SAR TEST REPORT

FCC 47 CFR Part 2.1093
Industry Canada RSS-102

RF-Exposure evaluation of portable equipment

Report Reference No. .... :	G0M-1503-4620-TFC093SR-V01
Testing Laboratory .... :	Eurofins Product Service GmbH
Address .... :	Storkower Str. 38c 15526 Reichenwalde Germany
Accreditation .... :	A2LA Accredited Testing Laboratory, Certificate No.: 1983.01 FCC Filed Test Laboratory, Reg.-No.: 96970 IC OATS Filing assigned code: 3470A
Applicant's name .... :	BARTEC PIXAVI AS
Address .... :	Domkirkeplassen 2 4006 Stavanger NORWAY
Test specification:	
Standard.. :	FCC 47 CFR Part 2 §2.1093 FCC OET Bulletin 65 Supplement C 01-01 IEEE Std. 1528 - 2003 IEEE Std. 1528 - 2013 IC RSS-102 Issue 5 Safety Code 6 (2015)
Non-standard test method…………..:	None
Test scope………….. .... :	complete Radio compliance test
Equipment under test (EUT):	
Product description	Wireless camera (Standard version)
Model No.	OrbitX ST
Additional Model(s)	OrbitX EX
Brand Name(s)	None
Hardware version	Rev 2
Firmware / Software version	478
Contains	FCC-ID: YML-ORBITX IC: 9249A-ORBITX
Test result	**Passed**

eurofins | Product Service

Possible test case verdicts:	
- neither assessed nor tested:	N/N
- required by standard but not appl. to test object:	N/A
- required by standard but not tested:	N/T
- not required by standard for the test object:	N/R
- test object does meet the requirement:	P (Pass)
- test object does not meet the requirement:	F (Fail)

Testing:

Date of receipt of test item:	2015-04-21	
Date (s) of performance of tests:	2015-04-20 - 2015-05-26	
Compiled by:	Matthias Handrik	
Tested by (+ signature): (Responsible for Test)	Burkhard Pudell	B. Pudell
Approved by (+ signature):	Christian Weber	C. Weber
Date of issue:	2015-08-04	
Total number of pages:	109	

General remarks:

The test results presented in this report relate only to the object tested.

The results contained in this report reflect the results for this particular model and serial number. It is the responsibility of the manufacturer to ensure that all production models meet the intent of the requirements detailed within this report.

Additional comments:

According to FCC –Inquiry how measure SAR for a helmet camera:

Response to Inquiry to FCC (Tracking Number 796709) (TCB) - Bartec Helmet Camera measure on flat phantom with head simulating liquid.

BARTEC PIXAVI

BARTEC PIXAVI Stavanger, Norway April-23-15

Title	**BARTEC PIXAVI OrbitX Model Differences Declaration**
Document ID	PX-ORBITX-Models-DoC
Revision	1
Project	OrbitX
Author	David Wightman
Created	23.04.2015
Last	23.04.2015
Nature of document	~~CONFIDENTIAL~~
Contents	**Contents:** Bartec Pixavi ORBITX RoHS Declaration of Conformity

Revision History

Revision	Date	Change	Revised by
1	23.04.2015		

1

BARTEC PIXAVI

BARTEC PIXAVI

BARTEC PIXAVI Stavanger, Norway April-23-15

BARTEC PIXAVI OrbitX Model Differences Statement

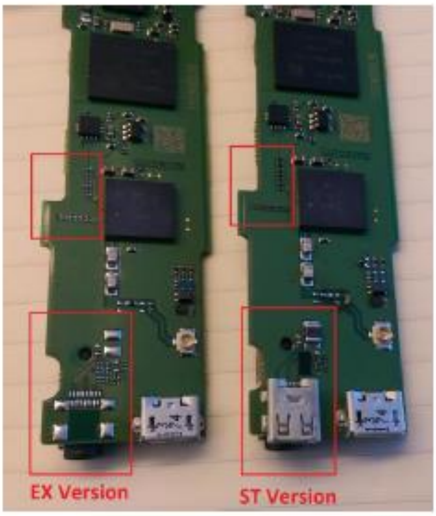
To whom it may concern,

The OrbitX comes in two models, an OrbitX-EX model and an OrbitX-ST model. Both models are identical except for the following differences highlighted below. There are no differences to the radio section between models.

HDMI

The **ST model** includes circuitry to support a Micro-HDMI connection and mechanics to give access to the HDMI port.

The **EX model** uses the same PCB, but does not have the HDMI components populated.



2

BARTEC PIXAVI

SILICON POTTING

The EX model is made for Hazardous areas and therefore is filled with a silicon potting in the following area. The antenna is not enclosed in Silicon.

The ST model is not filled with silicon potting.

Version History

Version	Issue Date	Remarks	Revised by
01	2015-08-04	Initial Release	

REPORT INDEX

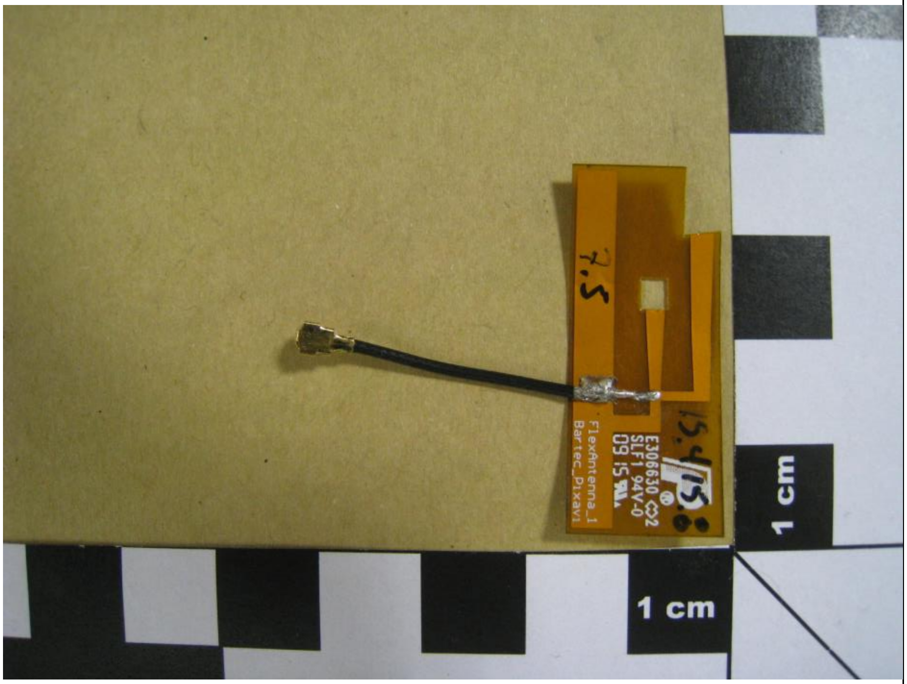
1 Equipment (Test item) Description

Description	Wireless camera (Standard version)	
Model	OrbitX ST	
Additional Model(s)	OrbitX EX	
Brand Name(s)	None	
Serial number	None	
Hardware version	Rev 2	
Software / Firmware version	478	
Contains FCC-ID	YML-ORBITX	
Contains IC	9249A-ORBITX	
Equipment type	End product	
Prototype or production unit	Identical Prototype	
Device category	Handset	
Environment	General public	
Radio technologies	Bluetooth WLAN IEEE 802.11a,b,g,n	
Operating frequency ranges	Bluetooth : 2402 – 2480 MHz IEEE 802.11 b,g,n : 2.4 GHz : 2412 – 2462 MHz (20 MHz) IEEE 802.11 g,n : 2422 – 2452 MHz (40 MHz) IEEE 802.11 a,n : 5180 – 5240 MHz (20 MHz) IEEE 802.11 b,g,n : 5190 – 5230 MHz (40 MHz)	
Modulations	GFSK / PI/4-DQPSK / 8-DPSK / BPSK / QPSK / 16-QAM / 64-QAM	
Antenna	Type	integrated
	Model	unspecified
	Manufacturer	Custom
	Gain	0dBi
Power supply	V_{NOM}	3.7 VDC (Lithium Battery)
AC/DC-Adaptor	Model	N/A
	Vendor	N/A
	Input	N/A
	Output	N/A
Accessories	None	
Manufacturer	Bartec Pixavi AS Domkirkeplassen 2 4006 Stavanger Norway	

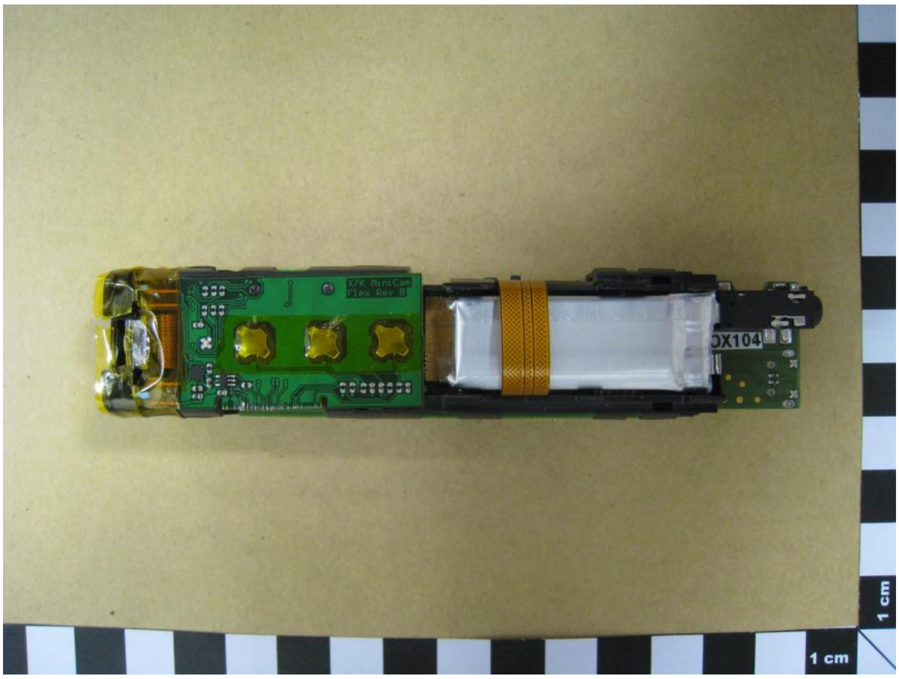
1.1 Equipment photos

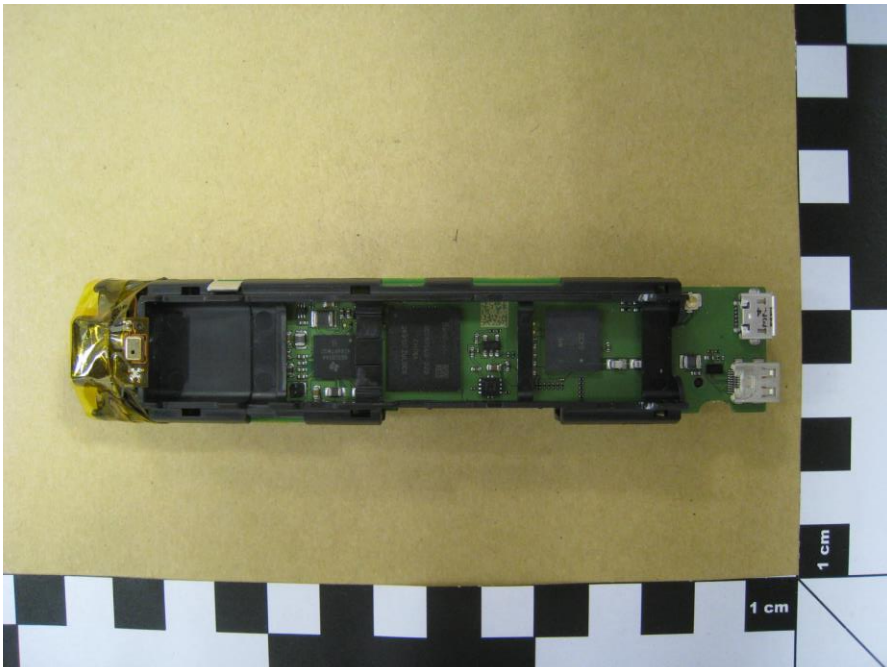
EUT TOP

EUT BOTTOM

EUT antenna


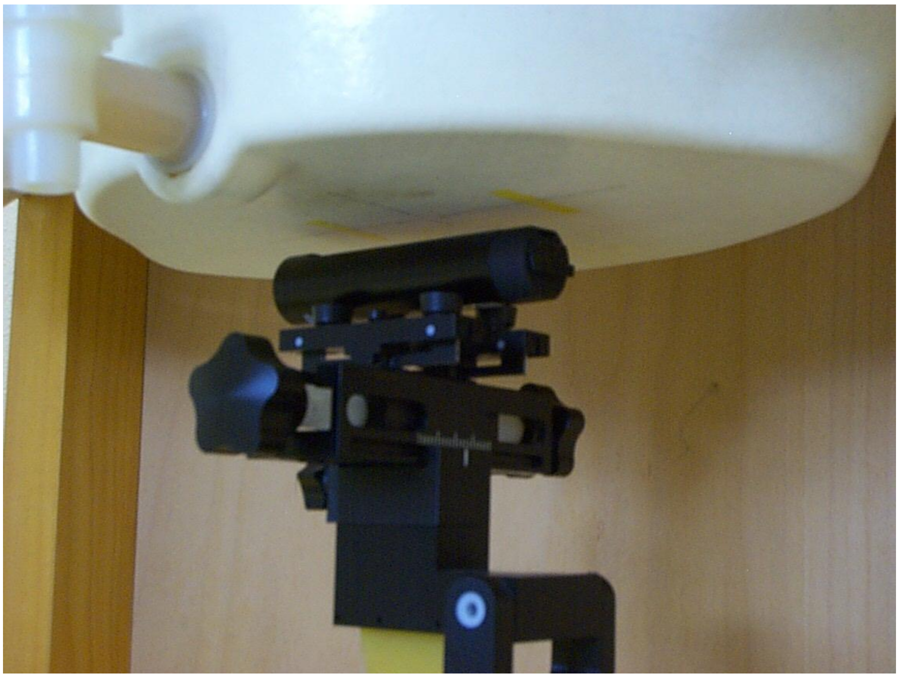
EUT antenna housing


EUT PCB TOP


EUT PCB BOTTOM


1.2 Equipment setup photos

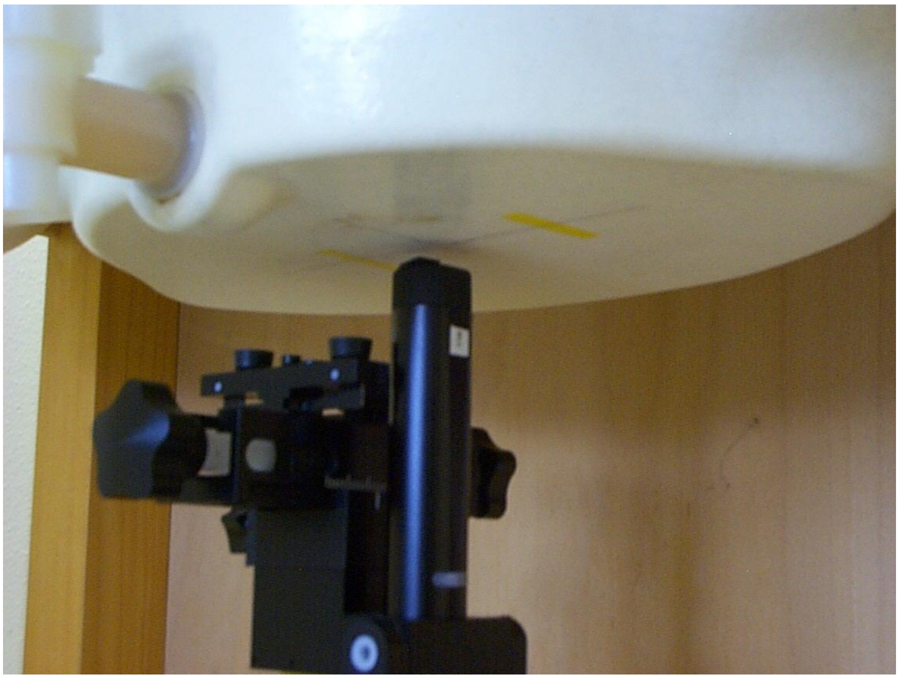
EUT TOP 10mm

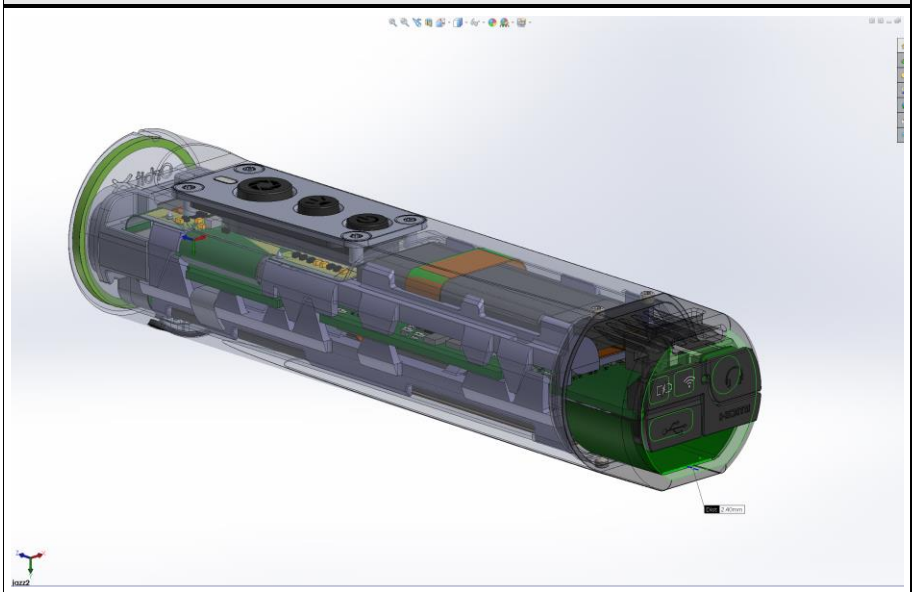


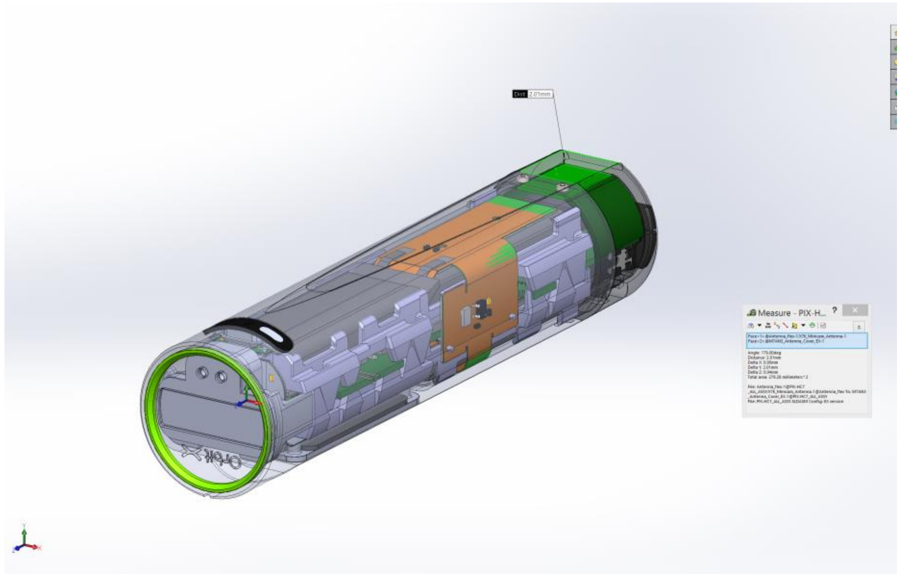
EUT LEFT 10mm

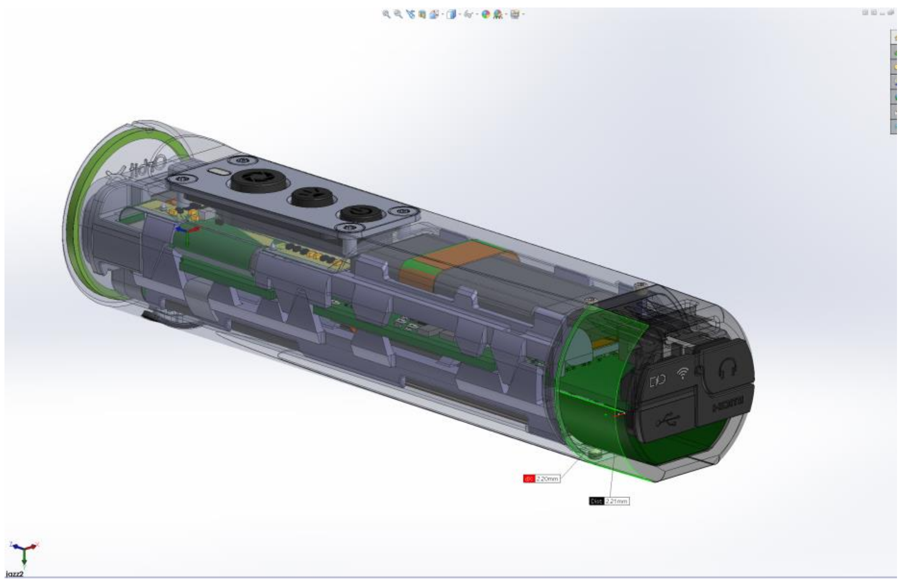
EUT RIGHT 10mm

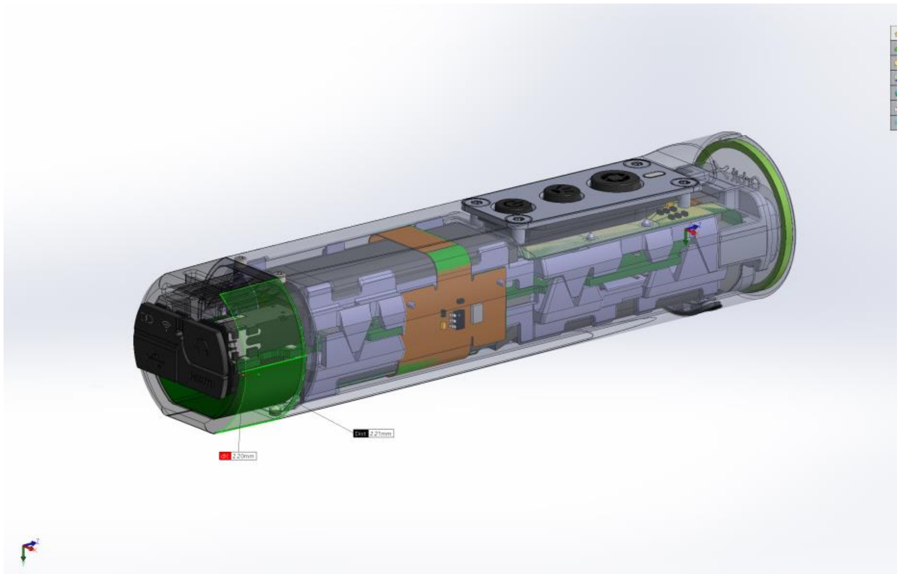
EUT BOTTOM 10mm

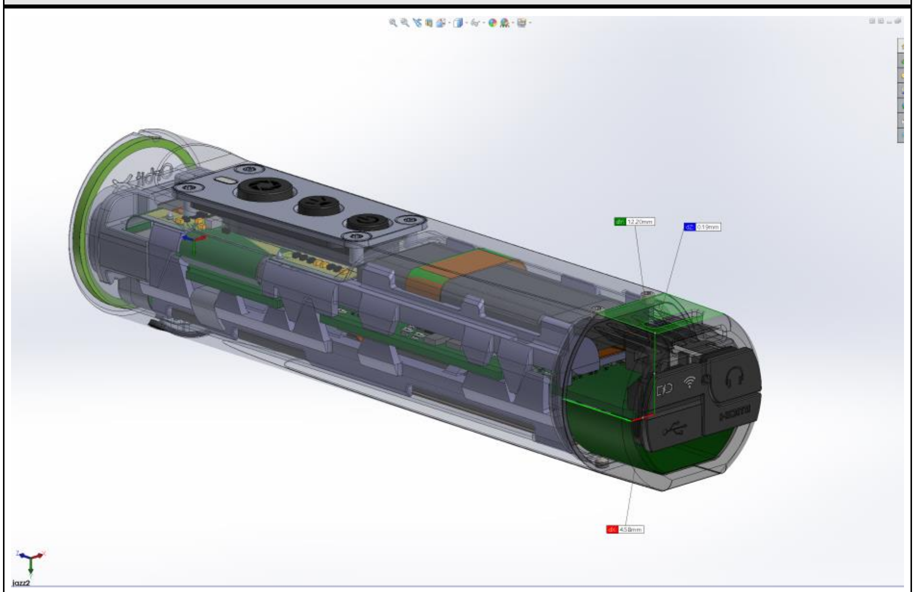
EUT BACK 10mm


Antenna back


Antenna bottom


Antenna left


Antenna right


Antenna top


Top : 12.2mm
Bottom: 2.0mm
Back : 2.4mm
Right : 2.2mm
Left : 2.2mm

1.3 Reference Documents

Document
KDB Publication 447498 : Mobile and Portable Device RF Exposure Procedures and Equipment Authorization Polices
KDB Publication 648474 : SAR Evaluation Considerations for Handsets with Multiple Transmitters and Antennas
KDB Publication 648474 : Review and Approval Policies for SAR Evaluation of Handsets with Multiple Transmitters and Antennas
KDB Publication 865664 : SAR measurement procedures for devices operating between 100 MHz to 6 GHz
KDB Publication 941225: SAR Measurement Procedures for 3G Devices
KDB Publication 941225: 3GPP R6 HSPA and R7 HSPA+ SAR Guidance
KDB Publication 941225: Recommended SAR Test Reduction Procedures for GSM/GPRS/EDGE
KDB Publication 941225: SAR Test Consideration for LTE Handsets and Data Modems
KDB Publication 447498 : SAR Measurement Procedures for USB Dongle Transmitters
KDB Publication 248227 : SAR Measurement Procedures for 802.11 a/b/g Transmitters
KDB Publication 450824 : SAR Probe Calibration and System Verification considerations for measurements from 150 MHz to 3 GHz

1.4 Supporting Equipment Used During Testing

Product Type*	Device	Manufacturer	Model No.	Comments
SIM	Bluetooth tester	Rohde & Schwarz	CBT	
AE	Laptop	DELL	Latitude E6420	

AE : Auxiliary/Associated Equipment

SIM : Simulator (Not Subjected to Test)

1.5 Supported standalone operating modes

Mode	Modulation	Frequency range	Duty cycle
Bluetooth	GFSK, PI/4-DQPSK, 8-DPSK	2402 – 2480 MHz	78%
802.11b/g/n 20MHz	OFDM	2412 – 2462 MHz	100%
802.11/g/n 40MHz	OFDM	2422 – 2452 MHz	100%
802.11a/n 20 MHz	OFDM	5180 – 5240 MHz	100%
802.11a/n 40 MHz	OFDM	5190 – 5230 MHz	100%

1.6 Conducted Power Values

According to KDB 447498 D01 v05r02 the conducted power values of all operating modes have been measured in order to determine the worst case source-based averaged power values.

The conducted power values for the various operating modes of the WiFi transmitter were measured according to KDB 248227 D01 v01r02

Bluetooth

Bluetooth							
Channel	Frequency [MHz]	Peak (Burst) RMS Power [dBm]			Source-based time averaged Power [dBm]		
		BR (GFSK)	EDR (PI/4-DQPSK)	EDR (8-DPSK)	BR (GFSK)	EDR (PI/4-DQPSK)	EDR (8-DPSK)
		DH5	2-DH5	3-DH5	DH5	2-DH5	3-DH5
0	2402	9.60	3.50	3.50	**8.49**	2.39	2.39
39	2441	9.40	3.10	3.10	8.29	1.99	1.99
78	2480	9.50	2.90	3.00	8.39	1.79	1.89

IEEE 802.11 b

IEEE 802.11b						
Mode	Channel	Frequency	Source-based time average power [dBm]			
			Data Rate [Mbps]			
			1	2	5.5	11
IEEE 802.11b	1	2412	11.81	12.35	12.54	12.48
	6	2437	**12.30**	12.31	12.37	12.43
	11	2462	12.25	12.25	12.34	12.43

IEEE 802.11 g

IEEE 802.11g										
Mode	Channel	Frequency	Source-based time average power [dBm]							
			Data Rate [Mbps]							
			6	9	12	18	24	36	48	54
IEEE 802.11g	1	2412	9.85	9.76	9.87	9.58	9.62	9.54	9.70	9.08
	6	2437	11.82	11.92	11.95	11.87	11.64	10.62	9.94	9.05
	11	2462	9.67	9.69	9.70	9.68	9.81	9.70	9.60	9.04

IEEE 802.11 gn (20MHz)

IEEE 802.11n / 20 MHz / Long Guard Interval / 1 Stream												
Mode	Channel	Frequency	Bandwidth [MHz]	Guard Interval [ns]	Source-based time average power [dBm]							
					Data Rate [Mbps]							
					MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
					6.5	13	19.5	26	39	52	58.5	65
IEEE 802.11n	1	2412	20	400/800	9.62	9.94	9.94	9.97	9.90	9.75	9.20	8.09
	6	2437	20	400/800	11.71	11.78	11.80	**11.85**	11.02	10.05	9.38	8.30
	11	2462	20	400/800	9.72	9.88	9.89	9.93	9.97	9.73	9.08	8.03

IEEE 802.11 gn (40MHz)

IEEE 802.11n / 40 MHz / Long Guard Interval / 1 Stream												
Mode	Channel	Frequency	Bandwidth [MHz]	Guard Interval [ns]	Source-based time average power [dBm]							
					Data Rate [Mbps]							
					MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
					13.5	27	40.5	54	81	108	121.5	135
IEEE 802.11n	3	2422	40	400/800	7.58	7.75	7.62	7.59	7.47	7.62	7.73	7.34
	7	2442	40	400/800	10.15	10.11	10.25	9.95	10.05	8.54	8.57	7.25
	9	2452	40	400/800	7.70	7.80	7.58	7.49	7.58	7.57	7.59	7.22

IEEE 802.11 a

IEEE 802.11a											
Mode	Band	Channel	Frequency	Source-based time average power [dBm]							
				Data Rate [Mbps]							
				6	9	12	18	24	36	48	54
IEEE 802.11a	U-NII-1	36	5180	9.19	9.54	9.39	9.38	9.18	9.31	9.24	9.17
		40	5200	9.61	9.65	9.55	9.45	9.40	9.67	9.49	9.40
		44	5220	9.71	9.84	9.87	9.70	9.65	9.92	9.70	9.63
		48	5240	10.00	10.06	10.02	9.93	9.90	10.15	9.91	9.82

IEEE 802.11 an (20MHz)

IEEE 802.11n / 20 MHz / Long Guard Interval / 1 Stream													
Mode	Band	Channel	Frequency	Bandwidth [MHz]	Guard Interval [ns]	Source-based time average power [dBm]							
						Data Rate [Mbps]							
						MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
						6.5	13	19.5	26	39	52	58.5	65
IEEE 802.11n	U-NII-1	36	5180	20	400/800	9.39	9.59	9.64	9.69	9.34	9.43	9.37	7.53
		40	5200			9.65	9.81	9.74	9.63	9.56	9.74	9.67	7.80
		44	5220			10.01	10.06	10.01	10.04	9.72	9.89	9.84	8.00
		48	5240			10.21	10.25	10.30	10.29	9.99	10.11	10.04	8.24

IEEE 802.11 an (40MHz)

IEEE 802.11n / 40 MHz / Long Guard Interval / 1 Stream													
Mode	Band	Channel	Frequency	Bandwidth [MHz]	Guard Interval [ns]	Source-based time average power [dBm]							
						Data Rate [Mbps]							
						MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
						13.5	27	40.5	54	81	108	121.5	135
IEEE 802.11n	U-NII-1	38	5190	40	400/800	9.37	9.61	9.40	9.28	9.34	9.37	9.48	6.55
		46	5230			9.04	10.18	10.11	10.02	9.90	9.99	10.08	7.21

According to KDB 248227 v01r02 SAR measurements are performed for 802.11b and the data rate of 1 Mbps.

According to KDB 248227 v01r02 SAR measurements are performed for 802.11gn and the data rate of MCS3.

According to KDB 248227 v01r02 SAR measurements are performed for 802.11a and the data rate of 6 Mbps.

According to KDB 248227 v01r02 SAR measurements are performed for 802.11an and the data rate of MCS2.

1.7 Standalone Operational Mode Test Exclusion

According to KDB 447498 D01 v05r02 for standalone SAR evaluation the test exclusion power condition is given by

$$\frac{\mathrm{ax}\, Power, mW}{test\ distance, mm} \cdot \sqrt{f_{GHz}} \leq 3.0$$

for test separation distance ≤ 50mm.For test separation distances > 50mm, the SAR test exclusion threshold is:

$$P_{TH}[mW] = Power\ allowed\ at\ numeric\ threshold\ for\ 50mm + (test\ distance, mm - 50mm) \cdot \frac{f[MHz]}{150} \ ,$$
$$100\ MHz < \ f < 1500\ MHz$$

$$P_{TH}[mW] = Power\ allowed\ at\ numeric\ threshold\ for\ 50mm + (test\ distance, mm - 50mm) \cdot 10 \ ,$$
$$1500\ MHz < \ f < 6\ GHz$$

Mode	Pmax [mW]	Antenna	Top		Left		Right		Bottom		Back		Front	
			Antenna distance to user[mm]	SAR Test Exclusion Threshold [mW]	Antenna distance to user[mm]	SAR Test Exclusion Threshold [mW]	Antenna distance to user[mm]	SAR Test Exclusion Threshold [mW]	Antenna distance to user[mm]	SAR Test Exclusion Threshold [mW]	Antenna distance to user[mm]	SAR Test Exclusion Threshold [mW]	Antenna distance to user[mm]	SAR Test Exclusion Threshold [mW]
Bluetooth; 2402 MHz,GFSK	8.65	MAIN	12.21	*19 / 7	12.21	*19 / 7	12.21	*19 / 7	12	*19 / 7	12.4	*19 / 7		
IEEE 802.11b; 2437 MHz, 1Mbps	18.57	MAIN	12.21	*19 / 7	12.21	*19 / 7	12.21	*19 / 7	12	*19 / 7	12.4	*19 / 7		
IEEE 802.11n; 2437 MHz, 20MHz; MCS3	16.9	MAIN	12.21	*19 / 7	12.21	*19 / 7	12.21	*19 / 7	12	*19 / 7	12.4	*19 / 7		
IEEE 802.11a; 5240 MHz, 6Mbps	11.58	MAIN	12.21	*13 / 6	12.21	*13 / 6	12.21	*13 / 6	12	*13 / 6	12.4	*13 / 6		
IEEE 802.11n; 5240 MHz, 20MHz; MCS2	12.3	MAIN	12.21	*13 / 6	12.21	*13 / 6	12.21	*13 / 6	12	*13 / 6	12.4	*13 / 6		

For all operating modes for which the maximum source-based average output power is larger than the corresponding SAR test exclusion threshold power level SAR measurement was performed.

For FCC no SAR measurements were performed. For IC SAR measurement were performed, the measurement results are also used for the multiband conformity

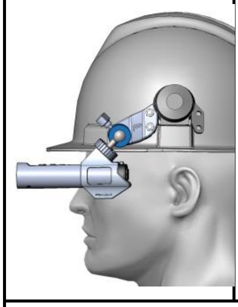
*x / y – SAR Test Exclusion Threshold for FCC / y – Exemption limits for IC

1.8 Supported concurrent (multi-transmitter) operating modes

The ability of all other transmitters to transmit simultaneously is given in the following table:

	Bluetooth	WLAN b/g/n	WLAN a/n
Bluetooth	N/A	N/A	Yes
WLAN b/g/n	N/A	N/A	N/A
WLAN a/n	Yes	N/A	N/A

1.9 Supported use cases

Use case		Distance to human body	corresponding test configuration
		10mm TOP (worst case) 10mm BOTTOM (worst case) 10mm LEFT (worst case) 10mm RIGHT (worst case) 10mm BACK (worst case) 10mm (worst case)	close proximity to the human ear
EUT placed at human head			

1.10 Radio Test Modes

Mode	Settings
Bluetooth	Mode = DH5 Modulation = GFSK Duty cycle = 78% Power level = maximum Antenna = integrated
IEEE 802.11b	Mode = 802.11b Modulation = DSSS Duty cycle = 100% Data rate = 1 Mbps Power level = “15” Antenna = integrated
IEEE 802.11gn	Mode = 802.11g/n 20MHz Modulation = OFDM Duty cycle = 100% Data rate = MCS 3 Power level = “15” Antenna = integrated
IEEE 802.11a	Mode = 802.11a Modulation = OFDM Duty cycle = 100% Data rate = 6 Mbps Power level = “15” Antenna = integrated
IEEE 802.11an	Mode = 802.11b/n 20MHz Modulation = OFDM Duty cycle = 100% Data rate = MCS 2 Power level = “15” Antenna = integrated

1.11 Test Positions

Position	Description
TOP-10MM	EUT top side 10mm distance to the phantom.
BOTTOM-10MM	EUT bottom side 10mm distance to the phantom.
LEFT-10MM	EUT left side 10mm distance to the phantom.
RIGHT-10MM	EUT right side 10mm distance to the phantom.
BACK-10MM	EUT back 10mm distance to the phantom.

1.12 Test Equipment Used During Testing

SAR Measurement					
Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
Stäubli Robot	Stäubli	RX90B L	EF00271	functional test	functional test
Stäubli Robot Controller	Stäubli	CS7MB	EF00272	functional test	functional test
DASY 5 Measurement Server	Schmid & Partner		EF00273	functional test	functional test
Control Pendant	Stäubli		EF00274	functional test	functional test
Dell Computer	Schmid & Partner	Intel	EF00275	functional test	functional test
Data Acquisition Electronics	Schmid & Partner	DAE3V1	EF00276	2014-09	2015-09
Dosimetric E-Field Probe	Schmid & Partner	ET3DV6	EF00279	2014-09	2015-09
Dosimetric E-Field Probe	Schmid & Partner	EX3DV4	EF00826	2014-09	2015-09
System Validation Kit	Schmid & Partner	D300V3	EF00299	2012-09	2015-09
System Validation Kit	Schmid & Partner	D450V3	EF00300	2012-09	2015-09
System Validation Kit	Schmid & Partner	D900V2	EF00281	2012-09	2015-09
System Validation Kit	Schmid & Partner	D1800V2	EF00282	2012-09	2015-09
System Validation Kit	Schmid & Partner	D1900V2	EF00283	2012-09	2015-09
System Validation Kit	Schmid & Partner	D2450V2	EF00284	2012-09	2015-09
System Validation Kit	Schmid & Partner	D5GHZV2	EF00827	2012-11	2015-11
Flat phantom	Schmid & Partner	V 4.4	EF00328	no calibration required	no calibration required
Oval flat phantom	Schmid & Partner	ELI 4	EF00289	functional test	functional test
Mounting Device	Schmid & Partner	V 3.1	EF00287	functional test	functional test
Millivoltmeter	Rohde & Schwarz	URV 5	EF00126	2013-08	2016-08
Power sensor	Rohde & Schwarz	NRV-Z2	EF00003	2014-09	2016-09
RF signal generator	Rohde & Schwarz	SMP 02	EF00165	2013-05	2015-05
Insertion unit	Rohde & Schwarz	URV5-Z4	EF00322	2014-09	2015-09
Directional Coupler	HP	HP 87300B	EF00288	functional test	functional test
Radio Communication Tester	Rohde & Schwarz	CMD65	EF00625	ICO (initial calibration only)	ICO (initial calibration only)
Universal Radio Communication Tester	Rohde & Schwarz	CMU 200	EF00304	2014-05	2015-05
Network Analyzer 300 kHz to 3 GHz	Agilent	8752C	EF00140	2014-06	2015-06
Dielectric Probe Kit	Agilent	85070C	EF00291	functional test	functional test
Dielectric Probe Kit	SPEAG	DAK-3.5	EF00945	2014-09	2015-09
DAK Measurement Software	SPEAG	DAKS	EF00965	-	-
Thermometer	LKM electronic GmbH	DTM3000	EF00967	2014-09	2015-09

2 Result Summary

OET Bulletin 65 Supplement C, RSS-102					
Product Specific Standard Section	**Requirement – Test**	**Reference Method**	**Maximum SAR [W/kg]**	**Result**	**Remarks**
OET Bulletin 65 Suppl. C Section 2 RSS-102 Section 3	Single-band conformity	KDB Publication 447498 KDB Publication 248227 KDB Publication 865664	0.147	PASS	
OET Bulletin 65 Suppl. C Section 2 RSS-102 Section 3	Multi-band conformity	KDB Publication 447498 KDB Publication 648474 KDB Publication 865664	0.228	PASS	
Remarks:					

3 Definitions

The specific absorption rate (SAR) is defined as the time derivative of the incremental energy (*dW*) absorbed by (dissipated in) an incremental mass (*dm*) contained in a volume element *(dV*) of a given density (ρ_t), expressed in watts per kilogram (W/kg)

$$SAR = d/dt\ (dW/dm) = d/dt\ (dW/\rho_t dV) = \sigma/\rho_t\ |E_t|^2$$

where

$$dW/dt = \int_V E\ J\ dV = \int_V \sigma E^2\ dV$$

3.1 Controlled Exposure

The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity. Warning labels placed on low-power consumer devices such as cellular telephones are not considered sufficient to allow the device to be considered under the occupational/controlled category and the general population/uncontrolled exposure limits apply to these devices.

3.2 Uncontrolled Exposure

In general, occupational/controlled exposure limits are applicable to situations in which persons are exposed as a consequence of their employment, who have been made fully aware of the potential for exposure and can exercise control over their exposure. This exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means. Awareness of the potential for RF exposure in a workplace or similar environment can be provided through specific training as part of a RF safety program. If appropriate, warning signs and labels can also be used to establish such awareness by providing prominent information on the risk of potential exposure and instructions on the risk of potential exposure and instructions on methods to minimize such exposure risks.

3.3 Localized SAR

Compliance with the localized SAR limits is demonstrated using the head and trunk limit because this SAR limit is only half the limbs limit value. The values are obtained by SAR measurements according to EN 62209-2.

4 Localized SAR Measurement Equipment

The measurements were performed with Dasy5 automated near-field scanning system comprised of high precision robot, robot controller, computer, e-field probe, probe alignment unit, phantoms, non-conductive phone positioned and software extension.

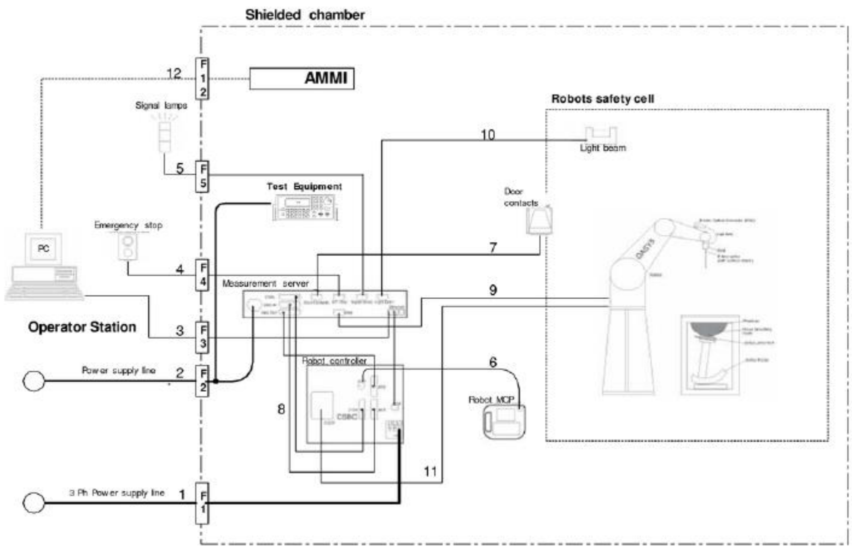
4.1 Complete SAR DASY5 Measurement System

Measurements are performed using the DASY5 automated assessment system made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland.

DASY 5 SAR Measurement Setup

The following Diagram show the elements involved in the measurement setup.

DASY 5 SAR Measurement Diagram

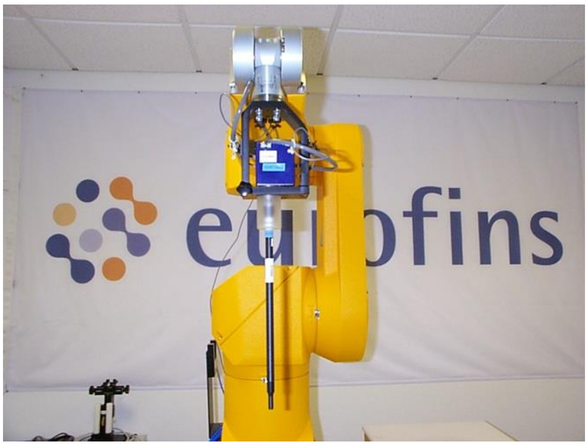


The DASY5 system for performing compliance tests consists of the following items:

DASY5 SAR Measurement System	
Device	Description:
RX90BL	A standard high precision 6-axis robot (Stäubli RX family) with controller, teach pendant and software.
Probe Alignment Unit	A probe alignment unit which improves the (absolute) accuracy of the probe positioning.
Teach Pendant	The Manual Control Pendant (MCP), also called the manual teach pendant, is the user interface to the robot. In DASY, it is used for certain installation and teach procedures
Signal Lamps	External warning lamp which indicates when the robot arm is powered-on and if the robot is under software control or in manual mode (controlled with the teach pendant).
DAE	The data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
E-Field Probes	Isotropic E-Field probe optimized and calibrated for E-field measurements in free space.
EOC	The electro-optical converter (EOC) performs the conversion between optical and electrical signals
Measurement Server	The functions of the measurement server is to perform the time critical task such as signal filtering, surveillance of the robot operation, fast movement interrupts.
Control Computer	A computer operating Windows 2000 or Windows NT with DASY 4 Software.
Control Software	DASY4 and SEMCAD post processing Software
SAM Twin Phantom	The SAM twin phantom enabling testing left-hand and right-hand usage.
Flat Phantom	Flat Phantom (only for body-mounted transceivers operating below 800 MHz).
Tissue simulating liquid	Tissue simulating liquid mixed according to the given recipes.
Device Holder	The device holder for handheld mobile phones.
System Validation Dipoles	System validation dipoles allowing to validate the proper functioning of the system.

4.2 Robot Arm

Robot arm



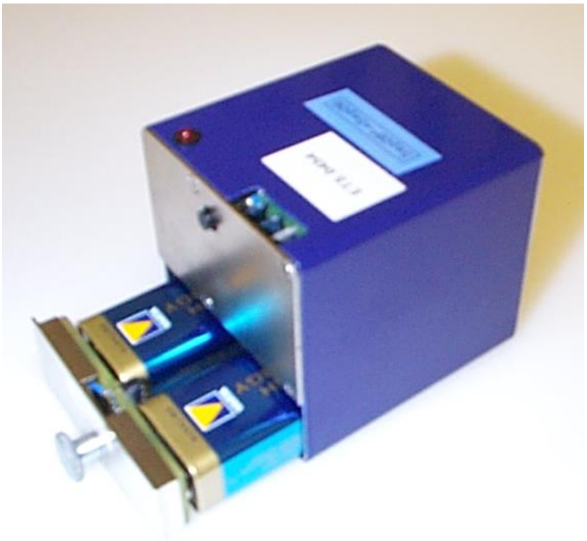
The DASY5 system uses the high precision robots RX90BL type out of the newer series from Stäubli SA (France).

The RX robot series have many features that are important for our application:

- High precision (repeatability 0.02 mm)
- High reliability (industrial design)
- Jerk-free straight movements
- Low ELF interference (the closed metallic construction shields against motor control fields)
- 6-axis controller

4.3 Data Acquisition Electronics

Data Acquisition Electronics



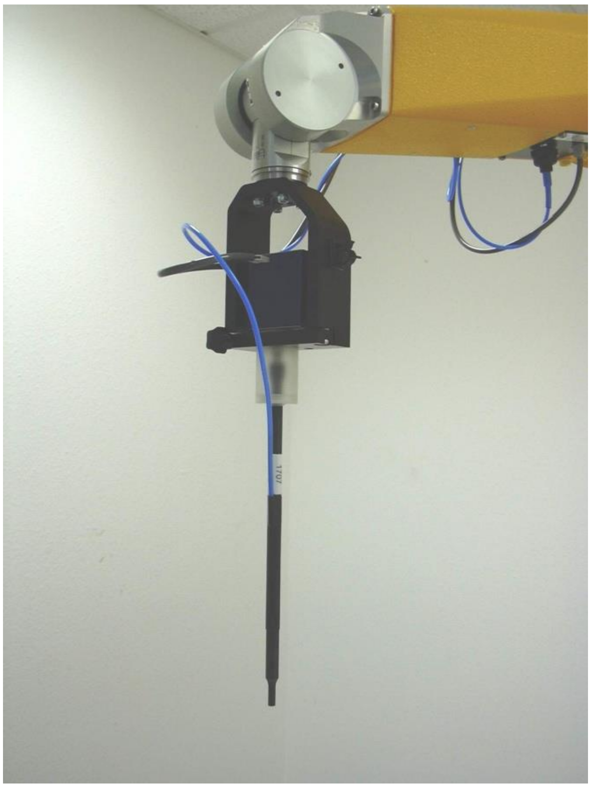
The data acquisition electronics (DAE3) consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information as well as an optical uplink for commands and the clock.

The mechanical probe mounting device includes two different sensor systems for frontal and sideways probe contacts. They are used for mechanical surface detection and probe collision detection. The input impedance of the DAE3 is 200M Ohm; the inputs are symmetrical and floating. Common mode rejection is above 80dB.

4.4 Isotropic E-Field Probe ≤ 3 GHz

Probe Specifications

Isotropic E-Field Probe ET3DV6



Construction:

One dipole parallel, two dipoles normal to probe axis built-in shielding against static charges.

Calibration:

In air from 10 MHz to 2.5 GHz,
In brain and muscle simulating tissue at Frequencies of 835MHz, 900MHz, 1800MHz, 1900 MHz and 2450 MHz

Frequency:

10MHz to > 3GHz,
Linearity ±0.2dB (30MHz to 3GHz)

Directivity:

±0.2dB in HSL (rotation around probe axis)
±0.4dB in HSL (rotation normal to probe axis)

Dynamic Range:

5µW/g to > 100mW/g

Linearity:

±0.2dB

Dimensions:

Overall Length: 330mm (Tip: 16mm),
Tip Diameter: 6.8mm (Body: 12mm),
Distance from probe tip to dipole centers: 2.7mm

Application:

General dosimetry up to 3 GHz
Compliance tests of mobile phones
Fast automatic scanning in arbitrary phantoms

4.5 Isotropic E-Field Probe ≤ 6 GHz

Probe Specifications

Isotropic E-Field Probe EX3DV4

Construction:

One dipole parallel, two dipoles normal to probe axis built-in shielding against static charges.

Calibration:

In air from 10 MHz to 6 GHz,
In brain and muscle simulating tissue at Frequencies of 5200, 5500, 5800

Frequency:

10MHz to 6GHz,
Linearity ±0.2dB (30MHz to 6GHz)

Directivity:

±0.3dB in HSL (rotation around probe axis)
±0.5dB in tissue material (rotation normal to probe axis)

Dynamic Range:

10µW/g to > 100mW/g

Linearity:

±0.2dB

Dimensions:

Overall Length: 337mm (Tip: 20mm),
Tip Diameter: 2.5mm (Body: 12mm),
Distance from probe tip to dipole centers: 1mm

Application:

General dosimetry up to 6 GHz
Compliance tests of mobile phones
Fast automatic scanning in arbitrary phantoms

4.6 Test phantom and positioner

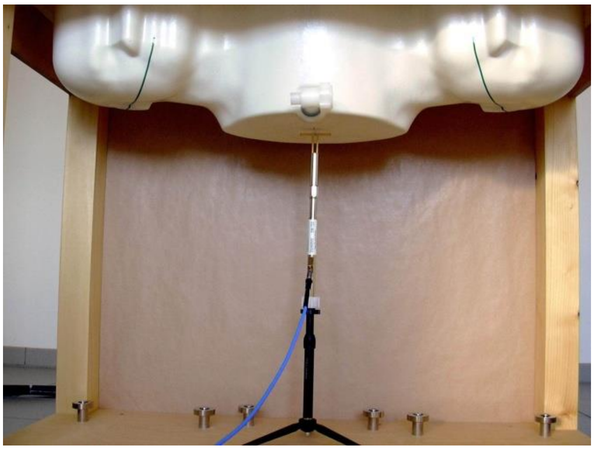
The positioner and test phantoms are manufactured by SPEAG. The test phantoms are used for all tests i.e. for both validation testing and device testing. The positioner and test phantom conforms to the requirements of EN 62209 and IEEE 1528.

The SPEAG device holder was used to position the test device in all tests whilst a tripod was used to position the validation dipoles in the test arch.

Probe Positioner	SAM Twin Phantom
	
ELI4 phantom	**Flat phantom**
	

4.7 System Validation Dipoles

A set of calibration dipoles (D2450V2, D5GHzV2) is included as a part of the SAR measurement setup. These are used for the validation of the test setup after its installation and prior to the EUT measurements. The calibration dipole is placed in the position normally occupied by the EUT. All calibration dipoles have the same height which allows an exact fitting below the center point of the test phantom. The dipole center is 10mm below the surface of the test phantom.

2450MHz Dipole	5000MHz Dipole
	

5 Single-band SAR Measurement

After successful completion of the tissue and system verification the SAR values of the EUT are measured according to the following description.

5.1 General measurement description

The measurement is performed for each frequency band of the device. If the width of the transmit frequency band exceeds 1% of its center frequency, than the channels at the lowest and highest frequencies should also be tested. Furthermore, if the width of the transmit band exceeds 10% of its center frequency the following formula is used to determine the number of channels:

$$N_C=2 \cdot \text{roundup}[10\cdot(f_{high} - f_{low})/f_c] + 1$$

First the device is tested on the center channel of each frequency band used by the device. An operation mode and configuration with maximum transmit power is established. If battery operated equipment is used, the batteries are fully charged.

SAR measurements are performed using the steps outlined in the next section for all relevant operational modes, EUT configurations and measurement positions.

For the condition (position, configuration, operational mode) that provides the highest spatial-average SAR value on the center channel, the other channels are also tested.

Additionally all other conditions where the spatial-average SAR value is within 3dB of the SAR limit are also tested on all determined test frequencies.

5.2 SAR measurement description

First the local SAR value at a test point within 10mm or less in normal direction from the inner surface of the phantom is measured. This SAR value is used to determine the measurement drift during SAR measurement.

Next an area scan is performed over an area larger than the projection of the EUT with antenna on the surface of the phantom with a spatial grid step of 10mm.

From the scanned SAR distribution the position of maximum SAR value is identified as well as any local SAR maxima within 2dB of the maximum value that are not within the zoom scan volume. (The additional peaks are only measured when the primary peak is within 2dB of the SAR limit.)

The zoom-scan volume constructed on the peak SAR position is scanned with a grid step of 5mm. The measured data are extracted and the local SAR value for each measurement point is calculated. The measured values are interpolated over a fine-mesh within the scan volume and the average SAR value over 10g mass is calculated.

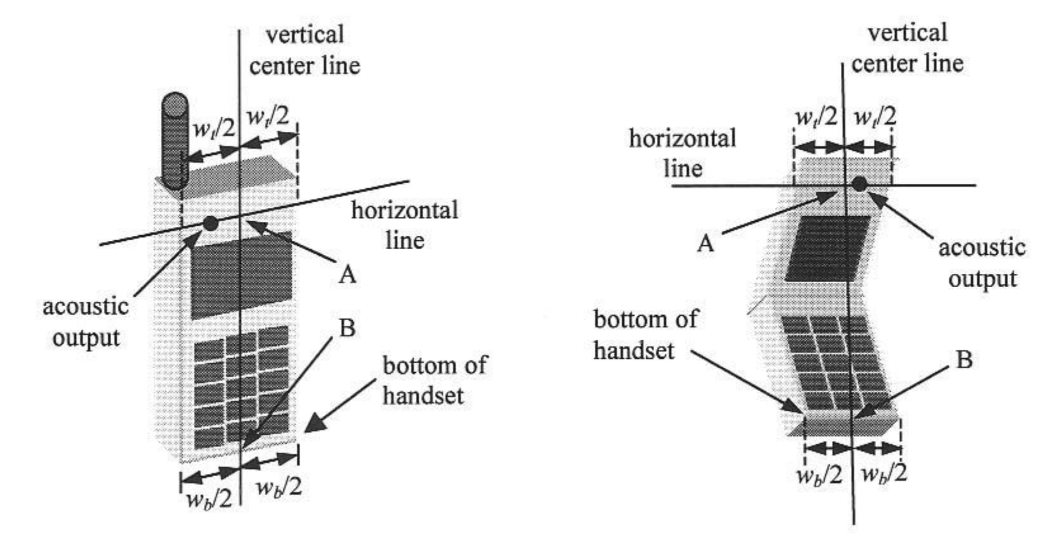
At the end of the measurement the reference point measured at the beginning of the measurement is measured again and from the difference the drift is calculated.

5.3 Reference lines and points for Handsets

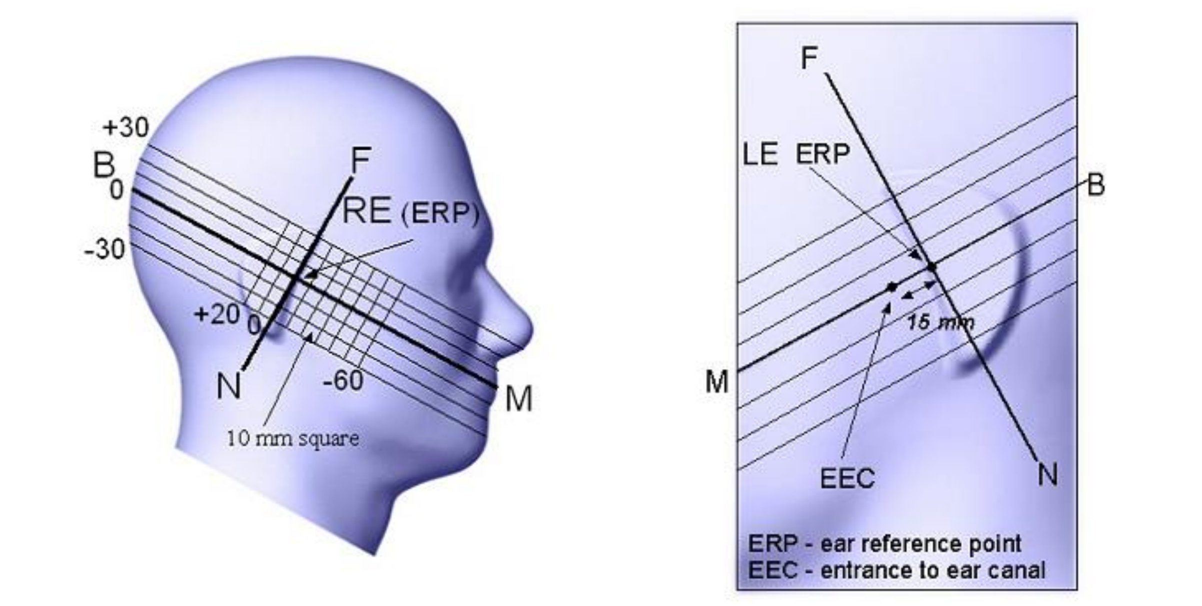
For all measurement positions of the EUT, the EUT has to be place in a specific orientation with respect to the phantom. The orientation of the EUT relative to the phantom is defined by reference lines and points.

According to IEEE 1528, the reference lines and points shall be positioned at the EUT as shown in the following figure.

Reference lines and points on EUT acc. to IEEE 1528

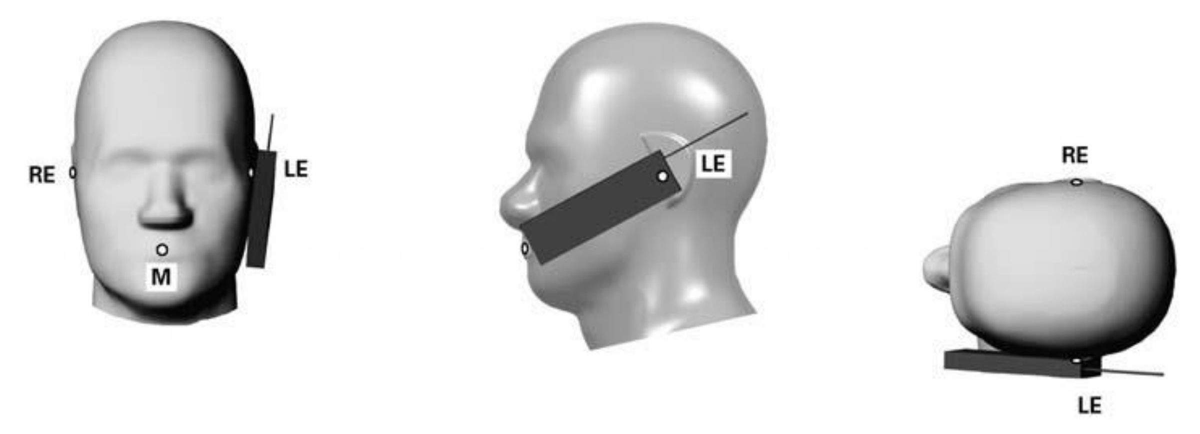


Reference lines and points on human head acc. to IEEE 1528



5.4 Test positions relative to the Head

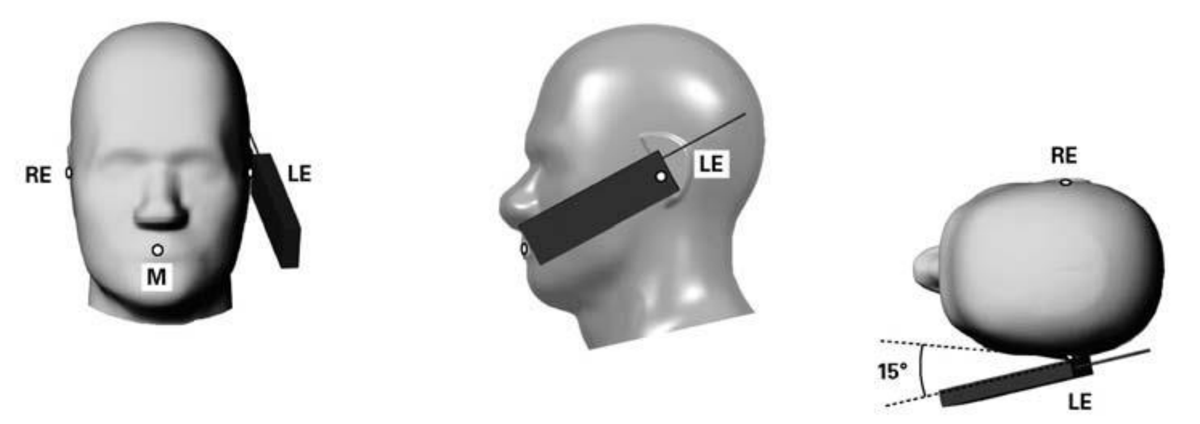
Cheek position

Cheek positions according to IEEE 1528


The handset is positioned close to the surface of the phantom such that point A is on the (virtual) extension of the line passing through points RE and LE on the phantom (see Figure), such that the plane defined by the vertical centerline and the horizontal line of the handset is approximately parallel to the sagittal plane of the phantom. Next the handset is translated towards the phantom along the line passing through RE and LE until handset point A touches the pinna at the ERP.

While the handset is maintained in this plane, it is rotated around the LE-RE line until the vertical centerline is in the plane normal to the plane containing B-M and N-F lines, i.e., the Reference Plane. Then it is rotated around the vertical centerline until the handset (horizontal line) is parallel to the N-F line. While the vertical centerline is maintained in the Reference Plane, point A is kept on the line passing through RE and LE, and the handset is maintained in contact with the pinna, the handset is rotated about the N-F line until any point on the handset is in contact with a phantom point below the pinna on the cheek.

Tilt position

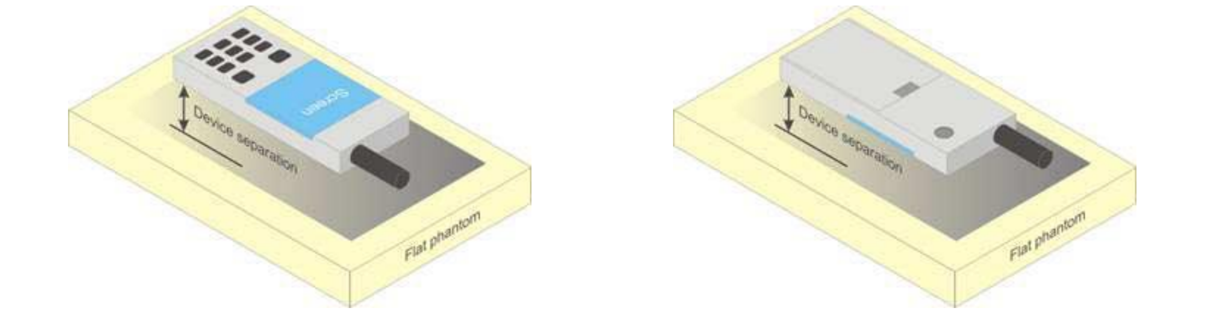
Tilt positions according to IEEE 1528


First the EUT is placed in the cheek position. Next the handset is moved away from the pinna along the line passing through RE and LE far enough to allow a rotation of the handset away from the cheek by 15°. Then the handset is rotated around the horizontal line by 15°.

The handset is moved towards the phantom on the line passing through RE and LE until any part of the handset touches the ear. The tilt position is obtained when the contact point is on the pinna. See Figure. If contact occurs at any location other than the pinna, e.g., the antenna at the back of the phantom head, the angle of the handset should be reduced. In this case, the tilt position is obtained if any point on the handset is in contact with the pinna and a second point on the handset is in contact with the phantom, e.g., the antenna with the back of the head

5.5 Test positions relative to the human body

Body positions according to IEEE 1528



In body worn configuration the device is positioned parallel to the phantom surface with either top or bottom side of the EUT facing against the phantom.

The separation distance of the EUT is selected according to the use case of the EUT (e.g. with belt clip or holster).

5.6 Measurement Uncertainty

Measurement Uncertainty according to IEEE 1528							
Error Description	**Uncertainty Value**	**Probability Distribution**	**Div.**	**c_i (1g)**	**c_i (10g)**	**Std. Unc. 1g**	**Std. Unc. 10g**
Measurement System							
Probe Calibration	±6.55%	N	1	1	1	±6.55%	±6.55%
Axial Isotropy	±4.7%	R	$\sqrt{3}$	0.7	0.7	±1.9%	±1.9%
Hemispherical Isotropy	±9.6%	R	$\sqrt{3}$	0.7	0.7	±3.9%	±3.9%
Linearity	±4.7%	R	$\sqrt{3}$	1	1	±2.7%	±2.7%
Modulation Response	±2.4%	R	$\sqrt{3}$	1	1	±1.4%	±1.4%
System Detection Limits	±1.0%	R	$\sqrt{3}$	1	1	±0.6%	±0.6%
Boundary effects	±2.0%	R	$\sqrt{3}$	1	1	±1.2%	±1.2%
Readout Electronics	±0.3%	N	1	1	1	±0.3%	±0.3%
Response Time	±0.8%	R	$\sqrt{3}$	1	1	±0.5%	±0.5%
Integration Time	±2.6%	R	$\sqrt{3}$	1	1	±1.5%	±1.5%
RF Ambient Noise	±3.0%	R	$\sqrt{3}$	1	1	±1.7%	±1.7%
RF Ambient Reflections	±3.0%	R	$\sqrt{3}$	1	1	±1.7%	±1.7%
Probe Positioner	±0.8%	R	$\sqrt{3}$	1	1	±0.5%	±0.5%
Probe Positioning	±6.7%	R	$\sqrt{3}$	1	1	±3.9%	±3.9%
Post processing	±4.0%	R	$\sqrt{3}$	1	1	±2.3%	±2.3%
Test Sample Related							
Device Holder	±3.6%	N	1	1	1	±3.6%	±3.6%
Test Sample Positioning	±2.9%	N	1	1	1	±2.9%	±2.9%
Power Scaling	±0%	R	$\sqrt{3}$	1	1	±0%	±0%
Power Drift	±5.0%	R	$\sqrt{3}$	1	1	±2.9%	±2.9%
Phantom and Setup Related							
Phantom Uncertainty	±7.9%	R	$\sqrt{3}$	1	1	±4.6%	±4.6%
SAR correction	±1.9%	R	$\sqrt{3}$	1	0.84	±1.1%	±0.9%
Liquid conductivity (measured)	±2.5%	N	1	0.78	0.71	±2.0%	±1.8%
Liquid permittivity (measured)	±2.5%	N	1	0.26	0.26	±0.1%	±0.1%
Temperature uncertainty - Conductivity	±5.2%	R	$\sqrt{3}$	0.78	0.71	±2.3%	±2.1%
Temperature uncertainty - Permittivity	±0.8%	R	$\sqrt{3}$	0.23	0.26	±0.1%	±0.1%
Combined Standard Uncertainty						±12.8%	±12.7%
Expanded Standard Uncertainty						**±25.6%**	**±25.4%**

6 Test Conditions and Results

6.1 Recipes for Tissue Simulating Liquids

Body Tissue Simulating Liquids					
Ingredient	M 450-B weight (%)	M 900-B weight (%)	M 1800-B weight (%)	M 1950-A weight (%)	M 2450-B weight (%)
Water	46.21	50.75	70.17	69.79	68.64
Sugar	51.17	48.21			
Cellulose	0.18				
Salt	2.34		0.39	0.2	
Preventol	0.08	0.1			
DGBE			29.44	30	31.37
Head Tissue Simulating Liquids					
Ingredient	HSL 450-A weight (%)	HSL 900-B weight (%)	HSL 1800-F weight (%)	HSL 1950-B weight (%)	HSL 2450-B weight (%)
Water	38.91	40.29	55.24	55.41	55
Sugar	56.93	57.9			
Cellulose	0.25	0.24			
Salt	3.79	1.38	0.31	0.08	
Preventol	0.12	0.18			
DGBE			44.45	44.51	45

Water: deionized water, resistivity ≥ 16 MΩ
Sugar: refined white sugar
Salt: pure NaCl
Cellulose: Hydroxyethyl-cellulose
Preservative: Preventol D-7
DGBE: Diethylenglycol-monobuthyl ether

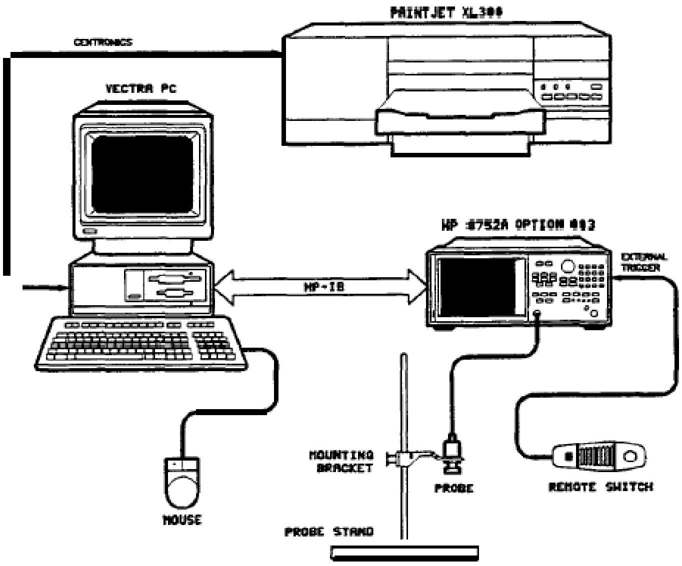
The parameters for the different frequencies are defined in the corresponding compliance standards (e.g., IEEE 1528-2003, IEC 62209-1)

The HBBL3-6GHz and MBBL 3-6 GHz liquids are direct from Speag.

6.2 Test Conditions and Results – Tissue Validation

Tissue Validation acc. to FCC OET Bulletin 65 Suppl. C / IC RSS-102					Verdict: PASS
Test according to measurement reference		Reference Method			
		OET Bulletin 65 Supplement C			
Target Values					
Frequency [MHz]	Head		Body		Permitted tolerance [%]
	Relative dielectric constant ε_r	Conductivity σ [S/m]	Relative dielectric constant ε_r	Conductivity σ [S/m]	
150	52.3	0.76	61.9	0.80	≤ ±5
300	45.3	0.87	58.2	0.92	≤ ±5
450	43.5	0.87	56.7	0.94	≤ ±5
835	41.5	0.90	55.2	0.97	≤ ±5
900	41.5	0.97	55.0	1.05	≤ ±5
915	41.5	0.98	55.0	1.06	≤ ±5
1450	40.5	1.20	54.0	1.30	≤ ±5
1610	40.3	1.29	53.8	1.40	≤ ±5
1800 – 2000	40.0	1.40	53.3	1.52	≤ ±5
2450	39.2	1.80	52.7	1.95	≤ ±5
3000	38.5	2.40	52.0	2.73	≤ ±5
5200	36.0	4.66	49.0	5.30	≤ ±5
5500	35.6	4.96	48.6	5.65	≤ ±5
5800	35.3	5.27	48.2	6.00	≤ ±5

Test setup



Test procedure

1. The dielectric probe kit is calibrated using the standards air, short circuit and deionized water
2. The tissue simulating liquid is measured using the dielectric probe
3. Target values are compared to the measurement values and deviations are determined

Test results

Frequency [MHz]	Tissue	Measured ε_r	Target ε_r	Delta ε_r [%]	Measured σ [S/m]	Target σ [S/m]	Delta σ [%]
2450	Head	37.68	39.20	-3.9	1.87	1.80	3.9
*2402	Head	37.84	39.28	-3.7	1.80	1.76	2.3
*2412	Head	37.80	39.27	-3.7	1.81	1.77	2.3
2437	Head	37.69	39.22	-3.9	1.85	1.79	3.4
*2442	Head	37.68	39.21	-3.9	1.86	1.79	3.9
*2462	Head	37.66	39.18	-3.9	1.89	1.81	4.4
*2480	Head	37.63	39.16	-3.9	1.92	1.83	4.9
5200	Head	35.84	36.0	-0.4	4.43	4.66	-4.9
*5180	Head	35.88	36.02	-0.4	4.40	4.64	-5.0
*5240	Head	35.70	35.96	-0.7	4.50	4.70	-4.3

Comments:

6.3 Test Conditions and Results – System Validation

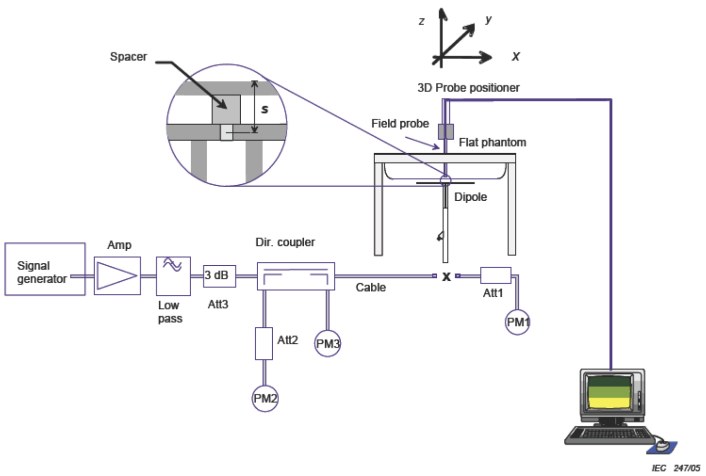
System Validation acc. to FCC OET Bulletin 65 Suppl. C / IC RSS-102	Verdict: PASS
Test according to measurement reference	Reference Method
	OET Bulletin 65 Supplement C / IEEE 1528
Test frequency range	Tested frequencies
	2450 MHz , 5200 MHz
Test mode	unmodulated CW

Target Values

Frequency [MHz]	Target SAR value [W/kg (1g)]	Permitted tolerance [%]
2450	13.2 @ 250mW	≤ ±10
5200	7.99 @ 100mW	≤ ±10

The target reference values are taken from the calibration sheets (see annex)

Test setup



Test procedure

1. The dipole antenna input power is set to 250mW
2. The reference dipole is positioned under the phantom
3. With the dipole antenna powered the SAR value is measured
4. The measured SAR values are compared to the target SAR values

Test results

Frequency [MHz]	Input power [mW]	Measured SAR value [W/kg (1g)]	Target SAR value [W/kg (1g)]	Delta [%]
2450	250	14.2	13.2	7.58
2450	250	14.18	13.2	7.42
5200	100	8.41	7.99	5.26
5200	100	8.43	7.99	5.51

Comments:

6.4 Test Conditions and Results – Standalone SAR Measurement

Standalone SAR acc. to FCC OET Bulletin 65 Suppl. C / IC RSS-102	**Verdict: PASS**	
Test according to measurement reference	Reference Method	
	FCC OET Bulletin 65 Supplement C / IC RSS-102 Issue 4	
Room temperature	22.0 – 22.6 °C	
Liquid depth	15.5 cm	
Environment	general public	
Limits		
Region	Occupational SAR values [W/kg]	General public SAR values [W/kg]
Wholebodyaverage SAR	0.4	0.08
Localized SAR (Head and trunk) SAR averaging mass = 1g	8	1.6
Localized SAR (Limbs) SAR averaging mass = 10g	20	4

Test results

Mode	Position	Channel	Frequency [MHz]	Drift [dB]	Scaling Factor*	Measured SAR [W/kg (1g)]	Reported SAR [W/kg (1g)] **	SAR Limit [W/kg (1g)]
Bluetooth DH5	Bottom 10mm	0	2402	-0.04	1.585	0.064	0.101	1.6
Bluetooth DH5	Left 10mm	0	2402	0.04	1.585	0.027	0.043	1.6
Bluetooth DH5	Right 10mm	0	2402	-0.02	1.585	0.022	0.035	1.6
Bluetooth DH5	Top 10mm	0	2402	0.07	1.585	0.010	0.016	1.6
Bluetooth DH5	Back 10mm	0	2402	0.07	1.585	0.052	0.082	1.6
IEEE 802.11b	Back 10mm	6	2437	0.08	1.585	0.028	0.044	1.6
IEEE 802.11b	Top 10mm	6	2437	-0.02	1.585	0.014	0.022	1.6
IEEE 802.11b	Bottom 10mm	6	2437	-0.00	1.585	0.093	0.147	1.6
IEEE 802.11b	Left 10mm	6	2437	-0.05	1.585	0.038	0.060	1.6
IEEE 802.11b	Right 10mm	6	2437	-0.04	1.585	0.038	0.060	1.6
IEEE 802.11gn	Top 10mm	6	2437	0.06	1.585	0.005	0.008	1.6
IEEE 802.11gn	Bottom 10mm	6	2437	-0.02	1.585	0.040	0.063	1.6
IEEE 802.11gn	Left 10mm	6	2437	0.09	1.585	0.018	0.029	1.6
IEEE 802.11gn	Right 10mm	6	2437	0.04	1.585	0.015	0.024	1.6
IEEE 802.11gn	Back 10mm	6	2437	0.03	1.585	0.018	0.029	1.6
IEEE 802.11a	Top 10mm	48	5240	0.00	1.585	0.001	0.002	1.6
IEEE 802.11a	Bottom 10mm	48	5240	-0.01	1.585	0.080	0.127	1.6
IEEE 802.11a	Left 10mm	48	5240	-0.1	1.585	0.029	0.046	1.6
IEEE 802.11a	Right 10mm	48	5240	0.09	1.585	0.017	0.027	1.6

IEEE 802.11a	Back 10mm	48	5240	0.03	1.585	0.013	0.021	1.6
IEEE 802.11an	Top 10mm	48	5240	0.10	1.585	0.001	0.002	1.6
IEEE 802.11an	Bottom 10mm	48	5240	0.06	1.585	0.040	0.063	1.6
IEEE 802.11an	Left 10mm	48	5240	-0.02	1.585	0.014	0.022	1.6
IEEE 802.11an	Right 10mm	48	5240	0.1	1.585	0.008	0.013	1.6
IEEE 802.11an	Back 10mm	48	5240	0.08	1.585	0.003	0.005	1.6
Overall maximum SAR value [W/kg (1g)]							**0.147**	**1.6**
Comments:*nominal maximum output power (including tune up tolerance) / measured conducted output power = scaling factor ** attached measurement plot: highest SAR value for the communication system								

SAR measurements were started with the highest power channel of the transmission band under investigation. Other measurement channels were omitted when the SAR value of the highest power channel was below 0.8 W/kg according to KDB 248227 v01r02.

According to KDB 865664 D02 v01r01 only the SAR plots for the highest SAR results for each EUT configuration and operating condition are given in the “SAR Results” part of the report.

6.5 Test Conditions and Results – Multi-band SAR Evaluation

Multi-band SAR Evaluation acc. to FCC / IC		Verdict: PASS
Limits		
Region	Occupational SAR values [W/kg]	General public SAR values [W/kg]
Whole body average SAR	0.4	0.08
Localized SAR (Head and trunk) SAR averaging mass = 1g	8	1.6
Localized SAR (Limbs) SAR averaging mass = 10g	20	4

Test results

Position	Bluetooth	Max. SAR: IEEE 802.11b/g/n	Max. SAR: IEEE 802.11a/n	Sum of 1g SAR	Ri (mm)	SPLSR	Sketch
TOP	0.016	N/A	0.002	0.018	N/A	N/A	N/A
BOTTOM	0.101	N/A	0.127	0.228	N/A	N/A	N/A
LEFT	0.043	N/A	0.046	0.089	N/A	N/A	N/A
RIGHT	0.035	N/A	0.027	0.062	N/A	N/A	N/A
BACK	0.082	N/A	0.021	0.103	N/A	N/A	N/A
Overall maximum SAR value [W/kg (1g)]				**0.228**			

ANNEX A Calibration Documents

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

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

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

Accreditation No.: SCS 108

Client **Eurofins**

Certificate No: DAE3-522_Sep14

CALIBRATION CERTIFICATE

Object	DAE3 - SD 000 D03 AA - SN: 522
Calibration procedure(s)	QA CAL-06.v28 Calibration procedure for the data acquisition electronics (DAE)
Calibration date:	September 17, 2014

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	01-Oct-13 (No:13976)	Oct-14
Secondary Standards	**ID #**	**Check Date (in house)**	**Scheduled Check**
Auto DAE Calibration Unit	SE UWS 053 AA 1001	07-Jan-14 (in house check)	In house check: Jan-15
Calibrator Box V2.1	SE UMS 006 AA 1002	07-Jan-14 (in house check)	In house check: Jan-15

	Name	Function	Signature
Calibrated by:	Dominique Steffen	Technician	
Approved by:	Fin Bomholt	Deputy Technical Manager	i.V.

Issued: September 17, 2014

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

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	404.208 ± 0.02% (k=2)	403.882 ± 0.02% (k=2)	404.721 ± 0.02% (k=2)
Low Range	3.96428 ± 1.50% (k=2)	3.95728 ± 1.50% (k=2)	3.97367 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	56.5 ° ± 1 °

Appendix (Additional assessments outside the scope of SCS108)

1. DC Voltage Linearity

High Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	200036.59	-0.80	-0.00
Channel X	+ Input	20007.79	3.33	0.02
Channel X	- Input	-20000.37	5.45	-0.03
Channel Y	+ Input	200037.53	0.19	0.00
Channel Y	+ Input	20004.45	0.10	0.00
Channel Y	- Input	-20001.11	4.89	-0.02
Channel Z	+ Input	200039.93	2.29	0.00
Channel Z	+ Input	20002.07	-2.13	-0.01
Channel Z	- Input	-20005.14	0.85	-0.00

Low Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	2000.68	-0.01	-0.00
Channel X	+ Input	200.76	0.21	0.11
Channel X	- Input	-198.84	0.67	-0.34
Channel Y	+ Input	2000.56	0.01	0.00
Channel Y	+ Input	200.46	-0.01	-0.00
Channel Y	- Input	-199.17	0.26	-0.13
Channel Z	+ Input	2000.50	0.01	0.00
Channel Z	+ Input	199.91	-0.66	-0.33
Channel Z	- Input	-201.19	-1.73	0.87

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	-3.99	-5.30
	- 200	7.38	5.55
Channel Y	200	0.38	-0.28
	- 200	-0.60	-0.29
Channel Z	200	15.86	15.99
	- 200	-17.84	-18.37

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	-	-1.68	-1.76
Channel Y	200	7.39	-	-1.38
Channel Z	200	6.24	5.61	-

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	15741	16854
Channel Y	15714	14825
Channel Z	16054	16288

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	1.56	0.18	2.94	0.60
Channel Y	0.07	-1.10	1.20	0.53
Channel Z	0.39	-0.91	1.96	0.57

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

ET00279

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

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

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

Accreditation No.: SCS 108

Client **Eurofins**

Certificate No: ET3-1711_Sep14

CALIBRATION CERTIFICATE

Object	ET3DV6 - SN:1711
Calibration procedure(s)	QA CAL-01.v9, QA CAL-12.v9, QA CAL-23.v5, QA CAL-25.v6 Calibration procedure for dosimetric E-field probes
Calibration date:	September 22, 2014

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter E4419B	GB41293874	03-Apr-14 (No. 217-01911)	Apr-15
Power sensor E4412A	MY41498087	03-Apr-14 (No. 217-01911)	Apr-15
Reference 3 dB Attenuator	SN: S5054 (3c)	03-Apr-14 (No. 217-01915)	Apr-15
Reference 20 dB Attenuator	SN: S5277 (20x)	03-Apr-14 (No. 217-01919)	Apr-15
Reference 30 dB Attenuator	SN: S5129 (30b)	03-Apr-14 (No. 217-01920)	Apr-15
Reference Probe ES3DV2	SN: 3013	30-Dec-13 (No. ES3-3013_Dec13)	Dec-14
DAE4	SN: 660	13-Dec-13 (No. DAE4-660_Dec13)	Dec-14
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-13)	In house check: Apr-16
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-13)	In house check: Oct-14

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

Issued: September 23, 2014

Glossary:

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,y,z
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization φ	φ rotation around probe axis
Polarization ϑ	ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\vartheta = 0$ is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005

Methods Applied and Interpretation of Parameters:

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