheek	11	2462	15.48	16.0	1.13	99.87 %	0.13	0.225	0.25
	WLAN2.4GHz	802.11b	Right Tilted	11	2462	15.48	16.0	1.13	99.87 %	0.16	0.196	0.22

12.2. Body SAR Results

<GSM>

Plot No.	Band	Mode	Test Position	Gap (cm)	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Scaling Factor	Power Drift (dB)	Measured SAR_{1g} (W/kg)	Reported SAR_{1g} (W/kg)
	GSM850	GPRS(4 Tx slots)	Front	1	190	836.60	28.03	28.5	1.11	-0.03	0.277	0.31
#6	GSM850	GPRS(4 Tx slots)	Back	1	190	836.60	28.03	28.5	1.11	0.01	0.419	**0.47**
	GSM850	GPRS(4 Tx slots)	Left Side	1	190	836.60	28.03	28.5	1.11	-0.08	0.185	0.21
	GSM850	GPRS(4 Tx slots)	Right Side	1	190	836.60	28.03	28.5	1.11	-0.16	0.134	0.15
	GSM850	GPRS(4 Tx slots)	Top Side	1	190	836.60	28.03	28.5	1.11	-	-	-
	GSM850	GPRS(4 Tx slots)	Bottom Side	1	190	836.60	28.03	28.5	1.11	-0.13	0.239	0.27
	GSM1900	GPRS(4 Tx slots)	Front	1	661	1880	25.93	26.5	1.14	-0.02	0.469	0.53
#7	GSM1900	GPRS(4 Tx slots)	Back	1	661	1880	25.93	26.5	1.14	-0.18	0.682	**0.78**
	GSM1900	GPRS(4 Tx slots)	Left Side	1	661	1880	25.93	26.5	1.14	-0.06	0.314	0.36
	GSM1900	GPRS(4 Tx slots)	Right Side	1	661	1880	25.93	26.5	1.14	-0.11	0.227	0.26
	GSM1900	GPRS(4 Tx slots)	Top Side	1	661	1880	25.93	26.5	1.14	-	-	-
	GSM1900	GPRS(4 Tx slots)	Bottom Side	1	661	1880	25.93	26.5	1.14	-0.05	0.406	0.46

<WCDMA>

Plot No.	Band	Mode	Test Position	Gap (cm)	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Scaling Factor	Power Drift (dB)	Measured SAR_{1g} (W/kg)	Reported SAR_{1g} (W/kg)
	WCDMA Band V	RMC	Front	1	4182	836.40	22.81	23.0	1.04	-0.06	0.336	0.35
#8	WCDMA Band V	RMC	Back	1	4182	836.40	22.81	23.0	1.04	-0.07	0.509	**0.53**
	WCDMA Band V	RMC	Left Side	1	4182	836.40	22.81	23.0	1.04	-0.09	0.224	0.23
	WCDMA Band V	RMC	Right Side	1	4182	836.40	22.81	23.0	1.04	-0.11	0.163	0.17

	WCDMA Band V	RMC	Top Side	1	4182	836.40	22.81	23.0	1.04	-0.18	-	-
	WCDMA Band V	RMC	Bottom Side	1	4182	836.40	22.81	23.0	1.04	-0.04	0.290	0.30
	WCDMA Band II	RMC	Front	1	9400	1880	22.82	23.0	1.04	0.03	0.539	0.56
	WCDMA Band II	RMC	Back	1	9262	1852.4	22.71	23.0	1.07	0.03	0.752	0.80
	WCDMA Band II	RMC	Back	1	9400	1880	22.82	23.0	1.04	0.02	0.781	0.81
#9	WCDMA Band II	RMC	Back	1	9538	1907.6	22.97	23.0	1.01	0.06	0.813	**0.82**
	WCDMA Band II	RMC	Left Side	1	9400	1880	22.82	23.0	1.04	0.04	0.372	0.39
	WCDMA Band II	RMC	Right Side	1	9400	1880	22.82	23.0	1.04	0.03	0.423	0.44
	WCDMA Band II	RMC	Top Side	1	9400	1880	22.82	23.0	1.04	-	-	-
	WCDMA Band II	RMC	Bottom Side	1	9400	1880	22.82	23.0	1.04	-0.18	0.406	0.42

<WLAN>

Plot No.	Band	Mode	Test Position	Gap (cm)	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Scaling Factor	D.C Factor	Power Drift (dB)	Measured SAR_{1g} (W/kg)	Reported SAR_{1g} (W/kg)
	WLAN2.4GHz	802.11b	Front	1	11	2462	15.48	16.0	1.13	99.87%	0.05	0.086	0.10
#10	WLAN2.4GHz	802.11b	Back	1	11	2462	15.48	16.0	1.13	99.87%	0.13	0.140	**0.16**
	WLAN2.4GHz	802.11b	Left Side	1	11	2462	15.48	16.0	1.13	99.87%	0.07	0.066	0.07
	WLAN2.4GHz	802.11b	Right Side	1	11	2462	15.48	16.0	1.13	99.87%	-	-	-
	WLAN2.4GHz	802.11b	Top Side	1	11	2462	15.48	16.0	1.13	99.87%	-0.07	0.072	0.08
	WLAN2.4GHz	802.11b	Bottom Side	1	11	2462	15.48	16.0	1.13	99.87%	-	-	-

13.SAR Measurement Variability

SAR measurement variability must be assessed for each frequency band, which is determined by the SAR probe calibration point and tissue-equivalent medium used for the device measurements. When both head and body tissue-equivalent media are required for SAR measurements in a frequency band, the variability measurement procedures should be applied to the tissue medium with the highest measured SAR, using the highest measured SAR configuration for that tissue-equivalent medium.

The following procedures are applied to determine if repeated measurements are required.

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.

SAR Measurement Variability for Body WCDMA Band II(1g)

Frequency		Mode	Test Position	Spacing (mm)	Original SAR (W/kg)	First Repeated SAR (W/kg)	The Ratio	Second Repeated SAR (W/kg)
CH	MHz							
9538	1907.6	RMC	Back	10	0.813	0.795	1.02	/

14.Simultaneous Transmission Analysis

13.1. Simultaneous TX SAR Considerations

No.	Applicable Simultaneous Transmission
1.	2G/3G+ WLAN 2.4GHz
2.	2G/3G + Bluetooth

Note:

1. WLAN 2.4GHz and Bluetooth share the same antenna, and cannot transmit simultaneously.
2. EUT will choose either 2G/3G according to the network signal condition; therefore, 2G/3G cannot transmit simultaneously.

13.2. Evaluation of Simultaneous SAR

< Head Exposure Conditions>

Simultaneous transmission SAR for WLAN and GSM/WCDMA

Test Position	GSM850 SAR_{1-g} (W/Kg)	GSM1900 SAR_{1-g} (W/Kg)	WCDMA V SAR_{1-g} (W/Kg)	WCDMA II SAR_{1-g} (W/Kg)	WiFi SAR_{1-g} (W/Kg)	MAX. ΣSAR_{1-g} (W/Kg)	SAR_{1-g} Limit (W/Kg)	Peak location separation ratio	Simut. Meas. Required
Left Cheek	0.31	0.33	0.32	0.34	0.28	**0.62**	1.6		
Left Tilted	0.24	0.24	0.27	0.28	0.24	0.52	1.6		
Right Cheek	0.29	0.30	0.31	0.32	0.25	0.57	1.6		
Right Tilted	0.23	0.23	0.25	0.25	0.22	0.47	1.6		

<Body Exposure Conditions>

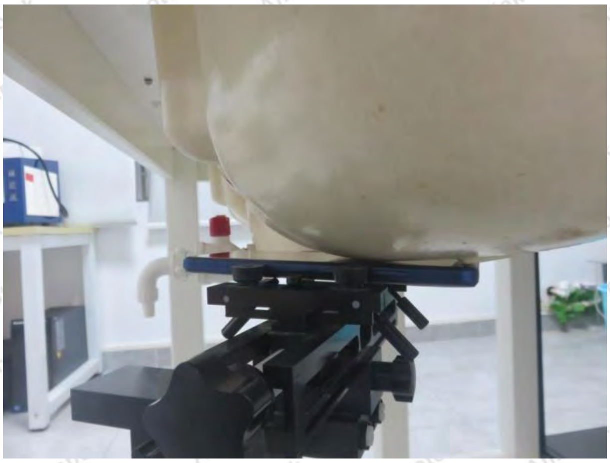
Test Position	GSM850 SAR_{1-g} (W/Kg)	GSM1900 SAR_{1-g} (W/Kg)	WCDMA V SAR_{1-g} (W/Kg)	WCDMA II SAR_{1-g} (W/Kg)	WiFi SAR_{1-g} (W/Kg)	MAX. ΣSAR_{1-g} (W/Kg)	SAR_{1-g} Limit (W/Kg)	Peak location separation ratio	Simut. Meas. Required
Front	0.31	0.53	0.35	0.56	0.10	0.66	1.6		
Back	0.47	0.78	0.53	0.82	0.16	**0.98**	1.6		
Left Side	0.21	0.36	0.23	0.39	0.07	0.46	1.6		
Right Side	0.15	0.26	0.17	0.44	-	0.44	1.6		
Top side	-	-	-	-	0.08	0.08	1.6		
Bottom Side	0.27	0.46	0.30	0.42	-	0.42	1.6		

14.Measurement Uncertainty

Uncertainty component	Tol. (±%)	Prob. dist.	Div.	ci (1g)	ci (10g)	1g ui (±%)	10g ui (±%)
Measurement system							
Probe calibration(*k*=1)	6.1	N	1	1	1	6.1	6.1
Axial isotropy	4.7	R			√0.5	1.9	1.9
Hemispherical isotropy	9.6	R		√0.5	√0.5	3.9	3.9
Boundary effect	1.0	R		1	1	0.6	0.6
Linearity	4.7	R		1	1	2.7	2.7
System detection limits	1.0	R		1	1	0.6	0.6
Modulation response	4.0	R		1	1	2.3	2.3
Readout electronics	1.0	N	1	1	1	1.0	1.0
Response time	0.8	R		1	1	0.5	0.5
Integration time	1.4	R		1	1	0.8	0.8
RF ambient conditions—noise	3.0	R		1	1	1.7	1.7
RF ambient conditions—reflections	3.0	R		1	1	1.7	1.7
Probe positioner mechanical tolerance	0.4	R		1	1	0.2	0.2
Probe positioning with respect to phantom shell	2.9	R		1	1	1.7	1.7
Extrapolation,interpolation,andintegrationsalgorithmsformax.SARevaluation	2.0	R		1	1	1.2	1.2
Test sample related							
Test sample positioning	2.9	N	1	1	1	2.9	2.9
Device holder uncertainty	3.6	N	1	1	1	3.6	3.6
Output power variation—SAR drift measurement	5.0	R		1	1	2.9	2.9
SAR scaling	0	R		0	0	0	0
Phantom and tissue parameters							
Phantom shell uncertainty—shape, thickness, and permittivity	6.1	R		1	1	3.5	3.5
UncertaintyinSARcorrectionfordeviationsinpermittivityandconductivity	1.9	N	1	1	0.84	1.9	1.6
Liquid conductivity measurement	2.5	N	1	0	0	0.0	0.0
Liquid permittivity measurement	2.5	N	1	0	0	0.0	0.0
Liquid conductivity—temperature uncertainty	3.4	R		0	0	0.0	0.0
Liquid permittivity—temperature uncertainty	0.4	R		0	0	0.0	0.0
Combined standard uncertainty		RSS				10.81	10.72
Expanded uncertainty(95%*confidenceinterval*)		*k*=2				21.62	21.45

Per KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz, 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 1528-2013 is not required in SAR reports submitted for equipment approval.

Appendix A. EUT Photos and Test Setup Photos



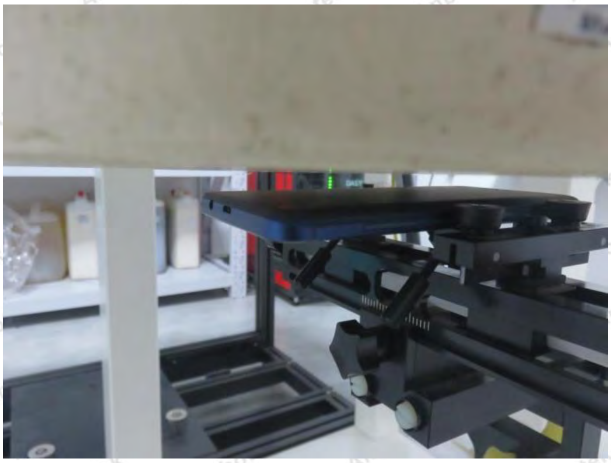
Left Head Touch

Right Head Touch

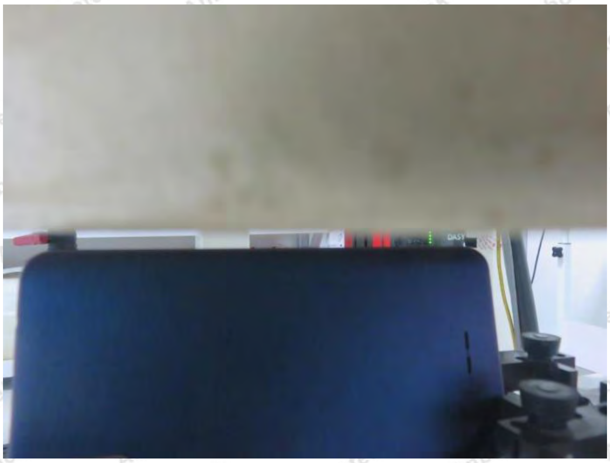
Left Head Tilt (15°)

Right Head Tilt (15°)

Body-worn Front Side (10mm)



Body-worn Rear Side (10mm)



Body-worn Left Side (10mm)

Body-worn Right Side (10mm)

Body-worn Top Side (10mm)

Body-worn Bottom Side (10mm)

Appendix B. Plots of SAR System Check

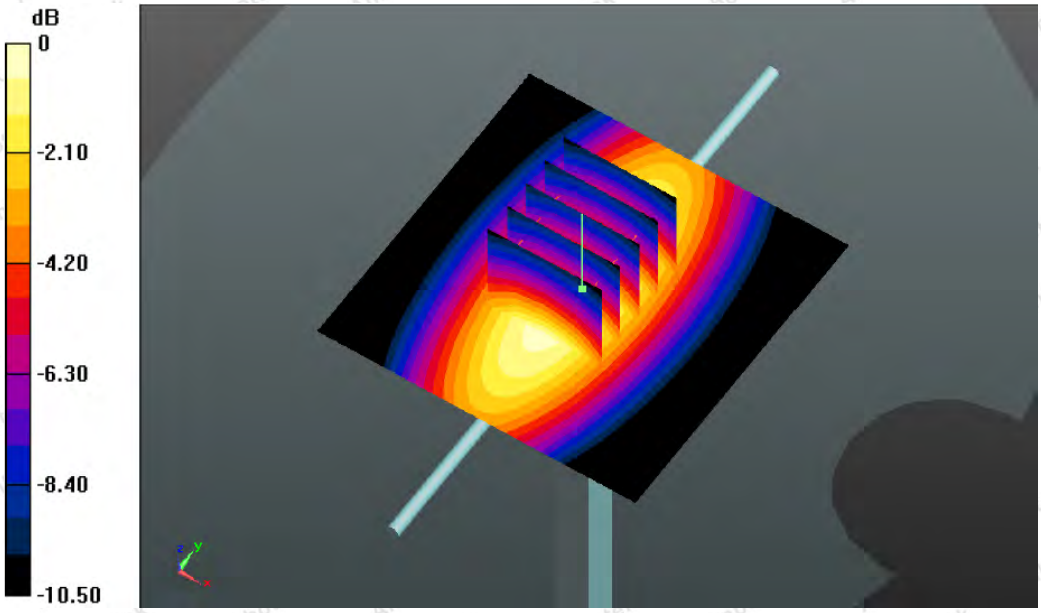
System Performance Check at 835 MHz Head

DUT: Dipole 835 MHz; Type: D835V2; Serial: 4d154
Date:2019-05-05
Communication System: CW; Frequency: 835 MHz;Duty Cycle: 1:1
Medium parameters used (interpolated): f = 835 MHz; σ = 0.92 S/m; εr = 41.62; ρ = 1000 kg/m3
Phantom section: Flat Section

DASY5 Configuration:
•Probe: EX3DV4 - SN7396; ConvF(9.71, 9.71, 9.71); Calibrated: 12,05.2018;
•Sensor-Surface: 4mm (Mechanical Surface Detection)
•Electronics: DAE4 Sn387; Calibrated: 06.09.2018
•Phantom: SAM 1; Type: SAM;
•Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

Area Scan (61x91x1): Measurement grid: dx=15.00 mm, dy=15.00 mm
Maximum value of SAR (interpolated) = 2.834 mW/g

Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=7mm, dy=7mm, dz=5mm
Reference Value = 49.865 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 3.286 W/kg
SAR(1 g) = 2.34 mW/g; SAR(10 g) = 1.52 mW/g
Maximum value of SAR (measured) = 2.825 mW/g



System Performance Check 835MHz Head 250mW

System Performance Check at 835 MHz Body

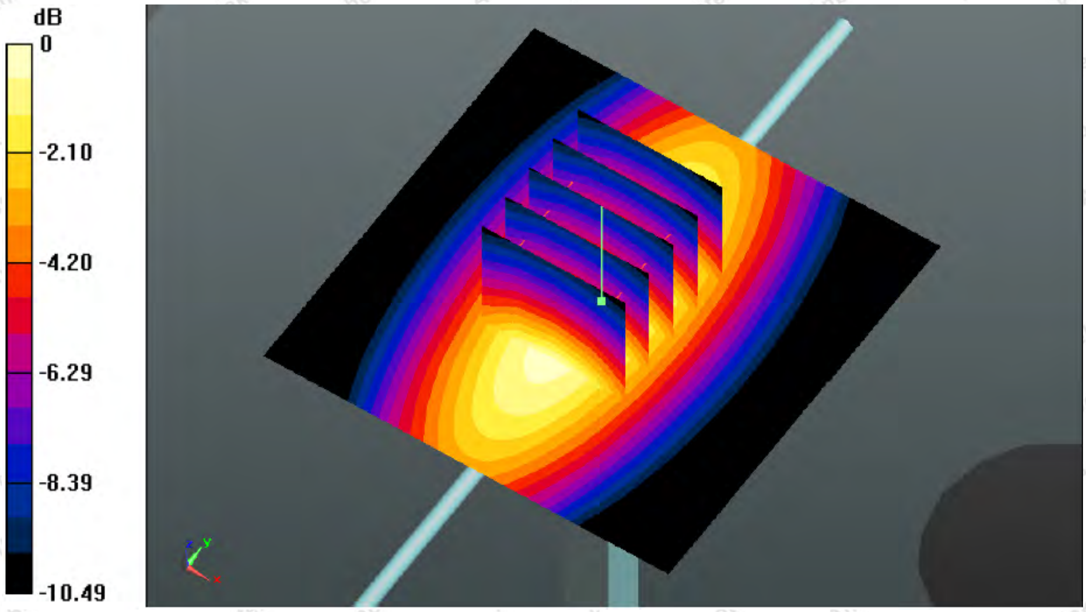
DUT: Dipole 835 MHz; Type: D835V2; Serial: 4d154
Date:2019-05-06
Communication System: CW; Frequency: 835 MHz;Duty Cycle: 1:1
Medium parameters used (interpolated): f = 835 MHz; σ = 0.96 S/m; ε_r = 55.15; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:
•Probe: EX3DV4 - SN7396; ConvF(9.88, 9.88, 9.88); Calibrated: 12,05.2018;
•Sensor-Surface: 4mm (Mechanical Surface Detection)
•Electronics: DAE4 Sn387; Calibrated: 06.09.2018
•Phantom: SAM 1; Type: SAM;
•Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

Area Scan (61x91x1): Measurement grid: dx=15.00 mm, dy=15.00 mm
Maximum value of SAR (interpolated) = 2.888 mW/g

Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 50.236 V/m; Power Drift = -0.02 dB
Peak SAR (extrapolated) = 3.339 W/kg
SAR(1 g) = 2.47 mW/g; SAR(10 g) = 1.59 mW/g

Maximum value of SAR (measured) = 2.871 mW/g



System Performance Check 835MHz Body 250mW

System Performance Check at 1900 MHz Head

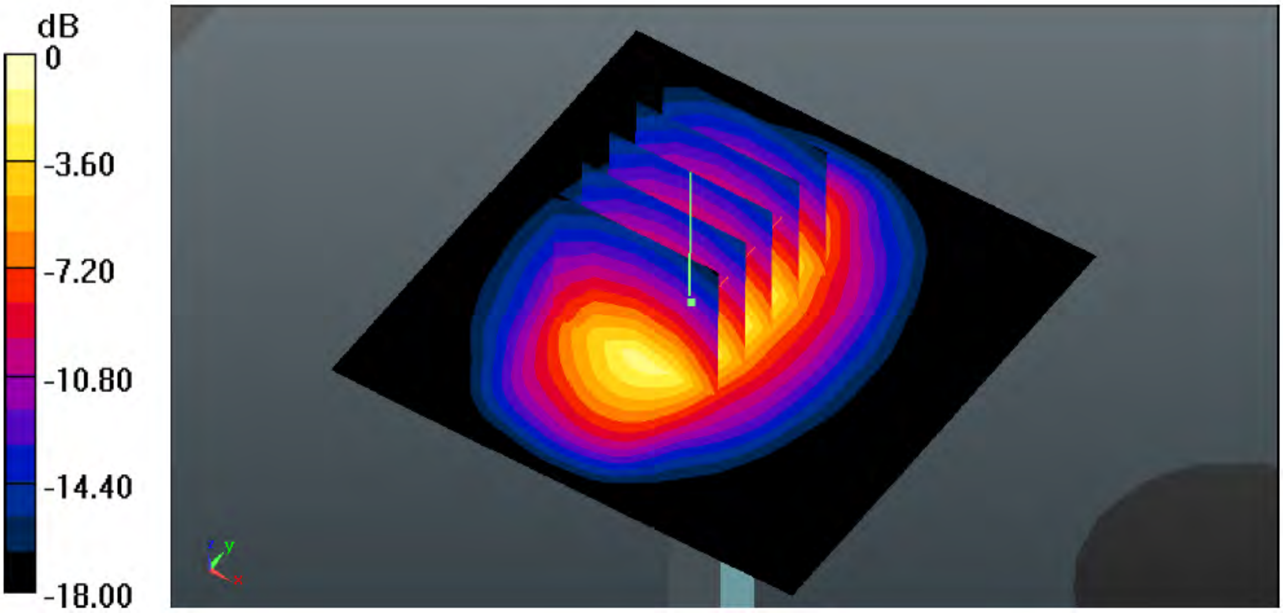
DUT: Dipole 1900 MHz; Type: D1900V2; Serial: 5d175
Date:2019-05-07
Communication System: CW; Frequency: 1900 MHz;Duty Cycle: 1:1
Medium parameters used (interpolated): f = 1900 MHz; σ = 1.42S/m; εr = 40.05; ρ = 1000 kg/m3
Phantom section: Flat Section

DASY5 Configuration:
Probe:EX3DV4 - SN7396; ConvF(8.13, 8.13, 8.13); Calibrated: 12,05.2018;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn387; Calibrated: 06.09.2018
Phantom: SAM 1; Type: SAM;
Measurement SW: DASY52, Version 52.8 (1); SEMCAD X Version 14.6.5 (6469)

Area Scan (61x91x1): Measurement grid: dx=15.00 mm, dy=15.00 mm
Maximum value of SAR (interpolated) = 10.61 W/kg

Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=7mm, dy=7mm, dz=5mm
Reference Value = 94.79 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 12.34 W/kg
SAR(1 g) = 9.62 W/kg; SAR(10 g) = 4.96 W/kg

Maximum value of SAR (measured) = 12.44 W/kg



System Performance Check 1900MHz Head 250mW

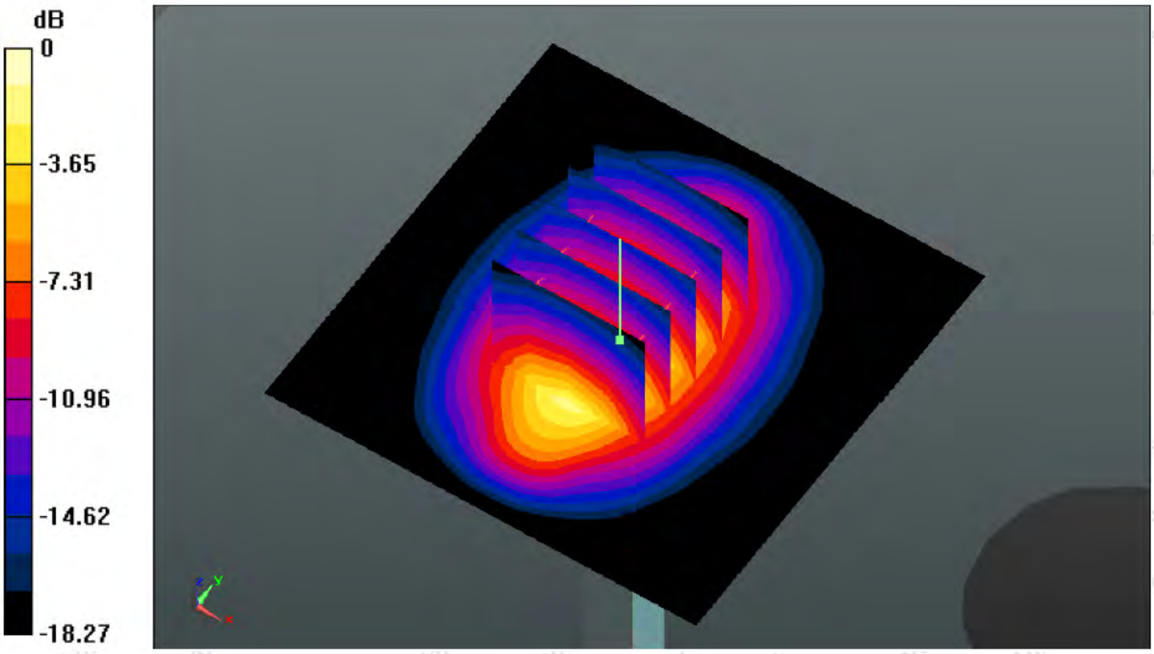
System Performance Check at 1900 MHz Body

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: 5d175
Date:2019-05-08
Communication System: CW; Frequency: 1900 MHz;Duty Cycle: 1:1
Medium parameters used (interpolated): f = 1900 MHz; σ = 1.53S/m; εr = 53.12; ρ = 1000 kg/m3
Phantom section: Flat Section

DASY5 Configuration:
Probe: EX3DV4 - SN7396; ConvF(7.97, 7.97, 7.97); Calibrated: 12,05.2018;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn387; Calibrated: 06.09.2018
Phantom: SAM 1; Type: SAM;
Measurement SW: DASY52, Version 52.8 (1); SEMCAD X Version 14.6.5 (6469)

Area Scan (61x91x1): Measurement grid: dx=15.00 mm, dy=15.00 mm
Maximum value of SAR (interpolated) = 15.187 mW/g
Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 87.679 V/m; Power Drift = -0.14 dB
Peak SAR (extrapolated) = 19.027 W/kg
SAR(1 g) = 10.3 mW/g; SAR(10 g) = 5.34 mW/g

Maximum value of SAR (measured) = 15.09 mW/g



System Performance Check 1900MHz Body250mW

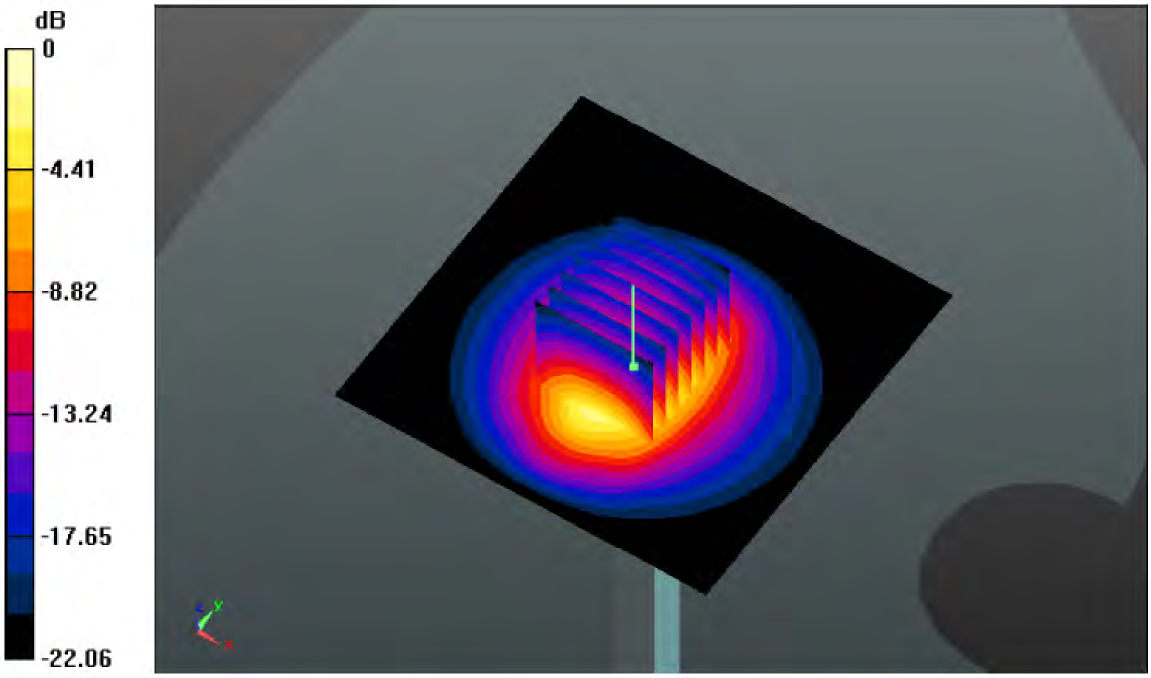
System Performance Check at 2450 MHz Head

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: 910
Date:2019-05-09
Communication System: CW; Frequency: 2450 MHz;Duty Cycle: 1:1
Medium parameters used (interpolated): f = 2450 MHz; σ = 1.79S/m; εr = 39.11; ρ = 1000 kg/m3
Phantom section: Flat Section

DASY5 Configuration:
Probe: EX3DV4 - SN7396; ConvF(7.57, 7.57, 7.57); Calibrated: 12,05.2018;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn387; Calibrated: 06.09.2018
Phantom: SAM 1; Type: SAM;
Measurement SW: DASY52, Version 52.8 (1); SEMCAD X Version 14.6.5 (6469)

Area Scan (61x91x1): Measurement grid: dx=10.00 mm, dy=10.00 mm
Maximum value of SAR (interpolated) = 19.313 mW/g
Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 84.314 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 25.703 W/kg
SAR(1 g) = 12.4 mW/g; SAR(10 g) = 5.8 mW/g

Maximum value of SAR (measured) = 18.871 mW/g



System Performance Check 2450MHz Head250mW

System Performance Check at 2450 MHz Body

Date:2019-05-10

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: 910

Communication System: CW; Frequency: 2450 MHz;Duty Cycle: 1:1

Medium parameters used (interpolated): f = 2450 MHz; σ = 1.94S/m; εr = 52.52; ρ = 1000 kg/m3

Phantom section: Flat Section

DASY5 Configuration:

Probe: EX3DV4 - SN7396; ConvF(7.53, 7.53, 7.53); Calibrated: 12,05.2018;

Sensor-Surface: 3mm (Mechanical Surface Detection)

Electronics: DAE4 Sn387; Calibrated: 06.09.2018

Phantom: SAM 1; Type: SAM;

Measurement SW: DASY52, Version 52.8 (1); SEMCAD X Version 14.6.5 (6469)

Area Scan (61x91x1): Measurement grid: dx=10.00 mm, dy=10.00 mm

Maximum value of SAR (interpolated) = 19.266 mW/g

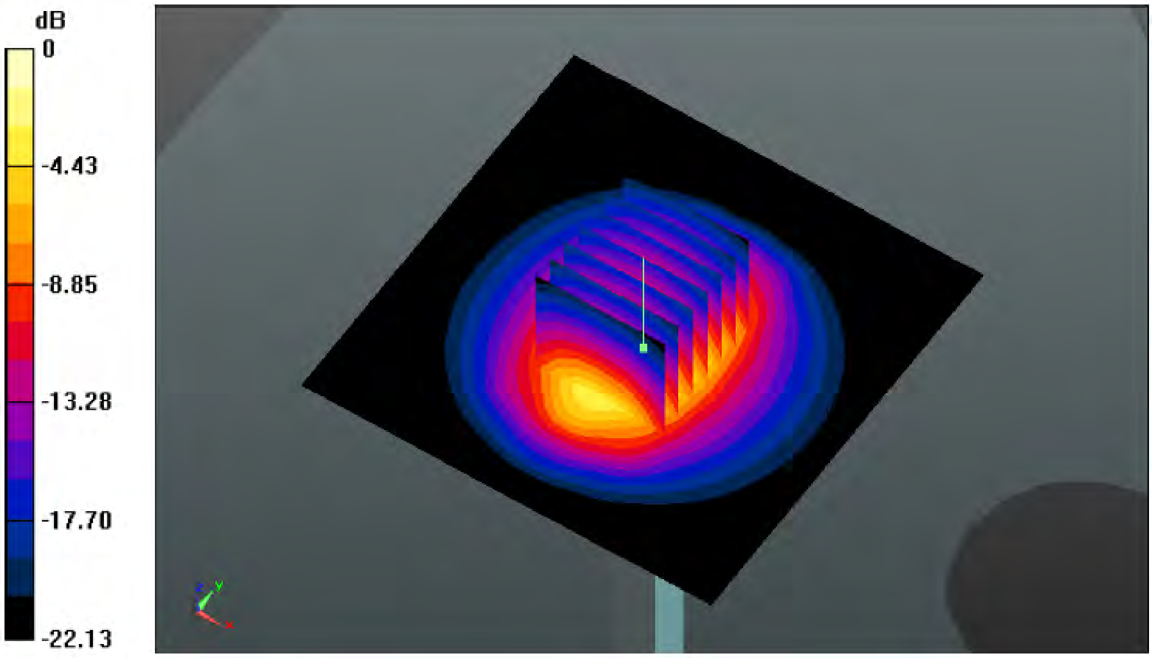
Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 84.170 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 26.174 W/kg

SAR(1 g) = 12.5 mW/g; SAR(10 g) = 5.76 mW/g

Maximum value of SAR (measured) = 19.27mW/g



System Performance Check 2450MHz Body250mW

Appendix C. Plots of SAR Test Data

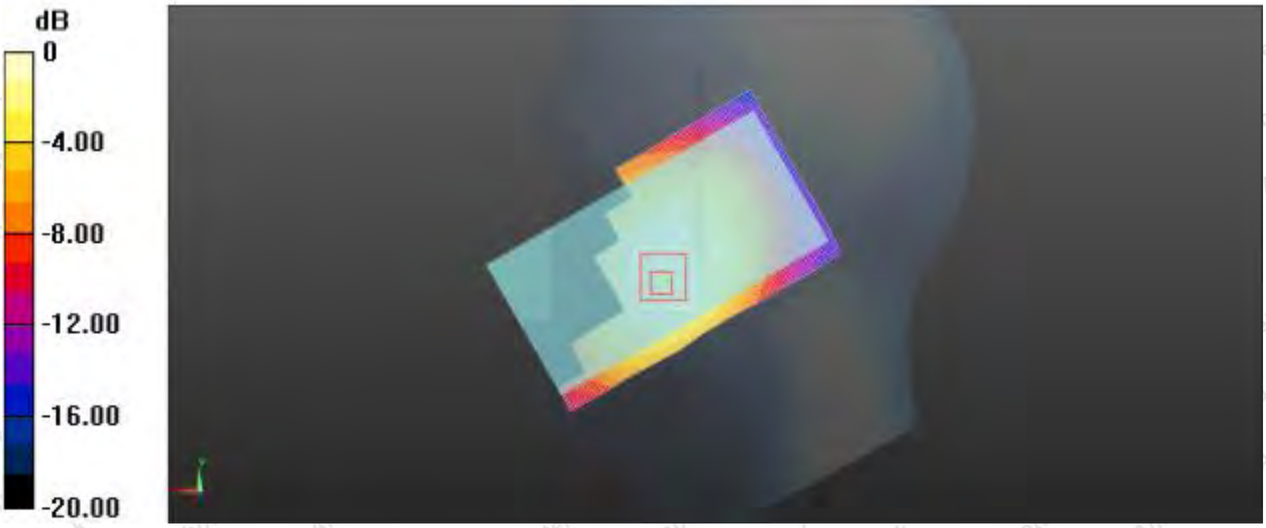
GSM850 Head

Date:2019-05-05
Communication System: Customer System; Frequency:836.6 MHz;Duty Cycle:1:8
Medium parameters used (interpolated): f=836.6 MHz; σ=0.91S/m; εr=41.48; ρ=1000 kg/m3
Phantom section: Left Section

DASY5 Configuration:
•Probe: EX3DV4 - SN7396; ConvF(9.71, 9.71, 9.71); Calibrated: 12,05.2018;
•Sensor-Surface: 4mm (Mechanical Surface Detection)
•Electronics: DAE4 Sn387; Calibrated: 06.09.2018
•Phantom: SAM 1; Type: SAM;
•Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

Area Scan (61x101x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 0.310 W/kg

Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 6.779 V/m; Power Drift = -0.07 dB
Peak SAR (extrapolated) = 0.314 mW/g
SAR(1 g) = 0.294 mW/g; SAR(10 g) = 0.251 mW/g
Maximum value of SAR (measured) = 0.302 W/kg



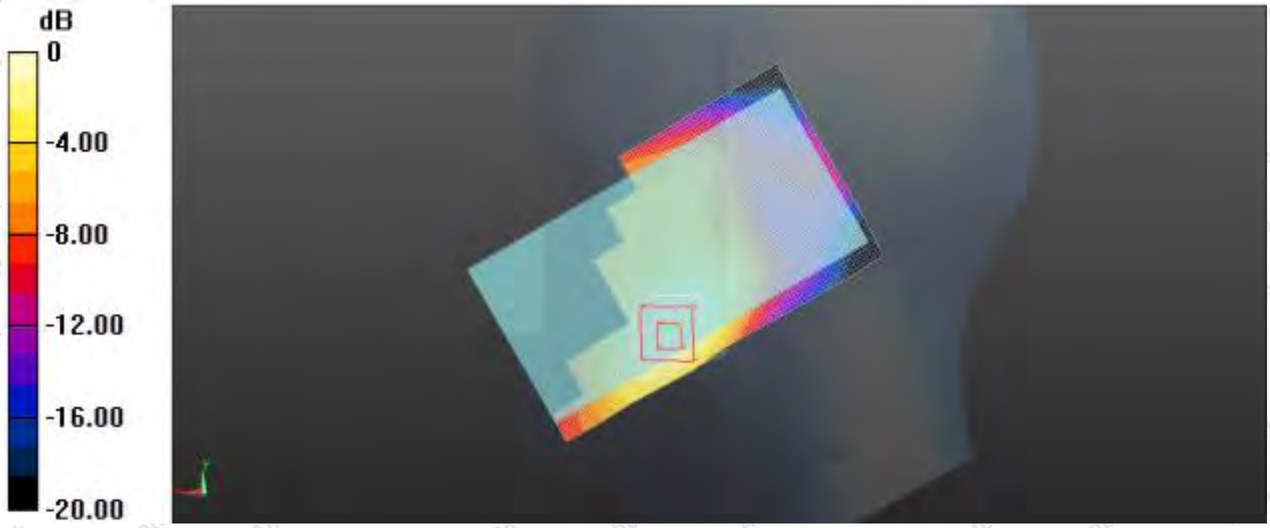
PCS1900 Head

Date:2019-05-07
Communication System: Customer System; Frequency: 1880.0 MHz;Duty Cycle: 1:8
Medium parameters used (interpolated): f = 1880.0 MHz; σ = 1.41 mho/m; ε = 40.01; ρ = 1000 kg/m
3
Phantom section: Left Section

DASY5 Configuration:
•Probe:EX3DV4 - SN7396; ConvF(8.13, 8.13, 8.13); Calibrated: 12,05.2018;
•Sensor-Surface: 4mm (Mechanical Surface Detection)
•Electronics: DAE4 Sn387; Calibrated: 06.09.2018
•Phantom: SAM 1; Type: SAM;
•Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

Area Scan (61x111x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 0.315 W/kg

Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 5.242 V/m; Power Drift = 0.10 dB
Peak SAR (extrapolated) = 0.468 mW/g
SAR(1 g) = 0.317 mW/g; SAR(10 g) = 0.180 mW/g
Maximum value of SAR (measured) = 0.325 W/kg



Left Head (PCS1900 Middle Channel)

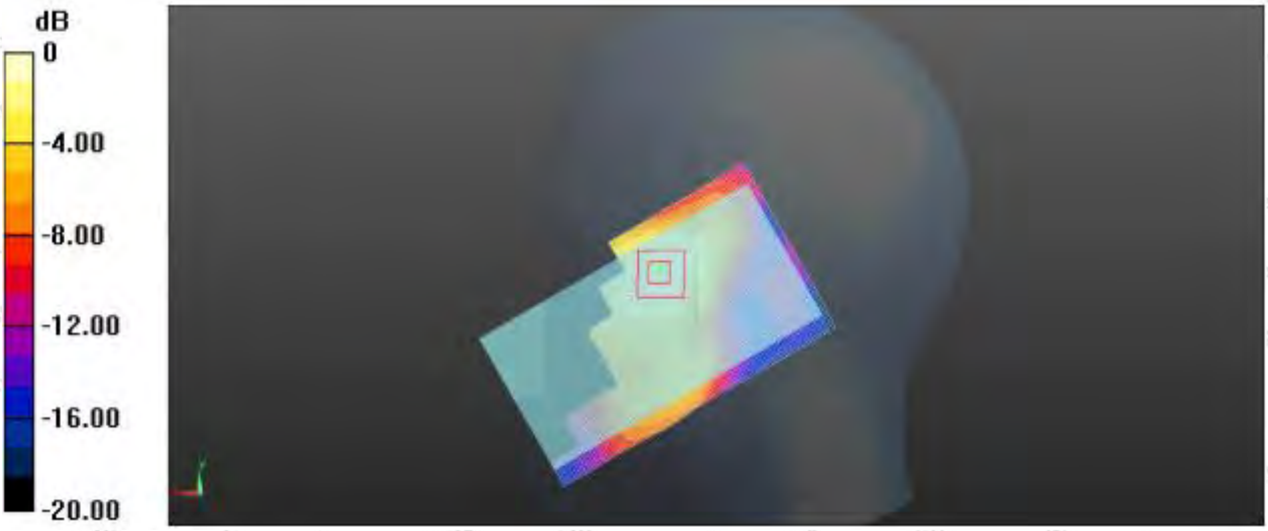
WCDMA Band V Head

Date:2019-05-05
Communication System: Customer System; Frequency: 836.6 MHz;Duty Cycle:1:1
Medium parameters used (interpolated): f=836.6 MHz; σ=0.91S/m; εr=41.48; ρ=1000 kg/m3
Phantom section: Left Head Section:

DASY5 Configuration:
•Probe: EX3DV4 - SN7396; ConvF(9.71, 9.71, 9.71); Calibrated: 12,05.2018;
•Sensor-Surface: 4mm (Mechanical Surface Detection)
•Electronics: DAE4 Sn387; Calibrated: 06.09.2018
•Phantom: SAM 1; Type: SAM;
•Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

Area Scan (51x101x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 0.324 W/kg

Zoom Scan (5x5x6)/Cube 0: Measurement grid: dx=7mm, dy=7mm, dz=5mm
Reference Value = 6.864 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 0.330 mW/g
SAR(1 g) = 0.310 mW/g; SAR(10 g) = 0.261 mW/g
Maximum value of SAR (measured) = 0.322 W/kg



Left Head Cheek (WCDMA Band V Middle Channel)

WCDMA Band II Head

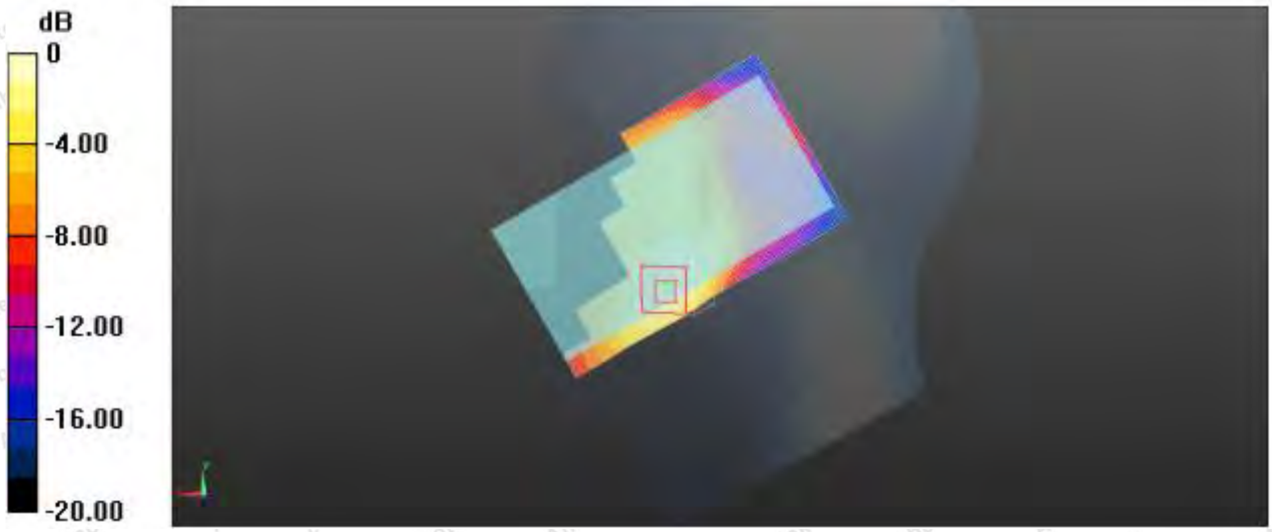
Date:2019-05-07
Communication System: Customer System; Frequency: 1880.0 MHz;Duty Cycle:1:1
Medium parameters used (interpolated): f =1880.0 MHz; σ = 1.41 mho/m; ε = 40.01; ρ=1000 kg/m3
Phantom section: Left Head Section:

DASY5 Configuration:

- Probe:EX3DV4 - SN7396; ConvF(8.13, 8.13, 8.13); Calibrated: 12,05.2018;
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn387; Calibrated: 06.09.2018
- Phantom: SAM 1; Type: SAM;
- Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

Area Scan (51x101x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 0.345 W/kg

Zoom Scan (5x5x6)/Cube 0: Measurement grid: dx=7mm, dy=7mm, dz=5mm
Reference Value = 6.796 V/m; Power Drift = -0.17 dB
Peak SAR (extrapolated) = 0.490 mW/g
SAR(1 g) = 0.330 mW/g; SAR(10 g) = 0.207 mW/g
Maximum value of SAR (measured) = 0.350 W/kg



Left Head Cheek (WCDMA Band II Middle Channel)

WLAN 802.11b Head

Date:2019-05-09
Communication System: Customer System; Frequency: 2462.0 MHz;
Medium parameters used (interpolated): f=2462.0 MHz; σ=1.79S/m; εr=39.00; ρ=1000 kg/m3
Phantom section: Left Head Section:

DASY5 Configuration:

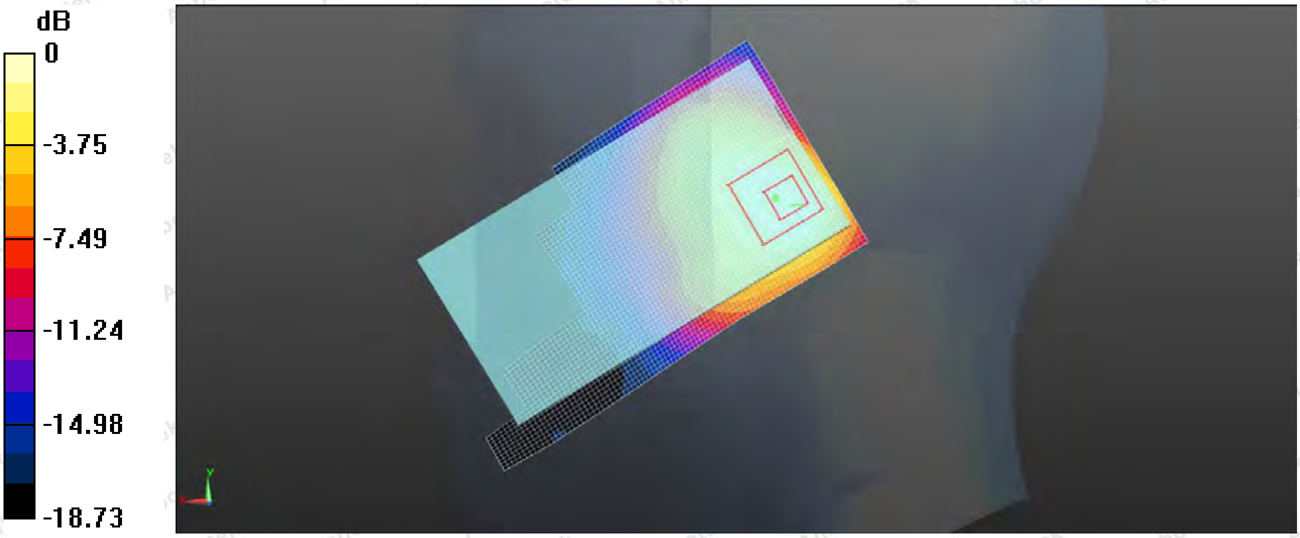
•Probe: EX3DV4 - SN7396; ConvF(7.57, 7.57, 7.57); Calibrated: 12,05.2018;
•Sensor-Surface: 4mm (Mechanical Surface Detection)
•Electronics: DAE4 Sn387; Calibrated: 06.09.2018
•Phantom: SAM 1; Type: SAM;
•Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

Area Scan (51x101x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 0.323 W/kg

Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 3.276 V/m; Power Drift =-0.07 dB
Peak SAR (extrapolated) = 0.331 mW/g

SAR(1 g) = 0.247 mW/g; SAR(10 g) = 0.124 mW/g

Maximum value of SAR (measured) = 0.326 W/kg



Left Head Cheek (WLAN high Channel)

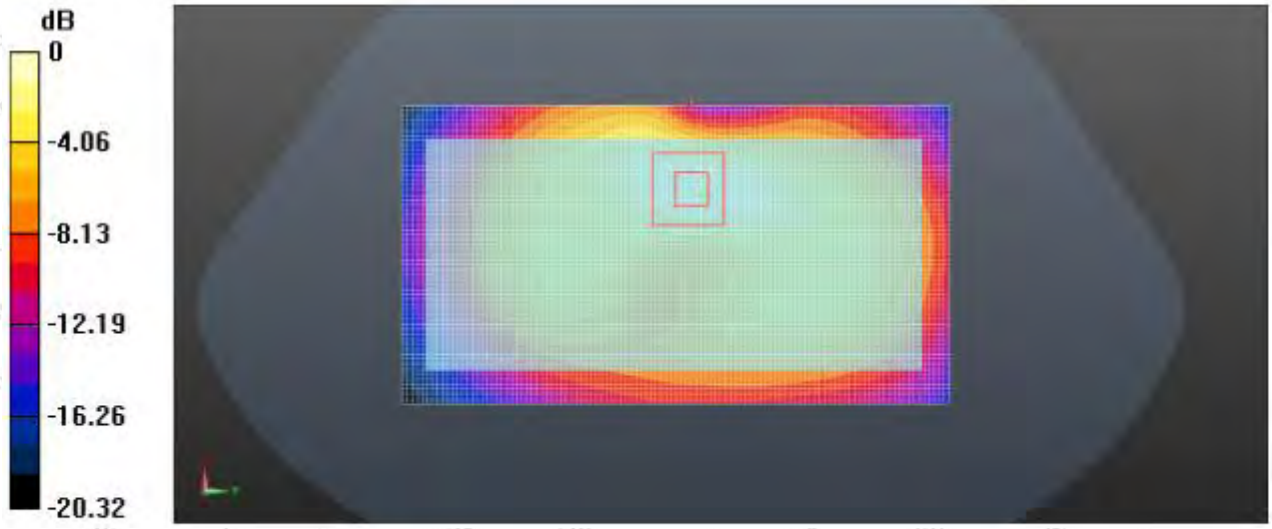
GSM850 GPRS 4TS Body

Date:2019-05-06
Communication System: Customer System; Frequency:836.6 MHz;Duty Cycle:1:2
Medium parameters used (interpolated): f=836.6 MHz; σ=0.97S/m; εr=55.10; ρ=1000 kg/m3
Phantom section: Flat Section:

DASY 5 Configuration:
•Probe: EX3DV4 - SN7396; ConvF(9.88, 9.88, 9.88); Calibrated: 12,05.2018;
•Sensor-Surface: 4mm (Mechanical Surface Detection)
•Electronics: DAE4 Sn387; Calibrated: 06.09.2018
•Phantom: SAM 1; Type: SAM;
•Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

Area Scan (51x101x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 0.437 W/kg

Zoom Scan (5x5x6)/Cube 0: Measurement grid: dx=7mm, dy=7mm, dz=5mm
Reference Value = 10.262 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 0.775 mW/g
SAR(1 g) = 0.419 mW/g; SAR(10 g) = 0.322 mW/g
Maximum value of SAR (measured) = 0.471 W/kg



Rear Side (GSM850 GPRS 4TS Middle Channel)

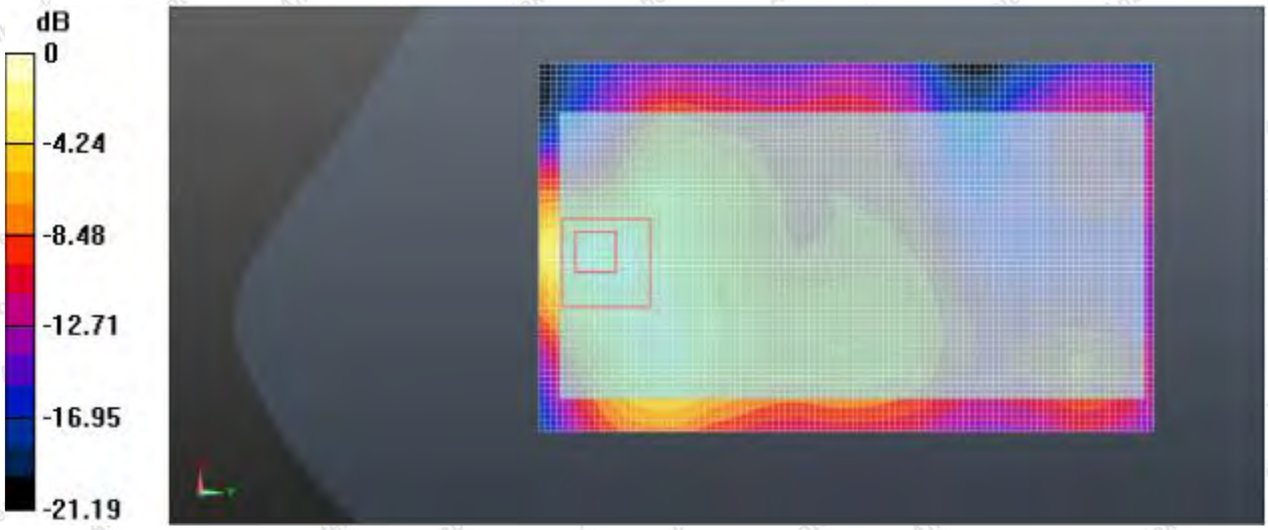
PCS1900 GPRS 4TS Body

Date:2019-05-08
Communication System: Customer System; Frequency: 1880.0 MHz;Duty Cycle: 1:2
Medium parameters used (interpolated): f = 1880.0 MHz; σ = 1.51 mho/m; ε = 53.21; ρ = 1000 kg/m 3
Phantom section: Flat Section

DASY5 Configuration:
•Probe: EX3DV4 - SN7396; ConvF(7.97, 7.97, 7.97); Calibrated: 12,05.2018;
•Sensor-Surface: 4mm (Mechanical Surface Detection)
•Electronics: DAE4 Sn387; Calibrated: 06.09.2018
•Phantom: SAM 1; Type: SAM;
•Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

Area Scan (51x101x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 0.763 W/kg

Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 8.472 V/m; Power Drift = -0.18 dB
Peak SAR (extrapolated) = 1.11 W/kg
SAR(1 g) = 0.682 W/kg; SAR(10 g) = 0.371 W/kg
Maximum value of SAR (measured) = 0.751 W/kg



Rear Side (PCS1900 GPRS 4TS Middle Channel)

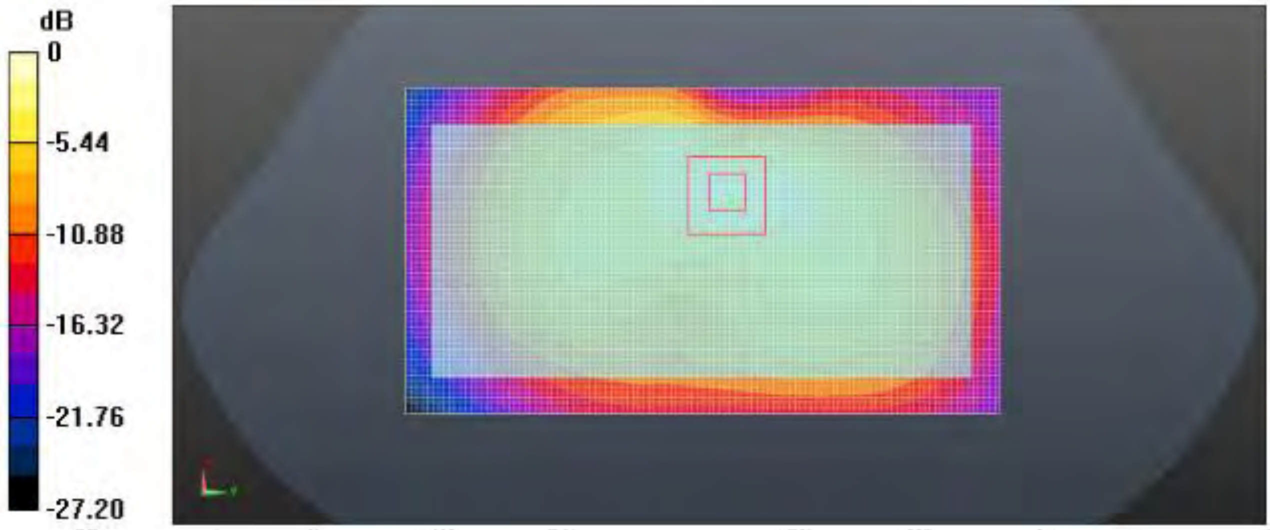
WCDMA Band V Body

Date:2019-05-06
Communication System: Customer System; Frequency: 836.6 MHz;Duty Cycle:1:1
Medium parameters used (interpolated): f=836.6 MHz; σ=0.97S/m; εr=55.10; ρ=1000 kg/m3
Phantom section: Flat Section

DASY5 Configuration:
•Probe: EX3DV4 - SN7396; ConvF(9.88, 9.88, 9.88); Calibrated: 12,05.2018;
•Sensor-Surface: 4mm (Mechanical Surface Detection)
•Electronics: DAE4 Sn387; Calibrated: 06.09.2018
•Phantom: SAM 1; Type: SAM;
•Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

Area Scan (51x101x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 0.721 mW/g

Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 18.243 V/m; Power Drift = -0.07 dB
Peak SAR (extrapolated) = 0.846 mW/g
SAR(1 g) = 0.509 mW/g; SAR(10 g) = 0.303 mW/g
Maximum value of SAR (measured) = 0.724 W/kg



Rear Side (WCDMA Band V Middle Channel)

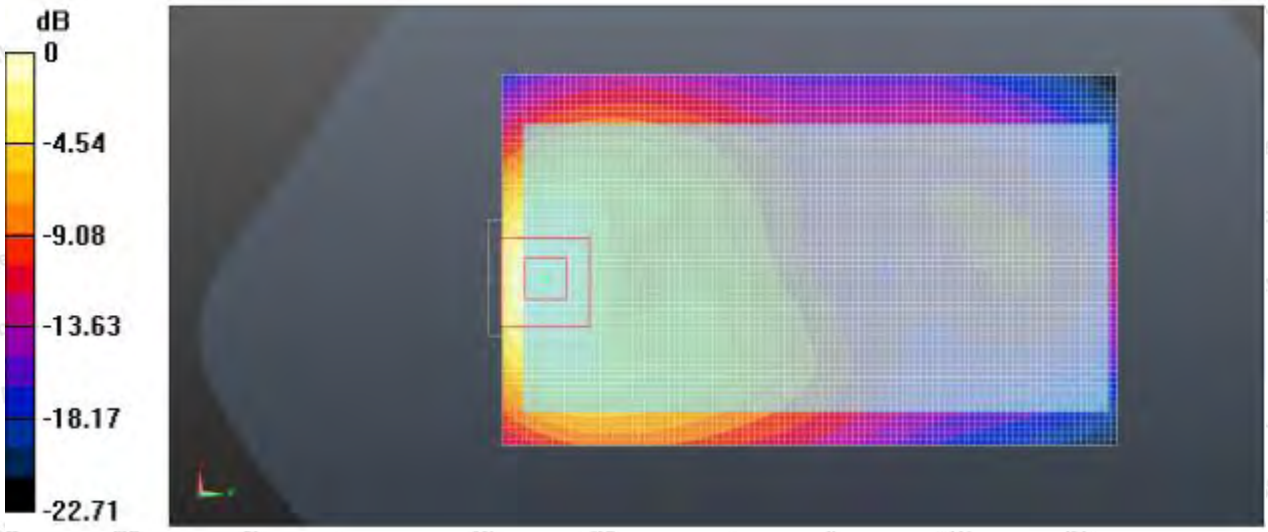
WCDMA Band II Body

Date:2019-05-08
Communication System: Customer System; Frequency: 1907.6 MHz;Duty Cycle:1:1
Medium parameters used (interpolated): f=1907.6 MHz; σ=1.53S/m; εr=53.11; ρ=1000 kg/m3
Phantom section: Flat Section

DASY5 Configuration:
•Probe: EX3DV4 - SN7396; ConvF(7.97, 7.97, 7.97); Calibrated: 12,05.2018;
•Sensor-Surface: 4mm (Mechanical Surface Detection)
•Electronics: DAE4 Sn387; Calibrated: 06.09.2018
•Phantom: SAM 1; Type: SAM;
•Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

Area Scan (51x101x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) =0.898 W/kg

Zoom Scan (5x5x6)/Cube 0: Measurement grid: dx=7mm, dy=7mm, dz=5mm
Reference Value = 9.724 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 1.635 mW/g
SAR(1 g) = 0.813 mW/g; SAR(10 g) = 0.422 mW/g
Maximum value of SAR (measured) = 0.907 W/kg



Rear Side (WCDMA Band II High Channel)

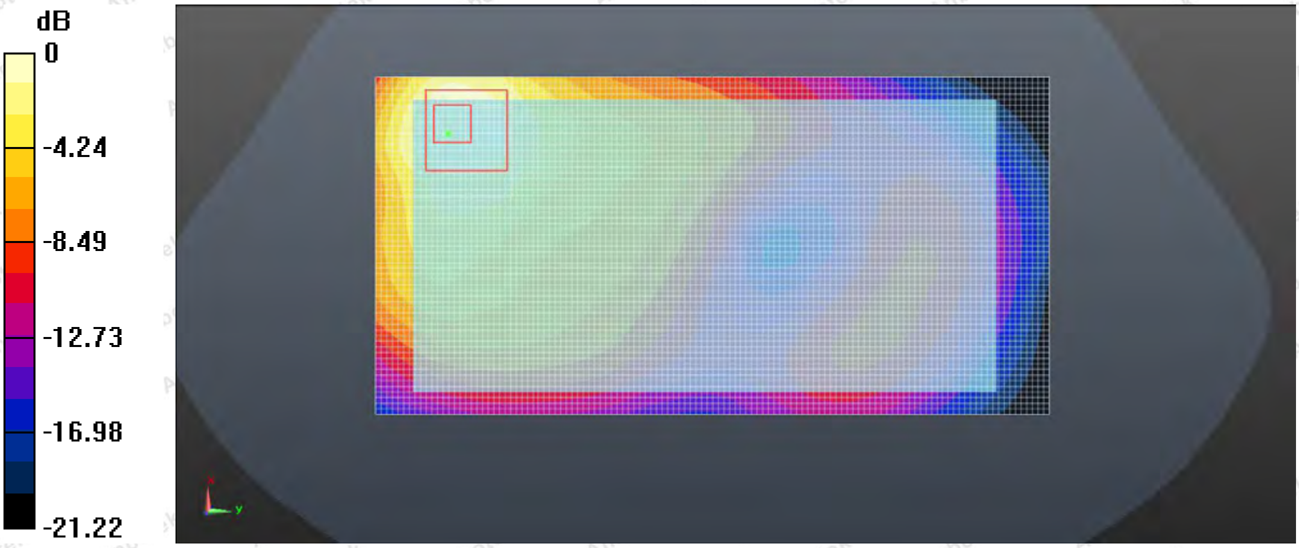
WLAN 802.11b Body

Date:2019-05-10
Communication System: Customer System; Frequency: 2462.0 MHz;Duty Cycle:1:1
Medium parameters used (interpolated): f= 2462.0 MHz; σ=1.94S/m; εr=52.50; ρ=1000 kg/m3
Phantom section : Flat Section

DASY5 Configuration:
•Probe: EX3DV4 - SN7396; ConvF(7.53, 7.53, 7.53); Calibrated: 12,05.2018;
•Sensor-Surface: 4mm (Mechanical Surface Detection)
•Electronics: DAE4 Sn387; Calibrated: 06.09.2018
•Phantom: SAM 1; Type: SAM;
•Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

Area Scan (51x101x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 0.143 W/kg

Zoom Scan (5x5x6)/Cube 0: Measurement grid: dx=7mm, dy=7mm, dz=5mm
Reference Value = 5.847 V/m; Power Drift = 0.13 dB
Peak SAR (extrapolated) = 0.244 mW/g
SAR(1 g) = 0.140 mW/g; SAR(10 g) = 0.106 mW/g
Maximum value of SAR (measured) = 0.155 W/kg



Rear side (WLAN 802.11b high Channel)

Appendix D. DASY System Calibration Certificate

In Collaboration with s p e a g CALIBRATION LABORATORY

中国认可 国际互认 校准 CALIBRATION CNAS L0570

Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China
Tel: +86-10-62304633-2218 Fax: +86-10-62304633-2209
E-mail: cttl@chinattl.com Http://www.chinattl.cn

Client Anbotek (Auden) Certificate No: Z18-98671

CALIBRATION CERTIFICATE

Object: EX3DV4 - SN:7396

Calibration Procedure(s): FF-Z12-006-08
Calibration Procedures for Dosimetric E-field Probes

Calibration date: May12, 2018

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)℃ and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Power Meter NRP2	101919	20-Jun-17 (CTTL, No.J17X07447)	Jun-18
Power sensor NRP-Z91	101547	20-Jun-17 (CTTL, No.J17X07447)	Jun-18
Power sensor NRP-Z91	101548	20-Jun-17 (CTTL, No.J17X07447)	Jun-18
Reference10dBAttenuator	18N50W-10dB	13-Mar-18(CTTL,No.J18X01547)	Mar-19
Reference20dBAttenuator	18N50W-20dB	13-Mar-18(CTTL, No.J18X01548)	Mar-19
Reference Probe EX3DV4	SN 7433	26-Sep-17(SPEAG,No.EX3-7433_Sep17)	Sep-18
DAE4	SN 549	13-Dec-17(SPEAG, No.DAE4-549_Dec17)	Dec -18
Secondary Standards	**ID #**	**Cal Date(Calibrated by, Certificate No.)**	**Scheduled Calibration**
SignalGeneratorMG3700A	6201052605	27-Jun-17 (CTTL, No.J17X04776)	Jun-18
Network Analyzer E5071C	MY46110673	13-Jan-18 (CTTL, No.J18X00285)	Jan -19

	Name	Function	Signature
Calibrated by:	Yu Zongying	SAR Test Engineer	
Reviewed by:	Lin Hao	SAR Test Engineer	
Approved by:	Qi Dianyuan	SAR Project Leader	

Issued: May13, 2018

In Collaboration with
s p e a g
CALIBRATION LABORATORY

Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China
Tel: +86-10-62304633-2218 Fax: +86-10-62304633-2209
E-mail: cttl@chinattl.com Http://www.chinattl.cn

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 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 300MHz to 3GHz)”, 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≤900MHz in TEM-cell; f>1800MHz: waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not effect 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 (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; VRx,y,z:*A,B,C 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≤800MHz) and inside waveguide using analytical field distributions based on power measurements for f >800MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty valued 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±50MHz to±100MHz.
- *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).

In Collaboration with
s p e a g
CALIBRATION LABORATORY

Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China
Tel: +86-10-62304633-2218 Fax: +86-10-62304633-2209
E-mail: cttl@chinattl.com Http://www.chinattl.cn

Probe EX3DV4

SN: 7396

Calibrated: May 12, 2018

Calibrated for DASY/EASY Systems

(Note: non-compatible with DASY2 system!)

In Collaboration with
s p e a g
CALIBRATION LABORATORY

Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China
Tel: +86-10-62304633-2218 Fax: +86-10-62304633-2209
E-mail: cttl@chinattl.com Http://www.chinattl.cn

DASY/EASY – Parameters of Probe: EX3DV4 – SN: 7396

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm(μV/(V/m)^2)^A	0.54	0.53	0.50	±10.0%
DCP(mV)^B	97.8	104.5	102.5	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB√μV	C	D dB	VR mV	Unc^E (k=2)
0	CW	X	0.0	0.0	1.0	0.00	199.9	±2.4%
		Y	0.0	0.0	1.0		203.3	
		Z	0.0	0.0	1.0		195.0	

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 Page 5 and Page 6).
^{B} Numerical linearization parameter: uncertainty not required.
^{E} Uncertainly is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

In Collaboration with
s p e a g
CALIBRATION LABORATORY

Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China
Tel: +86-10-62304633-2218 Fax: +86-10-62304633-2209
E-mail: cttl@chinattl.com Http://www.chinattl.cn

DASY/EASY – Parameters of Probe: EX3DV4 – SN: 7396

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)	Unct. (k=2)
750	41.9	0.89	9.82	9.82	9.82	0.30	0.85	±12.1%
835	41.5	0.90	9.71	9.71	9.71	0.15	1.36	±12.1%
900	41.5	0.97	9.87	9.87	9.87	0.16	1.37	±12.1%
1750	40.1	1.37	8.61	8.61	8.61	0.25	1.04	±12.1%
1900	40.0	1.40	8.13	8.13	8.13	0.24	1.01	±12.1%
2100	39.8	1.49	8.14	8.14	8.14	0.24	1.04	±12.1%
2300	39.5	1.67	7.85	7.85	7.85	0.40	0.75	±12.1%
2450	39.2	1.80	7.57	7.57	7.57	0.50	0.75	±12.1%
2600	39.0	1.96	7.38	7.38	7.38	0.64	0.68	±12.1%
5250	35.9	4.71	5.33	5.33	5.33	0.45	1.30	±13.3%
5600	35.5	5.07	4.89	4.89	4.89	0.45	1.35	±13.3%
5750	35.4	5.22	4.92	4.92	4.92	0.45	1.45	±13.3%

[C] Frequency validity above 300 MHz of ±100MHz only applies for DASY v4.4 and higher (Page 2), else it is restricted to ±50MHz. The uncertainty is the RSS of 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 frequency 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 the frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

TTL In Collaboration with s p e a g CALIBRATION LABORATORY

Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China
Tel: +86-10-62304633-2218 Fax: +86-10-62304633-2209
E-mail: cttl@chinattl.com Http://www.chinattl.cn

DASY/EASY – Parameters of Probe: EX3DV4 – SN: 7396

Calibration Parameter Determined in Body Tissue Simulating Media

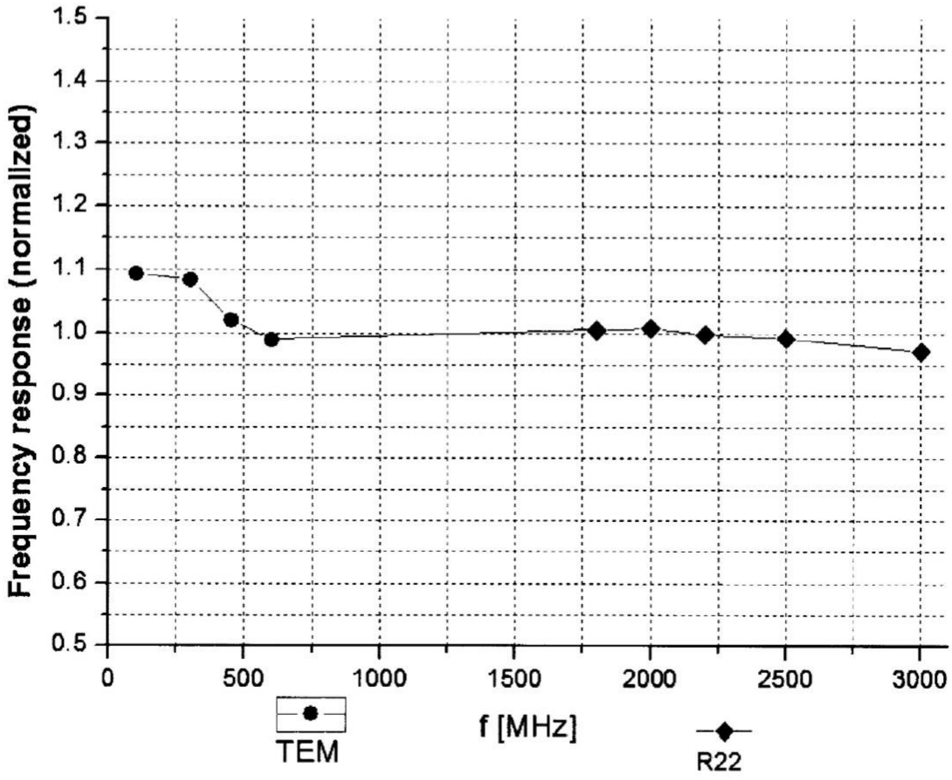
f [MHz][C]	Relative Permittivity [F]	Conductivity (S/m) [F]	ConvF X	ConvF Y	ConvF Z	Alpha[G]	Depth[G] (mm)	Unct. (k=2)
750	55.5	0.96	10.09	10.09	10.09	0.30	0.90	±12.1%
835	55.2	0.97	9.88	9.88	9.88	0.19	1.32	±12.1%
900	55.0	1.05	9.82	9.82	9.82	0.23	1.15	±12.1%
1750	53.4	1.49	8.24	8.24	8.24	0.24	1.06	±12.1%
1900	53.3	1.52	7.97	7.97	7.97	0.19	1.24	±12.1%
2100	53.2	1.62	8.18	8.18	8.18	0.19	1.39	±12.1%
2300	52.9	1.81	7.88	7.88	7.88	0.55	0.80	±12.1%
2450	52.7	1.95	7.53	7.53	7.53	0.46	0.89	±12.1%
2600	52.5	2.16	7.38	7.38	7.38	0.52	0.80	±12.1%
5250	48.9	5.36	4.93	4.93	4.93	0.45	1.80	±13.3%
5600	48.5	5.77	4.19	4.19	4.19	0.48	1.90	±13.3%
5750	48.3	5.94	4.52	4.52	4.52	0.48	1.95	±13.3%

[C] Frequency validity above 300 MHz of ±100MHz only applies for DASY v4.4 and higher (Page 2), else it is restricted to ±50MHz. The uncertainty is the RSS of 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 frequency 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 the frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

In Collaboration with
s p e a g
CALIBRATION LABORATORY

Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China
Tel: +86-10-62304633-2218 Fax: +86-10-62304633-2209
E-mail: cttl@chinattl.com Http://www.chinattl.cn

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



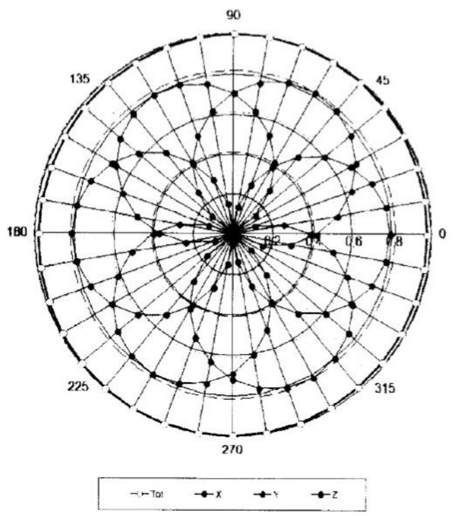
Uncertainty of Frequency Response of E-field: ±7.4% (k=2)

TTL In Collaboration with s p e a g CALIBRATION LABORATORY

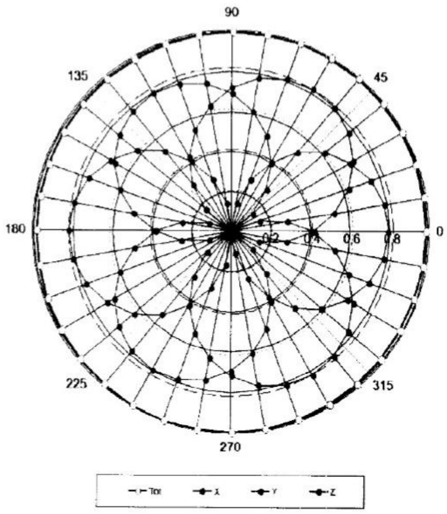
Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China
Tel: +86-10-62304633-2218 Fax: +86-10-62304633-2209
E-mail: cttl@chinattl.com Http://www.chinattl.cn

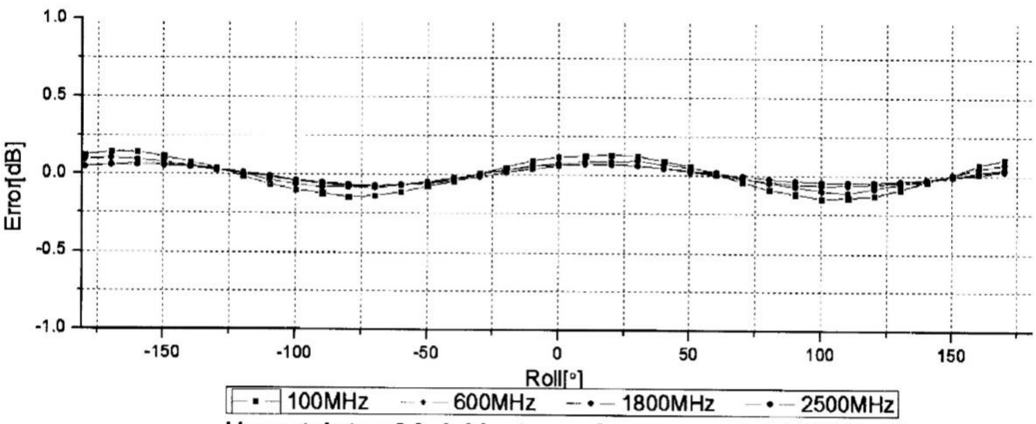
Receiving Pattern (Φ), θ=0°

f=600 MHz, TEM



f=1800 MHz, R22



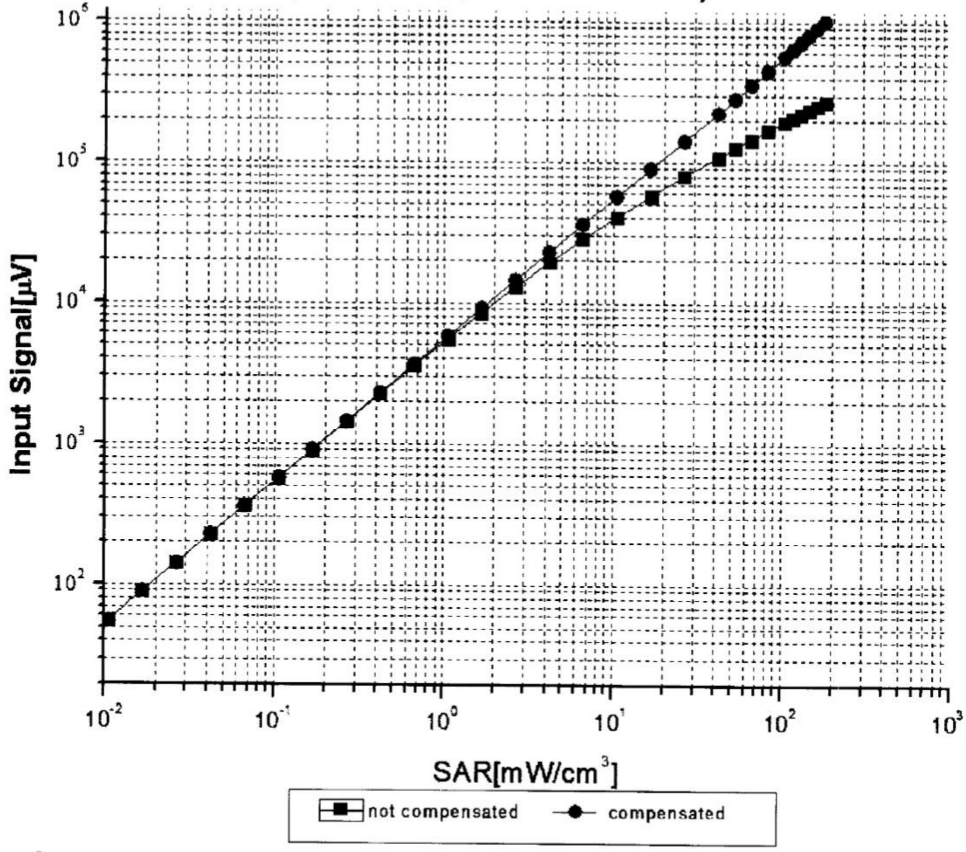


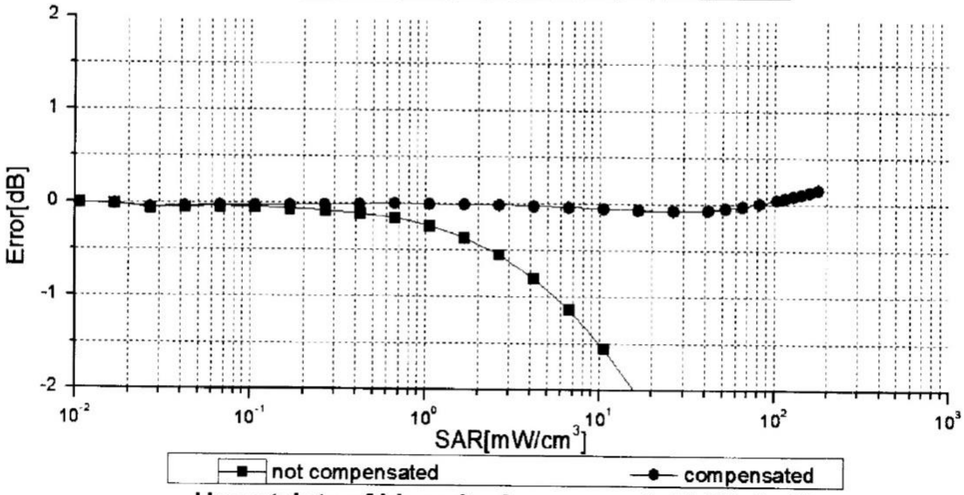
Uncertainty of Axial Isotropy Assessment: ±1.2% (k=2)

TTL In Collaboration with speag CALIBRATION LABORATORY

Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China
Tel: +86-10-62304633-2218 Fax: +86-10-62304633-2209
E-mail: cttl@chinattl.com Http://www.chinattl.cn

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





Uncertainty of Linearity Assessment: ±0.9% (k=2)

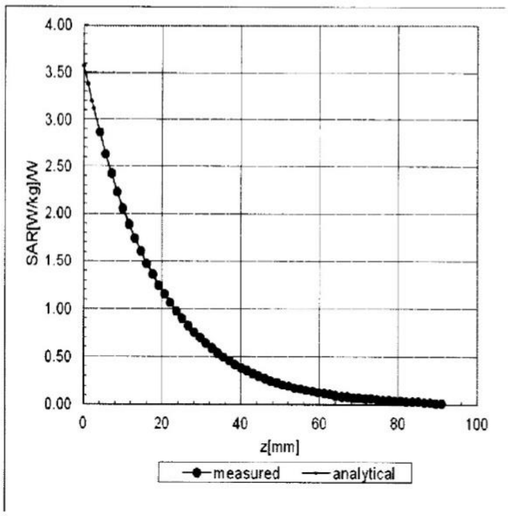
Certificate No: Z18-98671 Page 9 of 11

CTTL In Collaboration with s p e a g CALIBRATION LABORATORY

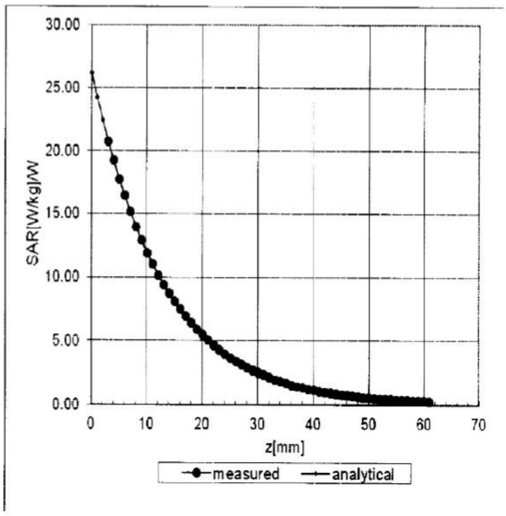
Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China
Tel: +86-10-62304633-2218 Fax: +86-10-62304633-2209
E-mail: cttl@chinattl.com Http://www.chinattl.cn

Conversion Factor Assessment

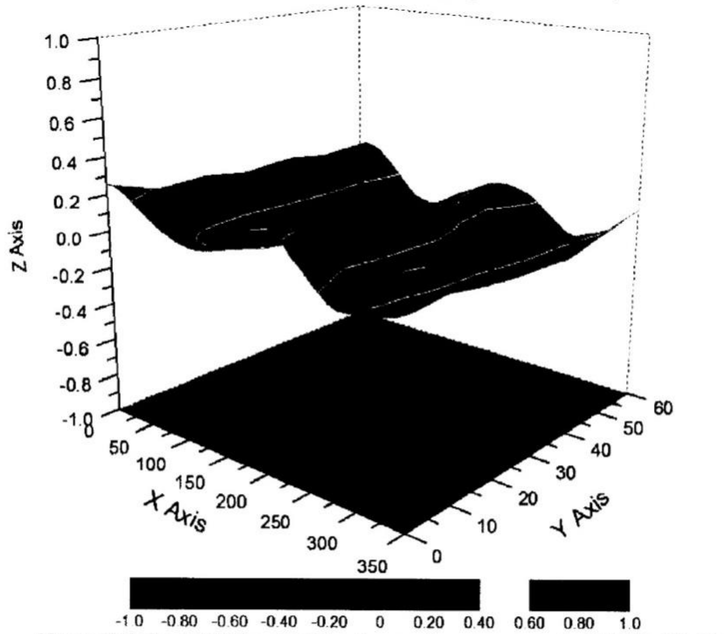
f=900 MHz, WGLS R9(H_convF)



f=1750 MHz, WGLS R22(H_convF)



Deviation from Isotropy in Liquid



Uncertainty of Spherical Isotropy Assessment: ±3.2% (K=2)

In Collaboration with
s p e a g
CALIBRATION LABORATORY

Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China
Tel: +86-10-62304633-2218 Fax: +86-10-62304633-2209
E-mail: cttl@chinattl.com Http://www.chinattl.cn

DASY/EASY – Parameters of Probe: EX3DV4 – SN: 7396

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	156.9
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disable
Probe Overall Length	337mm
Probe Body Diameter	10mm
Tip Length	9mm
Tip Diameter	2.5mm
Probe Tip to Sensor X Calibration Point	1mm
Probe Tip to Sensor Y Calibration Point	1mm
Probe Tip to Sensor Z Calibration Point	1mm
Recommended Measurement Distance from Surface	1.4mm

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

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.

Schmid & Partner Engineering

TN_BR040315AD DAE4.doc

11.12.2009

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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
C 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 **Anbotek (Auden)**

Certificate No: **DAE4-387_Sep08**

CALIBRATION CERTIFICATE

Object	DAE4 - SD 000 D04 BM - SN: 387
Calibration procedure(s)	QA CAL-06.v29 Calibration procedure for the data acquisition electronics (DAE)
Calibration date:	September 06, 2018

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	15-Aug-18 (No:21092)	Aug-19
Secondary Standards	**ID #**	**Check Date (in house)**	**Scheduled Check**
Auto DAE Calibration Unit	SE UWS 053 AA 1001	05-Jan-18 (in house check)	In house check: Jan-19
Calibrator Box V2.1	SE UMS 006 AA 1002	05-Jan-18 (in house check)	In house check: Jan-19

	Name	Function	Signature
Calibrated by:	Dominique Steffen	Laboratory Technician	
Approved by:	Sven Kühn	Deputy Manager	

Issued: September 03, 2018

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**

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	404.489 ± 0.02% (k=2)	404.852 ± 0.02% (k=2)	404.862 ± 0.02% (k=2)
Low Range	3.97827 ± 1.50% (k=2)	3.95875 ± 1.50% (k=2)	3.97982 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	53.0 ° ± 1 °

Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	200032.85	-3.31	-0.00
Channel X	+ Input	20007.64	1.88	0.01
Channel X	- Input	-20003.48	1.18	-0.01
Channel Y	+ Input	200034.23	-1.43	-0.00
Channel Y	+ Input	20006.60	0.91	0.00
Channel Y	- Input	-20004.04	0.72	-0.00
Channel Z	+ Input	200035.38	-0.83	-0.00
Channel Z	+ Input	20003.69	-2.11	-0.01
Channel Z	- Input	-20006.38	-1.59	0.01

Low Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	2001.63	0.08	0.00
Channel X	+ Input	202.29	0.70	0.35
Channel X	- Input	-197.90	0.60	-0.30
Channel Y	+ Input	2001.33	-0.07	-0.00
Channel Y	+ Input	200.86	-0.60	-0.30
Channel Y	- Input	-199.87	-1.23	0.62
Channel Z	+ Input	2001.61	0.27	0.01
Channel Z	+ Input	200.60	-0.70	-0.35
Channel Z	- Input	-199.51	-0.85	0.43

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	13.50	11.56
	- 200	-8.64	-11.18
Channel Y	200	-0.81	-1.28
	- 200	1.05	0.09
Channel Z	200	7.17	6.91
	- 200	-9.46	-9.01

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	-	-1.70	0.33
Channel Y	200	10.70	-	-0.38
Channel Z	200	7.11	7.89	-

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	15969	17466
Channel Y	15661	16162
Channel Z	15990	16190

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	0.73	-2.58	3.29	0.62
Channel Y	0.41	-0.49	1.23	0.40
Channel Z	-0.80	-1.88	0.30	0.42

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