DAkkS Deutsche Akkreditierungsstelle D-PL-12139-01-00

The Testcenter facility ‘Dosimetric Test Lab’ within IMST GmbH is accredited by the German National ‘Deutsche Akkreditierungsstelle GmbH (DAkkS)’ for testing according to the scope as listed in the accreditation certificate: D-PL-12139-01-00.

SAR Evaluation Report

EUT Information	
Manufacturer	buddi Limited
Model Name	Smart Tag Location QUAD
FCC ID	ZDLST3
IC number	20371-ST3
EUT Type	smart tag used for tracking
EUT Category	portable device
Prepared by	
Testing Laboratory	IMST GmbH, Test Center Carl-Friedrich-Gauß-Str. 2 – 4 47475 Kamp-Lintfort Germany
Prepared for	
Applicant	buddi Limited Talbot House, 17 Church Street WD3 1DE Rickmansworth United Kingdom
Test Specification	
Standard Applied	FCC CFR 47 § 2.1093; RSS-102 Issue 5 and the published KDB procedures
Exposure Category	General Public / Uncontrolled Exposure
Configuration	Extremity Exposure
Report Information	
Data Stored	60320_6160557_buddi_SmartTag
Issue Date	December 12, 2016
Revision Date	-
Revision Number	-
Remarks	This report relates only to the item(s) evaluated. This report shall not be reproduced, except in its entirety, without the prior written approval of IMST GmbH. The results and statements contained in this report reflect the evaluation for the certain model described above. The manufacturer is responsible for ensuring that all production devices meet the intent of the requirements described in this report.

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1 Subject of Investigation and Test Results

1.1 Technical Data of EUT

Product Specifications					
Operation Mode	GPRS 850 (Class 12; 4TX)	**TX Frequency Range [MHz]**	824.2 - 848.8	**Duty Cycle**	50 %*
	GPRS 1900 (Class 12; 4TX)		1850.2 - 1909.8		50 %*
	WCDMA 2 (RMC Rel.99; Data)		1852.4 - 1907.6		100 %
	WCDMA 5 (RMC Rel.99; Data)		826.4 - 846.6		100 %
	SRD		903.5 - 926.5		100 %
IMEI / SN	GPRS mode: 357520070101817 (IMST_01); WCDMA mode: 357520070096363 (IMST_02)				
Usage Configuration	Extremity Exposure				
Antenna Type	integrated				
Max. Output Power	see section 6.2				
Power Supply	3.7V lithium-polymer battery cell				
Used Accessory	On-Body-Charger (OBC)				
Notes: * Worst case GPRS duty cycle result in a scaling of 12/900 = 1.33%.					

1.2 Antenna Configuration

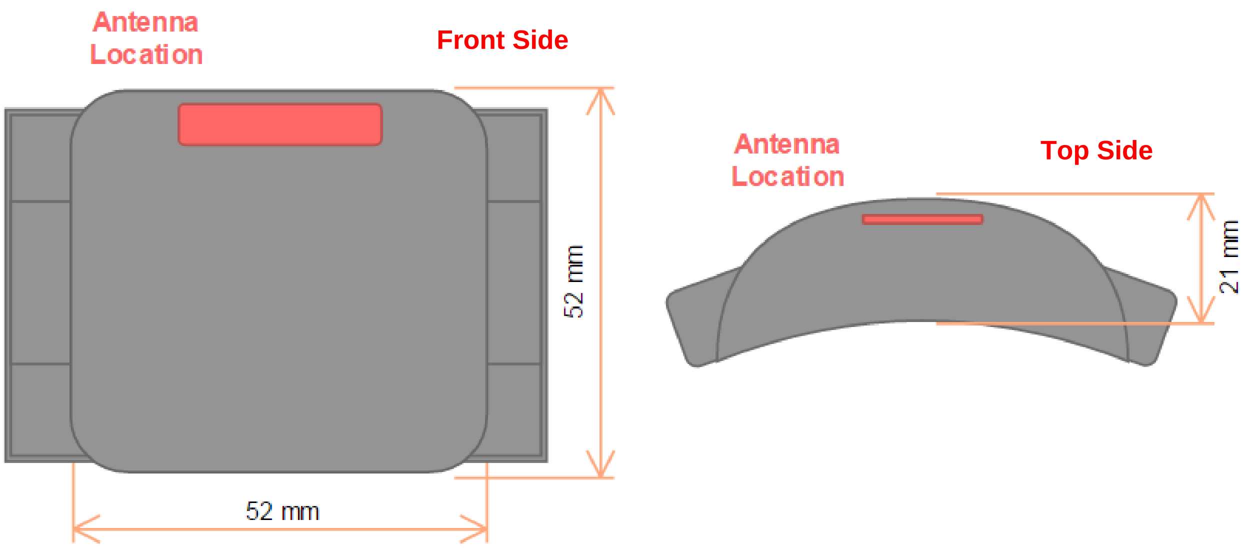

Fig. 1: Sketches of EUT and its antenna location (front and top side).

1.3 Test Specification / Normative References

The tests documented in this report were performed according to the standards and rules described below.

Test Specifications			
	Test Standard / Rule	**Description**	**Issue Date**
☒	IEEE 1528-2013	IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques.	June 14, 2013
☐	FCC CFR 47 § 2.1091	Code of Federal Regulations; Title 47. Radiofrequency radiation exposure evaluation: **Mobile Devices.**	October 01, 2010
☒	FCC CFR 47 § 2.1093	Code of Federal Regulations; Title 47. Radiofrequency radiation exposure evaluation: **Portable Devices.**	October 01, 2010
☒	RSS-102, Issue 5	Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)	March, 2015
Measurement Methodology KDB			
☒	KDB 865664 D01 v01r04	SAR measurement 100 MHz to 6 GHz	August 07, 2015
☒	KDB 865664 D02 v01r01	Exposure Reporting	October 23, 2015
Product KDB			
☒	KDB 447498 D01 v06	General RF Exposure Guidance	October 23, 2015
Technology KDB			
☒	KDB 941225 D01 v03r01	3G SAR Procedures	October 23, 2015

1.4 Attestation of Test Results

Highest MeasuredSAR$_{10g}$ [W/kg] in Extremity Exposure Condition									
Band	**Test Configuration**	**Frequency [MHz]**	**CH**	**Position**	**Gap [mm]**	**Pic.. No.**	**Highest Reported SAR$_{10g}$ [W/kg]**	**SAR$_{10g}$ Limit [W/kg]**	
GPRS 850 4TX	Config. 1	824.2	128	back	0	7	0.009	4.0	PASS
GPRS 1900 4TX	Config. 1	1910	810	back	0	7	0.042		PASS
WCDMA 2	Config. 1	1852	9262	back	0	7	1.951		PASS
WCDMA 5	Config. 2	836.6	4183	back	0	8	0.243		PASS
Notes: To establish a connection a base station simulator has been used.									

Prepared by: .... Reviewed by: ....

Dessislava Patrishkova
Test Engineer

Alexander Rahn
Quality Assurance

2 Exposure Criteria and Limits

In the USA the FCC exposure criteria [KDB 865664] are based on the withdrawn IEEE Standard C95.1-1999 [IEEE C95.1-1999].

General population / uncontrolled environments are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The exposures may occur in living quarters or workplaces.

Occupational / controlled environments are locations where there is exposure that may be incurred by persons who are aware of the potential for exposure as a concomitant of employment or by other cognizant persons. For exposure in controlled environments higher field strengths are admissible.

Human Exposure Limits				
Condition	**Uncontrolled Environment** (General Population)		**Controlled Environment** (Occupational)	
	SAR Limit [W/kg]	**Mass Avg.**	**SAR Limit [W/kg]**	**Mass Avg.**
SAR averaged over the whole body mass	0.08	whole body	0.4	whole body
Peak spatially-averaged SAR for the head, neck and trunk	1.6	1 g of tissue*	8.0	1 g of tissue*
Peak spatially-averaged SAR in the limbs	4.0	10 g of tissue*	20.0	10 g of tissue*
Note: *Defined as a tissue volume in the shape of a cube				

Table 1: SAR limits.

In this report the comparison between the FCC exposure limits and the measured data is made using the spatial peak SAR; the power level of the device under test guarantees that the whole body averaged SAR is not exceeded.

2.1 Distinction between Exposed Population, Duration of Exposure and Frequencies

The American Standard [IEEE C95.1-1999] distinguishes between controlled and uncontrolled environment. Controlled environments are locations where there is exposure that may be incurred by persons who are aware of the potential for exposure as a concomitant of employment or by other cognizant persons. Uncontrolled environments are locations where there is the exposure of individuals who have no knowledge or control of their exposure. The exposures may occur in living quarters or workplaces. For exposure in controlled environments higher field strengths are admissible. In addition the duration of exposure is considered.

Due to the influence of frequency on important parameters, as the penetration depth of the electromagnetic fields into the human body and the absorption capability of different tissues, the limits in general vary with frequency.

2.2 Distinction between Maximum Permissible Exposure and SAR Limits

The biological relevant parameter describing the effects of electromagnetic fields in the frequency range of interest is the specific absorption rate SAR (dimension: power/mass). It is a measure of the power absorbed per unit mass. The SAR may be spatially averaged over the total mass of an exposed body or its parts. The SAR is calculated from the r.m.s. electric field strength E inside the human body, the conductivity σ and the mass density ρ of the biological tissue:

$$SAR = \sigma \frac{E^2}{\rho} = c \frac{\partial T}{\partial t}\bigg|_{t \to 0+} \quad . \tag{1}$$

The specific absorption rate describes the initial rate of temperature rise $\partial T / \partial t$ as a function of the specific heat capacity *c* of the tissue. A limitation of the specific absorption rate prevents an excessive heating of the human body by electromagnetic energy.

As it is sometimes difficult to determine the SAR directly by measurement (e.g. whole body averaged SAR), the standard specifies more readily measurable maximum permissible exposures in terms of external electric *E* and magnetic field strength *H* and power density *S*, derived from the SAR limits. The limits for *E*, *H* and *S* have been fixed so that even under worst case conditions, the limits for the specific absorption rate SAR are not exceeded.

For the relevant frequency range the maximum permissible exposure may be exceeded if the exposure can be shown by appropriate techniques to produce SAR values below the corresponding limits.

3 The FCC Measurement Procedure

3.1 General Requirements

The test shall be performed in a laboratory with an environment which avoids influence on SAR measurements by ambient EM sources and any reflection from the environment itself. The ambient temperature shall be in the range of 20°C to 26°C and 30-70% humidity. All tests have been conducted according the latest version of all relevant KDBs.

3.2 Body-Worn Configurations

Body-worn operating configurations are tested with the belt-clips and holsters attached to the device and positioned against a flat phantom in a normal use configuration. Per FCC KDB 648474, 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 KDB 447498 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 headset connected to the handset, is > 1.2 W/kg, the highest reported SAR configuration for that wireless mode and frequency band should be repeated for that body worn accessory with a headset attached to the handset.

For purpose of determining test requirements, accessories may be divided into two categories: those that do not contain metallic components and those that do. For multiple accessories that do not contain metallic components, the device may be tested only with that accessory which provides the closest spacing to the body.

For multiple accessories that contain metallic components, the device must be tested with each accessory that contains a unique metallic component. If multiple accessories share an identical metallic component, only the accessory that provides the closest spacing to the body must be tested.

Devices that are designed to operate on the body of users using lanyards and straps, or without requiring additional body worn accessories, must be tested for SAR compliance using a conservative minimum test separation distance ≤ 5 mm to support compliance. Nevertheless, all accessories that contain metallic components must be tested for compliance additionally.

Other separation distances may be used, but they shall not exceed 2.5 cm.

3.2.1 Extremity exposure conditions

Devices that are designed or intended for use on extremities or mainly operated in extremity only exposure conditions; i.e. hands, wrist, feet and ankles, may require extremity SAR evaluation according 4.2.3 of KDB 447498 D01.

3.3 Phantom Requirements

For body-worn and other configurations a flat phantom shall be used which is comprised of material with electrical properties similar to the corresponding tissues.

3.4 Additional Information for 3G Devices

When the maximum output power and tune-up tolerance specified for production units in a secondary mode is ≤ ¼ dB higher than the primary mode or when the highest reported SAR of the primary mode is scaled by the ratio of specified maximum output power and tune-up tolerance of secondary to primary mode and the adjusted SAR is ≤ 1.2 W/kg, SAR measurement is not required for the secondary mode.

3.5 Test to be Performed

For devices with retractable antenna the SAR test shall be performed with the antenna fully extended and fully retracted. Other factors that may affect the exposure shall also be tested. For example, optional antennas or optional battery packs which may significantly change the volume, lengths, flip open/closed, etc. of the device, or any other accessories which might have the potential to considerably increase the peak spatial-average SAR value.

The SAR test shall be performed at the high, middle and low frequency channels of each operating mode.

3.6 Measurement Variability

According to KDB 865664 repeated measurements are required only when the measured 1-g SAR is ≥ 0.80 W/kg (respectively ≥ 2.00 W/kg for 10-g SAR). If the measured SAR value of the initial repeated measurement is < 1.45 W/kg for 1-g SAR (respectively < 3.625 W/kg for 10-g SAR) with ≤ 20% variation, only one repeated measurement is required to reaffirm that the results are not expected to have substantial variations, which may introduce significant compliance concerns. A second repeated measurement is required only if the measured result for the initial repeated measurement is within 10% of the SAR limit and vary by more than 20%, which are often related to device and measurement setup difficulties. The following procedures are applied to determine if repeated measurements are required.

1) Repeated measurement is not required when the original highest measured 1–g SAR is < 0.80 W/kg (respectively < 2.00 W/kg for 10-g SAR) steps 2 - 4 do not apply.

2) When the original highest measured 1-g SAR is ≥ 0.80 W/kg (respectively 10-g SAR ≥ 2.00 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 W/kg for 1-g SAR (respectively > 3.00 W/kg for 10-g

SAR) or when the original or repeated measurement is ≥ 1.45 W/kg for 1-g SAR (respectively > 3.625 W/kg for 10-g), or ~ 10% from the SAR limit.

4) Perform a third repeated measurement only if the original, first or second repeated measurement is ≥ 1.5 W/kg for 1-g SAR (respectively > 3.75 W/kg for 10-g) and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.

4 The Measurement System

DASY is an abbreviation of „Dosimetric Assessment System“ and describes a system that is able to determine the SAR distribution inside a phantom of a human being according to different standards. The DASY4 system consists of the following items as shown in Fig: 2. Additionally, Fig: 3 shows the equipment, similar to the installations in other laboratories.

- Fully compliant with all current measurement standards as stated in Fig. 4
- High precision robot with controller
- Measurement server (for surveillance of the robot operation and signal filtering)
- Data acquisition electronics DAE (for signal amplification and filtering)
- Field probes calibrated for use in liquids
- Electro-optical converter EOC (conversion from the optical into a digital signal)
- Light beam (improving of the absolute probe positioning accuracy)
- Two SAM phantoms filled with tissue simulating liquid
- DASY4 software
- SEMCAD

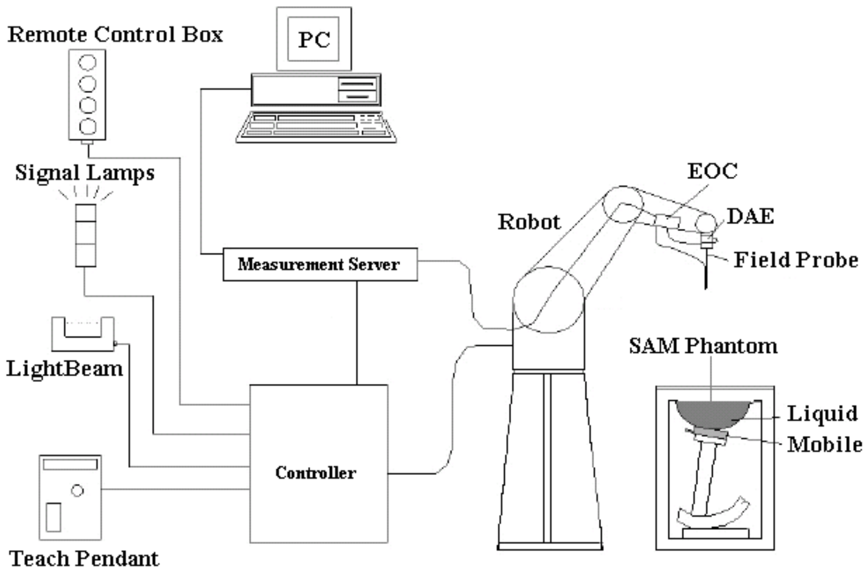

Fig. 2: The DASY4 measurement system.

Fig. 3: The measurement set-up with two SAM phantoms containing tissue simulating liquid.

The transmitter operating at the maximum power level is placed by a non metallic device holder (delivered from Schmid & Partner) in the above described positions at a shell phantom of a human being. The distribution of the electric field strength *E* is measured in the tissue simulating liquid within the shell phantom. For this miniaturised field probes with high sensitivity and low field disturbance are used. Afterwards the corresponding SAR values are calculated with the known electrical conductivity σ and the mass density ρ of the tissue in the SEMCAD FDTD software. The software is able to determine the averaged SAR values (averaging region 1 g or 10 g) for compliance testing.

The measurements are done by two scans: first a coarse scan determines the region of the maximum SAR, afterwards the averaged SAR is measured in a second scan within the shape of a cube.

4.1 Phantoms

TWIN SAM PHANTOM V4.0	
	Specific Anthropomorphic Mannequin defined in IEEE 1528 and IEC 62209-1 and delivered by Schmid & Partner Engineering AG. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. The details and the Certificate of conformity can be found in Fig. 5.
Shell Thickness	2 ± 0.2 mm (6 ± 0.2 mm at ear point)
Dimensions	Length: 1000 mm; Width: 500 mm Height: adjustable feet
Filling Volume	approx. 25 liters

4.2 E-Field-Probes

For the measurements the Dosimetric E-Field Probes ET3DV6R or EX3DV4 with following specifications are used. They are manufactured and calibrated in accordance with FCC and IEEE 1528-2013 recommendations annually by Schmid & Partner Engineering AG.

ET3DV6R	
Construction	Symmetrical design with triangular core Built-in optical fiber for surface detection system (ET3DV6 only) Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Dimensions	Overall length: 337 mm (Tip: 16 mm) Tip diameter: 6.8 mm (Body: 12 mm) Distance from probe tip to dipole centers: 2.7 mm
Frequency	10 MHz to 2.3 GHz Linearity: ± 0.2 dB (30 MHz to 2.3 GHz)
Directivity	Axial isotropy: ± 0.2 dB in TSL (rotation around probe axis) Spherical isotropy: ± 0.4 dB in TSL (rotation normal to probe axis)
Dynamic Range	5 µW/g to > 100 mW/g; Linearity: ± 0.2 dB
Calibration Range	450 MHz / 750 MHz / 900 MHz / 1750 MHz / 1900 MHz / 1950 MHz for head and body simulating liquid

EX3DV4	
Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Dimensions	Overall length: 337 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Typical distance from probe tip to dipole centers: 1 mm
Frequency	10 MHz to > 6 GHz Linearity: ± 0.2 dB (30 MHz to 6 GHz)
Directivity	Axial isotropy: ± 0.3 dB in TSL (rotation around probe axis) Spherical isotropy: ± 0.5 dB in TSL (rotation normal to probe axis)
Dynamic Range	10 µW/g to > 100 mW/g Linearity: ± 0.2 dB (noise: typically < 1 µW/g)
Calibration Range	1950 MHz / 2450 MHz / 2600 MHz / 3500 MHz / 5200 MHz / 5300 MHz / 5600 MHz / 5800 MHz for head and body simulating liquid

4.3 Measurement Procedure

The following steps are used for each test position:

- Establish a call with the maximum output power with a base station simulator. The connection between the mobile phone and the base station simulator is established via air interface.
- Measurement of the local E-field value at a fixed location (P1). This value serves as a reference value for calculating a possible power drift.
- Measurement of the SAR distribution with resolution settings for area scan and zoom scan according KDB 865664 D01 as shown in Table *2*.
- The used extrapolation and interpolation routines are all based on the modified Quadratic Shepard´s method [DASY4].
- Repetition of the E-field measurement at the fixed location (P1) and repetition of the whole procedure if the two results differ by more than ± 0.21dB.

<table>
<tr><th colspan="3"></th><th>≤ 3 GHz</th><th>≥ 3 GHz</th></tr>
<tr><td colspan="3">Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface</td><td>5 ± 1 mm</td><td>½·δ·ln(2) ± 0.5 mm</td></tr>
<tr><td colspan="3">Maximum probe angle from probe axis to phantom surface normal at the measurement location</td><td>30° ± 1°</td><td>20° ± 1°</td></tr>
<tr><td colspan="3" rowspan="2">Maximum area scan spatial resolution: Δx_{Area}, Δy_{Area}</td><td>≤ 2 GHz: ≤ 15 mm
2 - 3 GHz: ≤ 12 mm</td><td>3 - 4 GHz: ≤ 12 mm
4 - 6 GHz: ≤ 10 mm</td></tr>
<tr><td colspan="2">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.</td></tr>
<tr><td colspan="3">Maximum zoom scan spatial resolution: ΔX_{Zoom}, ΔY_{Zoom}</td><td>≤ 2 GHz: ≤ 8 mm
2 - 3 GHz: ≤ 5 mm*</td><td>3 - 4 GHz: ≤ 5 mm*
4 - 6 GHz: ≤ 4 mm*</td></tr>
<tr><td rowspan="3">Maximum zoom scan spatial resolution, normal to phantom surface</td><td colspan="2">Uniform grid: $\Delta Z_{Zoom}(n)$</td><td>≤ 5 mm</td><td>3 - 4 GHz: ≤ 4 mm
4 - 5 GHz: ≤ 3 mm
5 - 6 GHz: ≤ 2 mm</td></tr>
<tr><td rowspan="2">graded grid</td><td>$\Delta Z_{Zoom}(1)$: between 1st two points closest to phantom surface</td><td>≤ 4 mm</td><td>3 - 4 GHz: ≤ 3 mm
4 - 5 GHz: ≤ 2.5 mm
5 - 6 GHz: ≤ 2 mm</td></tr>
<tr><td>$\Delta Z_{Zoom}(n>1)$: between subsequent points</td><td colspan="2">≤ 1.5· $\Delta Z_{Zoom}(n-1)$</td></tr>
<tr><td>Minimum zoom scan volume</td><td colspan="2">x, y, z</td><td>≥ 30 mm</td><td>3 - 4 GHz: ≥ 28 mm
4 - 5 GHz: ≥ 25 mm
5 - 6 GHz: ≥ 22 mm</td></tr>
<tr><td colspan="5">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</td></tr>
</table>

Table 2: Parameters for SAR scan procedures.

5 System Verification and Test Conditions

5.1 Date of Testing

Date of Testing				
Band	**Exposure Condition**	**Frequency [MHz]**	**Date of System Check**	**Date of SAR Measurement**
GPRS 1900	Extremity	1900	December 06, 2016	December 06, 2016
WCDMA 2	Extremity	1900	December 06, 2016	December 07, 2016
WCDMA 5	Extremity	850	December 08, 2016	December 08, 2016
GPRS 850	Extremity	850	December 08, 2016	December 09, 2016

Table 3: Date of testing.

5.2 Tissue Simulating Liquid Recipes

Tissue Simulating Liquid								
Frequency Range [MHz]		**Water [%]**	**Sugar [%]**	**Cellulose [%]**	**Salt [%]**	**Preventol [%]**	**DGBE [%]**	**Triton X/100 [%]**
Head Tissue								
☐	300	37.1	56.1	0.9	5.8	0.2	-	-
☐	450	38.9	56.9	0.3	3.8	0.1	-	-
☐	835	40.3	57.9	0.2	1.4	0.2	-	-
☐	900	40.3	57.9	0.2	1.4	0.2	-	-
☐	1800	55.2	-	-	0.3	-	44.5	-
☐	1900	55.4	-	-	0.1	-	44.5	-
☐	2450	55.0	-	-	-	-	45.0	-
☐	2600	54.8	-	-	0.1	-	45.1	-
☐	5000 - 6000	65.5	-	-	-	-	17.2	17.25
Body Tissue								
☐	450	46.2	51.2	0.2	2.3	0.1	-	-
☒	835	52.4	45.0	1.0	1.5	0.1	-	-
☐	900	50.8	48.2	-	0.9	0.1	-	-
☐	1800	70.2	-	-	0.4	-	29.4	-
☒	1900	69.8	-	-	0.2	-	30.0	-
☐	2450	68.6	-	-	-	-	31.4	-
☐	2600	68.1	-	-	0.1	-	31.8	-
☐	5000 - 6000	78.6	-	-	-	-	10.7	10.7

Table 4: Recipes of the tissue simulating liquid.

5.3 Tissue Dielectric Parameters

For the measurement of the following parameters the Speag DAK-3.5 dielectric probe kit is used, representing the open-ended coaxial probe measurement procedure.

Tissue Simulating Liquids								
Ambient Temperature(C) : 22.0 ± 2			Liquid Temperature(C) : 23			Humidity (%) : 40.0 ± 5		
Band	Frequency [MHz]	Channel	Permittivity			Conductivity		
			Measured ε'	Target ε'	Delta +/- 5 [%]	Measured σ [S/m]	Target σ [S/m]	Delta +/- 5 [%]
GPRS 1900	*1900.0*	*System Check*	*52.1*	*53.3*	*-2.3*	*1.56*	*1.52*	*2.4*
	1850.2	512	52.3	53.3	-1.9	1.50	1.52	-1.0
	1880.0	661	52.1	53.3	-2.2	1.54	1.52	1.0
	1909.8	810	52.0	53.3	-2.4	1.57	1.52	3.1
WCDMA 2	*1900.0*	*System Check*	*52.1*	*53.3*	*-2.3*	*1.56*	*1.52*	*2.4*
	1852.4	9262	52.3	53.3	-1.9	1.50	1.52	-1.0
	1880.0	9400	52.1	53.3	-2.2	1.54	1.52	1.0
	1907.6	9538	52.0	53.3	-2.4	1.57	1.52	3.1
GSM 850	*835.0*	*System Check*	*52.8*	*55.2*	*-4.3*	*0.99*	*0.98*	*0.3*
	824.2	128	53.0	55.2	-4.1	0.97	0.98	-0.3
	836.6	190	52.8	55.2	-4.3	0.99	0.98	0.3
	848.8	251	52.7	55.2	-4.4	1.00	0.99	1.2
WCDMA 5	*835.0*	*System Check*	*52.8*	*55.2*	*-4.3*	*0.99*	*0.98*	*0.3*
	826.4	4132	53.0	55.2	-4.1	0.97	0.98	-0.3
	836.6	4183	52.8	55.2	-4.3	0.99	0.98	0.3
	846.6	4233	52.7	55.2	-4.4	1.00	0.99	0.9
Notes: The dielectric properties of the tissue simulating liquid must be measured within 24 h before the SAR testing. To comply with the required noise level (less than 12 mW/kg) periodically measurements without a DUT were conducted.								

Table 5: Parameters of the tissue simulating liquid.

5.4 Simplified Performance Checking

The simplified performance check was realized using the dipole validation kit. The input power of the dipole antenna was 250 mW (CW signal) and it was placed under the flat part of the SAM phantom. The target and measured results are listed in the table 3 and shown in plots 5 - 6. The target values were adopted from the calibration certificates found in the appendix.

System Check Results									
Frequency [MHz]	Tissue	Dipole	Dipole SN	SAR_{1g} [W/kg]			SAR_{10g} [W/kg]		
				Measured	Target	Delta [%]	Measured	Target	Delta [%]
835	Body	D835V2	470	2.51	2.34	-7.26	1.66	1.53	-8.50
1900	Body	D1900V2	535	9.61	9.93	3.22	5.19	5.3	2.08

Table 6: Dipole target and measured results.

6 SAR Measurement Conditions and Results

6.1 SAR Measurement Conditions

Test Conditions					
Band	**TX Range [MHz]**	**RX Range [MHz]**	**Used Channels**	**Crest Factor**	**Phantom**
GPRS 850	824.2 – 848.8	869.2 – 893.8	128, 190, 251	2	SAM Twin Phantom V4.0
GPRS 1900	1850.2 –1909.8	1930.2 – 1989.8	512, 661, 810	2	
WCDMA 5 (FDD)	826.4 – 846.6	871.4 – 891.6	4132, 4183, 4233	1	
WCDMA 2 (FDD)	1852.4 – 1907.6	1932.4 – 1987.6	9262, 9400, 9538	1	

Table 7: Used channels and crest factors during the test.

6.2 Output Power Values and Tune-Up Information

6.2.1 Output Power Values for GPRS

This device supports GPRS multislot class 12 and it does not support voice mode. According the following tables, GPRS 850/1900 with 4 TX represent the worst case, therefore measurements with 4 active time slots are conducted for GPRS 850/1900.

Max. Burst-Averaged Output Power (RMS) [dBm]										
Band	**Freq. [MHz]**	**CH**	**GPRS (GMSK / CS1)**				**EDGE (8-PSK / MCS5)**			
			1 TX	**2 TX**	**3 TX**	**4 TX**	**1 TX**	**2 TX**	**3 TX**	**4 TX**
850	824.2	128	33.3	33.3	32.5	31.4	27.7	27.6	26.8	25.7
	836.6	190	33.4	33.4	32.6	31.4	28.0	27.8	26.9	25.8
	848.8	251	33.3	33.4	32.5	31.4	27.9	27.6	26.8	25.5
1900	1850.2	512	29.9	29.9	29.1	27.9	25.8	26.2	25.3	23.6
	1880.0	661	29.8	29.8	29.0	27.8	26.0	26.0	25.3	24.1
	1909.8	810	29.7	29.7	28.8	27.6	25.9	25.9	25.0	23.5
Max. Frame-Averaged Output Power (RMS) [dBm]										
Band	**Freq. [MHz]**	**CH**	**GPRS (GMSK / CS1)**				**EDGE (8-PSK / MCS5)**			
			1 TX	**2 TX**	**3 TX**	**4 TX**	**1 TX**	**2 TX**	**3 TX**	**4 TX**
850	824.2	128	24.3	27.3	28.2	28.4	18.7	21.6	22.5	22.7
	836.6	190	24.4	27.4	28.3	28.4	19.0	21.8	22.6	22.8
	848.8	251	24.3	27.4	28.2	28.4	18.9	21.6	22.5	22.5
1900	1850.2	512	20.9	23.9	24.8	24.9	16.8	20.2	21.0	20.6
	1880.0	661	20.8	23.8	24.7	24.8	17.0	20.0	21.0	21.1
	1909.8	810	20.7	23.7	24.5	24.6	16.9	19.9	20.7	20.5

Table 8: Conducted output power and maximum transmit power values for GPRS mode.

6.2.2 Output Power Values for WCDMA

WCDMA was tested in RMC mode without HSPA according to the statement made from the manufacturer that the device does not support HSDPA or HSUPA.

For measurements in WCDMA, without HSDPA or HSUPA, the default test configuration is to establish a radio link between the DUT and a communication test set using a 12.2 kbps RMC configured Test Loop Mode 1 and TPC bits configured to all "1".

Maximum Peak-Averaged Output Power [dBm]			
Band	Freq. [MHz]	CH	WCDMA RMC
850 (FDD 5)	826.4	4132	23.9
	836.6	4183	23.8
	846.6	4233	23.6
1900 (FDD 2)	1852.4	9262	23.0
	1880.0	9400	23.3
	1907.6	9538	23.2

Table 9: Conducted output power and maximum transmit power values for WCDMA mode.

6.3 Tune-Up Information

Tune-up procedure according to KDB 447498 D01v06 is applicable. The measured SAR values are scaled according the tune-up information given by the manufacturer, shown below.

Tune-Up Information for WWAN Antenna [dBm]					
Antenna	Band	GPRS (GMSK / CS1)			
		1 TX	2 TX	3 TX	4 TX
WWAN	**850**	34.0	34.0	33.2	32.0
	1900	31.0	31.0	30.2	29.0
	WCDMA (RMC)				
	FDD5	24.0			
	FDD2	24.0			

Table 10: Output power tune-up information for GSM and WCDMA.

6.4 SAR Test Exclusion Consideration according to KDB 447498

Standalone SAR Test Exclusion Considerations for Extremity Exposure						
Communication System	**Freq. [MHz]**	**Distance [mm]**	**Pavg [dBm]**	**Pavg [mW]**	**Threshold 10g Comparison Values**	**SAR Test Exclusion (Yes/No)**
SRD 900	921	5	7.0	5.0	1.0	Yes

Table 11: SAR test exclusion for extremity exposure.

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

[(max power of channel. incl. tune-up tolerance mW)/(min test separation distance. mm)] [√f(GHz)]*

≤ 7.5 for 10g extremity SAR

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

6.5 SAR Results

The tables below contain the measured SAR values averaged over a mass of 1 g. SAR assessment was conducted in the worst case configuration with output power values according Table 9.

According KDB 447498 D01 V05, the reported SAR is the measured SAR value adjusted for maximum tune-up tolerance.

- Scaling Factor = tune-up limit power (mW) / RF power (mW)
- Reported SAR = measured SAR * scaling factor

Furthermore, testing of other required channels within the operating mode of frequency band is not required when the reported SAR for the mid-band or highest output power channel is ≤ 0.4 W/kg for transmission band ≥ 200 MHz.

Since the device has a curved shape (ankle worn usage) and would not sit flat on the phantom the plastic periphery material was cut out and removed in order to get a flat surface and as such to be tested as shown in Appendix A. There have been three configurations that have been applied as test positions for SAR measurements which are described in the following tables and could be seen in Appendix A.

6.6 SAR Results for GPRS Mode

The Smart Tag Location QUAD transmits a burst of data approximately 12 seconds long every 15 minutes as per the statement made from the manufacturer.

Low Duty Factor RF Exposure Evaluation			
Maximum Transmission Time [sec]	**Duty Cycle Period**		**Duty Factor**
	Min	**Sec**	
12	15	900	1.33 %

Table 12: Duty factor calculation for data transmission.

According to the table above, the worst case data transmission duty cycle would result in a scaling of 12/900 = 1.33% applicable to the measured SAR values as shown in Table 13.

SAR Results for WWAN Antenna (GPRS Bands)												
Band	**Freq. [MHz]**	**CH**	**Test Configuration***	**Spacing [mm]**	**Fig. No.**	**Measured SAR10g [W/kg]**	**EUT Output Power [dBm]**	**Tune Up Limit [dBm]**	**Power Drift [dBm]**	**Scaling Factor**	**Reported SAR10g [W/kg]**	**Plot No.**
Measured SAR Results for GPRS												
GPRS 850 (4TX)	836.6	190	config. 1, back	0	7	0.432	31.4	32	-0.129	1.148	0.496	-
			config. 2, back		8	0.111	31.4		-0.199	1.148	0.127	-
			config. 3, back		9	0.117	31.4		0.139	1.148	0.134	-
	824.2	128	config. 1, back		7	0.607	31.4		0.035	1.148	0.697	-
	848.8	251	config. 1, back		7	0.316	31.4		0.064	1.148	0.363	-
GPRS 1900 (4TX)	1880	661	config. 1, back	0	7	1.660	27.8	29	-0.145	1.318	2.188	-
			config. 2, back		8	1.410	27.8		-0.150	1.318	1.859	-
			config. 3, back		9	0.574	27.8		-0.017	1.318	0.757	-
	1850	512	config. 1, back		7	2.100	27.9		-0.116	1.288	2.705	-
	1910	810	config. 1, back		7	2.290	27.6		-0.105	1.380	3.161	-
Scaled SAR Results for GPRS to 1.33% Duty Factor Transmission												
GPRS 850 (4TX)	836.6	190	config. 1, back	0	7	0.006	31.4	32	-0.129	1.148	0.007	-
			config. 2, back		8	0.001	31.4		-0.199	1.148	0.002	-
			config. 3, back		9	0.002	31.4		0.139	1.148	0.002	-
	824.2	128	config. 1, back		7	0.008	31.4		0.035	1.148	0.009	1
	848.8	251	config. 1, back		7	0.004	31.4		0.064	1.148	0.005	-
GPRS 1900 (4TX)	1880	661	config. 1, back	0	7	0.022	27.8	29	-0.145	1.318	0.029	-
			config. 2, back		8	0.019	27.8		-0.150	1.318	0.025	-
			config. 3, back		9	0.008	27.8		-0.017	1.318	0.010	-
	1850	512	config. 1, back		7	0.028	27.9		-0.116	1.288	0.036	-
	1910	810	config. 1, back		7	0.031	27.6		-0.105	1.380	0.042	2

Notes: Since the measured scaled max 10-g SAR is < 2.0 W/kg measurement variability assessment according to KDB 865664 is not applicable.

configuration 1 - device with housing at back position towards the phantom

configuration 2 - device without housing at back position towards the phantom

configuration 3 - device with housing and on body charger (OBC) at back position towards the phantom

Table 13: SAR results for GPRS bands.

To control the output power stability during the SAR test the used DASY4 system calculates the power drift by measuring the e-field at the same location at the beginning and at the end of the measurement for each test position. These drift values can be found in the above tables labeled as: (Drift [dB]). This ensures that the power drift during one measurement is within 5%.

6.7 SAR Results for WCDMA Mode

SAR Results for WWAN Antenna (WCDMA Bands)												
Band	**Freq. [MHz]**	**CH**	**Test Configuration***	**Spacing [mm]**	**Fig. No.**	**Measured SAR10g [W/kg]**	**EUT Output Power [dBm]**	**Tune Up Limit [dBm]**	**Power Drift [dBm]**	**Scaling Factor**	**Reported SAR10g [W/kg]**	**Plot No.**
FDD 2 (RMC)	1880	9400	config. 1, back	0	7	1.480	23.3	24.0	-0.176	1.175	1.739	-
			config. 2, back	0	8	1.060	23.3		-0.182	1.175	1.245	-
			config. 3, back	0	9	0.320	23.3		0.004	1.175	0.376	-
	1852	9262	config. 1, back	0	7	1.550	23.0		0.081	1.259	1.951	3
	1908	9538	config. 1, back	0	7	1.520	23.2		-0.013	1.202	1.827	-
FDD 5 (RMC)	836.6	4183	config. 1, back	0	7	0.218	23.8	24.0	-0.184	1.047	0.228	-
			config. 2, back	0	8	0.232	23.8		-0.091	1.047	0.243	4
			config. 3, back	0	9	0.032	23.8		-0.036	1.047	0.034	-
	826.4	4132	config. 2, back	0	8	0.201	23.9		-0.105	1.023	0.206	-
	846.8	4233	config. 2, back	0	8	0.118	23.6		-0.093	1.096	0.129	-

Notes: *Since the measured 10-g SAR is < 2.0 W/kg measurement variability assessment according to KDB 865664 is not applicable.*

configuration 1 - device with housing at back position towards the phantom

configuration 2 - device without housing at back position towards the phantom

configuration 3 - device with housing and on body charger (OBC) at back position towards the phantom

Table 14: SAR results for WCDMA bands.

To control the output power stability during the SAR test the used DASY4 system calculates the power drift by measuring the e-field at the same location at the beginning and at the end of the measurement for each test position. These drift values can be found in the above tables labeled as: (Drift [dB]). This ensures that the power drift during one measurement is within 5%.

6.8 Estimated SAR for Standalone SAR Excluded Modes according KDB 447498

Since the WWAN and SRD antennas can´t transmit simultaneously, for SRD standard a SAR estimation based on KDB 447498 for SAR excluded modes is not applicable.

6.9 Multiple Transmitter Information

According KDB 447498, simultaneous transmission consideration for multiple transmitters needs to be addressed, if applicable. According the information given by the manufacturer, GSM and SRD can´t be active at the same time.

7 Administrative Measurement Data

7.1 Calibration of Test Equipment

Test Equipment				
Test Equipment	**Model**	**Serial Number**	**Last Calibration**	**Next Calibration**
DASY4 Systems				
Software Versions DASY4	V4.7	N/A	N/A	N/A
Software Versions SEMCAD	V1.8	N/A	N/A	N/A
Dosimetric E-Field Probe	ET3DV6R	1579	02/2016	02/2017
Data Acquisition Electronics	DAE 3	335	02/2016	02/2017
Phantom	SAM	1176	N/A	N/A
Phantom	SAM	1341	N/A	N/A
Dipoles				
Validation Dipole	D1900V2	535	03/2015	03/2017
Validation Dipole	D835V2	470	03/2015	03/2017
Material Measurement				
Network Analyzer	E5071C	MY46103220	07/2015	07/2017
Dielectric Probe Kit	DAK-3.5	1234	01/2016	01/2018
Power Meters				
Power Meter. Agilent	E4416A	GB41050414	02/2015	02/2017
Power Meter. Agilent	E4417A	GB41050441	02/2015	02/2017
Power Sensors				
Power Sensor. Agilent	E9301H	US40010212	03/2015	03/2017
Power Sensor. Agilent	E9301A	MY41495584	03/2015	03/2017
RF Sources				
Network Analyzer	E5071C	MY46103220	07/2015	07/2017
Rohde & Schwarz	SME300	100142	N/A	N/A
Amplifiers				
Mini Circuits	ZHL-42	D012296	N/A	N/A
Mini Circuits	ZHL-42	D031104#01	N/A	N/A
Mini Circuits	ZVE-8G	D031004	N/A	N/A
Radio Tester				
Rohde & Schwarz	MT8815B	6200576536	04/2016	04/2018

Table 15: Calibration of test equipment.

7.2 Uncertainty Assessment

Uncertainty Budget for SAR Measurements according to IEEE 1528-2013 (300 MHz - 6 GHz)								
Error Sources	**Uncertainty Value [± %]**	**Probability Distribution**	**Divisor**	**ci**	**ci**	**Standard Uncertainty [± %]**		**vi² or veff**
Measurement System				1g	10g	1g	10g	
Probe calibration	6.7	Normal	1	1	1	6.7	6.7	∞
Axial isotropy	0.3	Rectangular	√3	√0.5	√0.5	0.1	0.1	∞
Hemispherical isotropy	1.3	Rectangular	√3	√0.5	√0.5	0.5	0.5	∞
Boundary effects	1.0	Rectangular	√3	1	1	0.6	0.6	∞
Linearity	0.3	Rectangular	√3	1	1	0.2	0.2	∞
System detection limit	1.0	Rectangular	√3	1	1	0.6	0.6	∞
Modulation response	4.0	Rectangular	√3	1	1	2.3	2.3	∞
Readout electronics	0.3	Normal	1	1	1	0.3	0.3	∞
Response time	0.8	Rectangular	√3	1	1	0.5	0.5	∞
Integration time	1.4	Rectangular	√3	1	1	0.8	0.8	∞
RF ambient conditions - noise	3.0	Rectangular	√3	1	1	1.7	1.7	∞
RF ambient conditions - refl.	3.0	Rectangular	√3	1	1	1.7	1.7	∞
Probe positioner mech. tol.	0.4	Rectangular	√3	1	1	0.2	0.2	∞
Probe positioning	2.9	Rectangular	√3	1	1	1.7	1.7	∞
Algorithms for max SAR eval.	4.0	Rectangular	√3	1	1	2.3	2.3	∞
Test Sample Related								
Test sample positioning	2.9	Normal	1	1	1	2.9	2.9	145
Device holder uncertainty	3.6	Normal	1	1	1	3.6	3.6	5
SAR drift measurement (< 0.2 dB)	4.7	Rectangular	√3	1	1	2.7	2.7	∞
SAR scaling	2.0	Rectangular	√3	1	1	1.2	1.2	∞
Phantom and Set-up								
Phantom uncertainty	4.0	Rectangular	√3	1	1	2.3	2.3	∞
SAR correction for perm./cond.	1.9	Normal	1	1	0.84	1.9	1.6	∞
Liquid conductivity (meas.)	1.5	Normal	1	0.78	0.71	1.2	1.1	∞
Liquid permittivity (meas.)	1.2	Normal	1	0.23	0.26	0.3	0.3	∞
Liquid conductivity temp. unc.	2.9	Rectangular	√3	0.78	0.71	1.3	1.2	∞
Liquid permittivity temp. unc.	1.8	Rectangular	√3	0.23	0.26	0.2	0.3	∞
Combined Standard Uncertainty						10.4	10.3	
Coverage Factor for 95%						kp=2		
Expanded Standard Uncertainty						**20.8**	**20.7**	

Table 16: Uncertainty Budget for SAR Measurements.

Uncertainty Budget for SAR System Validation according to IEEE 1528-2013 (300 MHz - 6 GHz)								
Error Sources	**Uncertainty Value [± %]**	**Probability Distribution**	**Divisor**	**ci**	**ci**	**Standard Uncertainty [± %]**		**vi² or veff**
Measurement System				1g	10g	1g	10g	
Probe calibration	6.7	Normal	1	1	1	6.7	6.7	∞
Axial isotropy	0.3	Rectangular	√3	1	1	0.1	0.1	∞
Hemispherical isotropy	1.3	Rectangular	√3	0	0	0.0	0.0	∞
Boundary effects	1.0	Rectangular	√3	1	1	0.6	0.6	∞
Linearity	0.3	Rectangular	√3	1	1	0.2	0.2	∞
System detection limit	1.0	Rectangular	√3	1	1	0.6	0.6	∞
Modulation response	0.0	Rectangular	√3	0	0	0.0	0.0	∞
Readout electronics	0.3	Normal	1	1	1	0.3	0.3	∞
Response time	0.0	Rectangular	√3	0	0	0.0	0.0	∞
Integration time	0.0	Rectangular	√3	0	0	0.0	0.0	∞
RF ambient conditions - noise	1.0	Rectangular	√3	1	1	0.6	0.6	∞
RF ambient conditions - refl.	1.0	Rectangular	√3	1	1	0.6	0.6	∞
Probe positioner mech. tol.	0.4	Rectangular	√3	1	1	0.2	0.2	∞
Probe positioning	2.9	Rectangular	√3	1	1	1.7	1.7	∞
Algorithms for max SAR eval.	4.0	Rectangular	√3	1	1	2.3	2.3	∞
Validation Dipole								
Dev. of exp. dipole from num.	5.0	Normal	1	1	1	5.0	5.0	∞
Input power and SAR drift (< 0.2 dB)	4.7	Rectangular	√3	1	1	2.7	2.7	∞
Dipole axis to liquid distance (< 2deg)	2.0	Rectangular	√3	1	1	1.2	1.2	∞
Phantom and Set-up								
Phantom uncertainty	4.0	Rectangular	√3	1	1	2.3	2.3	∞
SAR correction for perm./cond.	1.9	Normal	1	1	0.84	1.9	1.6	∞
Liquid conductivity (meas.)	1.5	Normal	1	0.78	0.71	1.2	1.1	∞
Liquid permittivity (meas.)	1.2	Normal	1	0.23	0.26	0.3	0.3	∞
Liquid conductivity temp. unc.	2.9	Rectangular	√3	0.78	0.71	1.3	1.2	∞
Liquid permittivity temp. unc.	1.8	Rectangular	√3	0.23	0.26	0.2	0.3	∞
Combined Standard Uncertainty						10.0	10.0	
Coverage Factor for 95%						kp=2		
Expanded Standard Uncertainty						**20.0**	**19.9**	

Table 17: Uncertainty Budget for System Validation.

8 Report History

Revision History				
Revision	**Description of Revision**	**Date**	**Revised Page**	**Revised By**
/	Initial Release	December 12, 2016	-	-

END OF THE SAR REPORT

Please refer to separated appendix file for the following data:

Appendix A - Pictures

Appendix B - SAR Distribution Plots

Appendix C – System Verification Plots

Appendix D – Certificates of Conformity

Appendix E – Calibration Certificates for DAEs

Appendix F – Calibration Certificates for E-Field Probes

Appendix G – Calibration Certificates for Dipoles