Prüfbericht-Nr.: *Test Report No.:*	**50087609 004**	**Auftrags-Nr.:** *Order No.:*	164093954	**Seite 1 von 32** *Page 1 of 32*
Kunden-Referenz-Nr.: *Client Reference No.:*	N/A	**Auftragsdatum:** *Order date:*	24.05.2017	
Auftraggeber: *Client:*	**Paralenz Group ApS.** Refshalevej 163a ST.MF, Copenhagen K, 1432 Denmark			
Prüfgegenstand: *Test item:*	DIVE CAMERA			
Bezeichnung / Typ-Nr.: *Identification / Type No.:*	PDC-1			
Auftrags-Inhalt: *Order content:*	Test Report			
Prüfgrundlage: *Test specification:*	CFR Title 47 Part 2 Section 2.1093 IEEE 1528-2013 ANSI C95.1-2005 RSS-102 Issue 5	KDB 447498 D01 v06 KDB 865664 D02 v01r02 KDB 865664 D01 v01r04 KDB 24827 D01 v02r02		

Wareneingangsdatum: *Date of receipt:*	24.05.2017	Please refer to photo documents
Prüfmuster-Nr.: *Test sample No.:*	A000552029-0003	
Prüfzeitraum: *Testing period:*	01.07.2017 - 03.07.2017	
Ort der Prüfung: *Place of testing:*	EMTEK (Shenzhen) Co., Ltd.	
Prüflaboratorium: *Testing laboratory:*	TÜV Rheinland (Shenzhen) Co., Ltd.	
Prüfergebnis*: *Test result*:*	PASS	

geprüft von / *tested by:*

Datum *Date*	Name / Stellung *Name / Position*	Unterschrift *Signature*
11.07.2017	Hardy Suo / Assistant Project Manager	

kontrolliert von / *reviewed by:*

Datum *Date*	Name / Stellung *Name / Position*	Unterschrift *Signature*
11.07.2017	Sam Lin / Technical Certifier	

Sonstiges / *Other:*

FCC ID: 2AL8V-PDC1A

IC: 22808-PDC1A

HVIN: PDC-1

Zustand des Prüfgegenstandes bei Anlieferung: *Condition of the test item at delivery:* Prüfmuster vollständig und unbeschädigt *Test item complete and undamaged*

* Legende:	1 = sehr gut	2 = gut	3 = befriedigend	4 = ausreichend	5 = mangelhaft
	P(ass) = entspricht o.g. Prüfgrundlage(n)		F(ail) = entspricht nicht o.g. Prüfgrundlage(n)	N/A = nicht anwendbar	N/T = nicht getestet
Legend:	*1 = very good*	*2 = good*	*3 = satisfactory*	*4 = sufficient*	*5 = poor*
	P(ass) = passed a.m. test specification(s)		*F(ail) = failed a.m. test specification(s)*	*N/A = not applicable*	*N/T = not tested*

Table of Contents

1. General Remarks

1.1 Complementary Materials

All attachments are integral parts of this test report. This applies especially to the following Appendix:
Appendix A: System performance verification
Appendix B: Highest SAR Measurement results
Appendix C: Test Setup Photos
Appendix D: Calibration Certificate

2. Test Sites

2.1 Test Facilities

EMTEK (Shenzhen) Co., Ltd.
Address: Bldg. 69, Majialong Industry Zone, Nanshan District, Shenzhen, Guangdong, China.

FCC Registration No.: 406365
ISED Registration No.: 4480A-2

Note: The tests at the test site have been conducted under the supervision of a TÜV engineer.

2.2 List of Test and Measurement Instruments

Description	Manufacturer	Model No.	Serial No.	Last Cal.	Cal. Interval
Signal Generator	Agilent	N5181A	MY50145187	5/20/2017	1 year
RF Power Meter Dual Channel	BOONTON	4232A	10539	5/20/2017	1 year
Power Sensor	BOONTON	51011EMC	34236/34238	5/20/2017	1 year
Wideband Radio Communication Tester	R&S	CMW500	1201.0002K50-140822zk	5/20/2017	1 year
Signal Analyzer	Agilent	N9010A	My53470879	5/20/2017	1 year
Network Analyzer	Agilent	E5071C	MY46316645	5/20/2017	1 year
E-Field Probe	SPEAG	EX3DV4	3970	9/7/2016	1 year
DAE	SPEAG	DAE4	1418	9/5/2016	1 year
Dipole Validation Kits - 2450MHz	SPEAG	D2450V2	845	10/12/2016	3 years
Dual Directional Coupler	Agilent	EE393	TW5451008	5/20/2017	1 year
10dB Attenuator	Mini-Circuits	15542	3 1344	5/20/2017	1 year
10dB Attenuator	Mini-Circuits	15542	3 1415	5/20/2017	1 year
30dB Attenuator	Mini-Circuits	15542	3 1420	5/20/2017	1 year
Power Amplifier	MILMEGA	80RF1000-175	1059345	5/20/2017	1 year
Power Amplifier	MILMEGA	AS0102-55	1018770	5/20/2017	1 year
Power Amplifier	MILMEGA	AS1860-50	1059346	5/20/2017	1 year
Power Meter	Agilent	N1918A	MY54180006	5/20/2017	1 year

3. General Product Information

3.1 Product Function and Intended Use

The EUT is a DIVE CAMERA which that supports Bluetooth classic, Bluetooth BLE and IEEE 802.11 b/g/n protocols.

For details refer to user manual and circuit diagram.

3.2 Product Technical Details

Technical Specification	Value
Product Name	DIVE CAMERA
Model	PDC-1
Software Version:	1.2.1
Hardware Version:	LG-DIVE-MAIN REV D 1080
Type of Product	Protable Device
Exposure category:	Uncontrolled environment / general population
Bluetooth	
Bluetooth Version:	V4.0 dual mode
Frequency Range:	2402-2480MHz
Type of Modulation:	GFSK, Pi/4 DQPSK, 8DPSK
Data Rate:	1Mbps, 2Mbps, 3Mbps
Quantity of Channels	79/40
Channel Separation:	1MHz, 2MHz
Type of Antenna:	Internal Antenna
Antenna Gain:	2.0dBi max
Wi-Fi	
Support Standards:	802.11b/g/n-HT20
Frequency Range:	2412-2462MHz for 802.11b/g/n(HT20)
Type of Modulation:	CCK, OFDM, QPSK, BPSK, 16QAM, 64QAM
Data Rate:	1-11Mbps, 6-54Mbps, up to 72.2Mbps
Quantity of Channels	11 for 802.11b/g/n(HT20)
Channel Separation:	5MHz
Type of Antenna:	Internal Antenna
Antenna Gain:	2.0dBi max

3.3 Submitted Documents

3.3.1 Test specification(s)

ANSI C95.1-2005 IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

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.

KDB447498 D01: General RF Exposure Guidance v06: RF EXPOSURE PROCEDURES AND EQUIPMENT AUTHORIZATION POLICIES FOR MOBILE AND PORTABLE DEVICES.

KDB865664 D01SAR measurement 100 MHz to 6 GHz v01r04: SAR MEASUREMENT REQUIREMENTS FOR 100 MHz TO 6 GHz.

KDB865664 D02 RF Exposure Reporting v01r02: RF EXPOSURE COMPLIANCE REPORTING AND DOCUMENTATION CONSIDERATIONS.

KDB248227 D01 802.11 Wi-Fi SAR v02r02: SAR GUIDANCE FOR IEEE 802.11 (Wi-Fi) TRANSMITTERS.

3.3.2 RF exposure limits

It specifies the maximum exposure limit of **1.6 W/kg** as averaged over any 1 gram of tissue for portable devices being used within 20 cm of the user in the uncontrolled environment.

3.4 Summary of Measurement Results

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

Frequency Band	Head SAR Maximum SAR_{1g} (W/kg)	Body-worn Maximum SAR_{1g} (W/kg)	SAR_{1g} Limit (W/kg)
2.4GHz WLAN	0.100	0.153	1.6
Bluetooth	0.125	0.142	1.6

Remark:
*The highest reported SAR values for head and body-worn accessory are **0.125W/kg and 0.153W/kg,** respectively.*

The device is in compliance with Specific Absorption Rate (SAR) for general population/uncontrolled exposure limits (1.6 W/kg) specified in FCC 47 CFR Part 2.1093 and ANSI/IEEE C95.1, and had been tested in accordance with the measurement methods and procedure specified in IEEE 1528-2013, KDB 865664 D01 v01r04 and KDB 865664 D02 v01r02.

4. Specific Absorption Rate (SAR)

4.1 Introduction

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

4.2 SAR Definition

The SAR definition is the time derivative (rate) of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dv) of a given density (ρ). The equation description is as below:

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

SAR is expressed in units of Watts per kilogram (W/kg)
SAR measurement can be either related to the temperature elevation in tissue by

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

Where: C is the specific heat capacity, δ T is the temperature rise and δ t is the exposure duration, or related to the electrical field in the tissue by

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

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

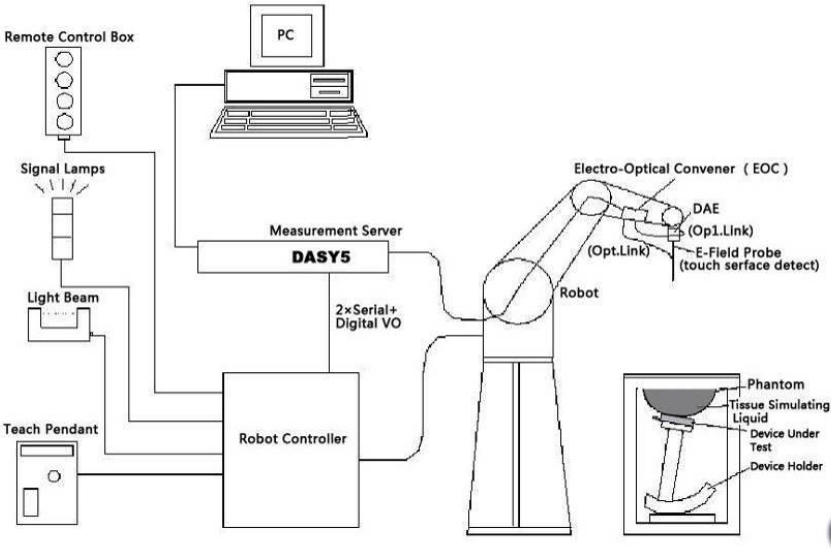
However for evaluating SAR of low power transmitter, electrical field measurement is typically applied.

5. SAR Measurement System Configuration

5.1 SAR Measurement System

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

- A standard high precision 6-axis robot (Stäubli RX family) with controller and software. An arm extension for accommodating the data acquisition electronics (DAE).
- A dosimetric probe, i.e. an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.
- A data acquisition electronic (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.
- A unit to operate the optical surface detector which is connected to the EOC.
- The Electro-Optical Coupler (EOC) performs the conversion from the optical into a digital electric signal of the DAE. The EOC is connected to the DASY5 measurement server.
- The DASY5 measurement server, which performs all real-time data evaluation for field measurements and surface detection, controls robot movements and handles safety operation. A computer operating Windows 7.
- DASY5 software and SEMCAD data evaluation software.
- Remote control with teach panel and additional circuitry for robot safety such as warning lamps, etc.
- The generic twin phantom enabling the testing of left-hand and right-hand usage.
- The device holder for handheld mobile phones.
- Tissue simulating liquid mixed according to the given recipes.
- System check dipoles allowing to validate the proper functioning of the system.



5.2 Test Enivronment

The DASY5 measurement system is placed at the head end of a room with dimensions:
5 x 2.5 x 3 m³, the SAM phantom is placed in a distance of 75 cm from the side walls and 1.1m from the rear wall. Above the test system a 1.5 x 1.5 m² array of pyramid absorbers is installed to reduce reflections from the ceiling.
The system allows the measurement of SAR values larger than 0.005 mW/g.

5.3 Probe Description

Isotropic E-Field Probe EX3DV4 for Dosimetric Measurements

Construction	Symmetrical design with triangular core Interleaved sensors Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)	
Calibration	ISO/IEC 17025 calibration service available.	
Frequency	10 MHz to >6 GHz (dosimetry); Linearity: ± 0.2 dB (30 MHz to 6 GHz)	
Directivity	± 0.3 dB in HSL (rotation around probe axis) ± 0.5 dB in tissue material (rotation normal to probe axis)	
Dynamic range	10 µW/g to > 100 mW/g; Linearity: ± 0.2 dB (noise: typically<1 µW/g)	
Dimensions	Overall length: 337 mm (Tip: 20mm) Tip length: 2.5 mm (Body: 12mm) Typical distance from probe tip to dipole centers: 1mm	
Application	High precision dosimetric measurements in any exposure scenario (e.g., very strong gradient fields). Only probe which enables compliance testing for frequencies up to 6 GHz with precision of better 30%.	

5.4 Probe Calibration Process

Dosimetric Assessment Procedure
Each E-Probe/Probe Amplifier combination has unique calibration parameters. SATIMO Probe calibration procedure is conducted to determine the proper amplifier settings to enter in the probe parameters. The amplifier settings are determined for a given frequency by subjecting the probe to a known E-field density (1 mW/cm2) using with CALISAR, Antenna proprietary calibration system.

Free Space Assessment Procedure
The free space E-field from amplified probe outputs is determined in a test chamber. This calibration can be performed in a TEM cell if the frequency is below 1 GHz and in a waveguide or other methodologies above 1 GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity and at the proper orientation with the field. The probe is rotated 360 degrees until the three channels show the maximum reading. The power density readings equates to 1mW/cm2.

Temperature Assessment Procedure
E-field temperature correlation calibration is performed in a flat phantom filled with the appropriate simulated head tissue. The E-field in the medium correlates with the temperature rise in the dielectric medium. For temperature correlation calibration a RF transparent thermistor-based temperature probe is used in conjunction with the E-field probe.

$$SAR = C\frac{\Delta T}{\Delta t}$$

Where:
Δt = exposure time (30 seconds),
C = heat capacity of tissue (brain or muscle),
ΔT = temperature increase due to RF exposure.

SAR is proportional to ΔT/Δt, the initial rate of tissue heating, before thermal diffusion takes place. The electric field in the simulated tissue can be used to estimate SAR by equating the thermally derived SAR to that with the E- field component.

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

Where:
σ = simulated tissue conductivity,
ρ = Tissue density (1.25 g/cm3 for brain tissue)

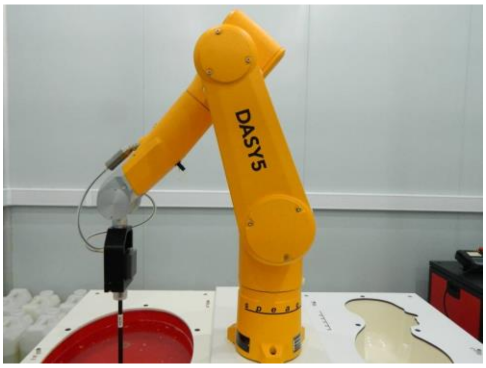
5.5 Other Test Equipment

5.5.1 Data Acquisition Electronics (DAE)

The data acquisition electronics consist of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder with a control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information, as well as an optical uplink for commands and the clock.
The mechanical probe mounting device includes two different sensor systems for frontal and sideways probe contacts. They are used for mechanical surface detection and probe collision detection.
The input impedance of the DAE is 200 MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.

5.5.2 Robot

The SPEAG DASY system uses the high precision robots (DASY5: TX60XL) type from Stäubli SA (France). For the 6-axis controller system, the robot controller version from Stäubli is used. The Stäubli robot series have many features that are important for our application:
High precision (repeatability 0.02mm)
High reliability (industrial design)
Low maintenance costs (virtually maintenance free due to direct drive gears; no belt drives)
Jerk-free straight movements (brushless synchron motors; no stepper motors)
Low ELF interference (motor control fields shielded via the closed metallic construction shields)



5.5.3 Measurement Server

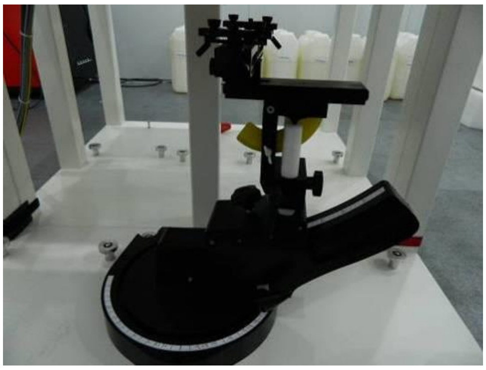
The Measurement server is based on a PC/104 CPU broad with CPU (DASY5: 400 MHz, Intel Celeron), chip disk (DASY5: 128MB), RAM (DASY5: 128MB). The necessary circuits for communication with the DAE electronic box, as well as the 16 bit AD converter system for optical detection and digital I/O interface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

Picture of Server for DASY 5

The measurement server performs all real-time data evaluation of field measurements and surface detection, controls robot movements and handles safety operation. The PC operating system cannot interfere with these time critical processes. All connections are supervised by a watchdog, and disconnection of any of the cables to the measurement server will automatically disarm the robot and disable all program-controlled robot movements. Furthermore, the measurement server is equipped with an expansion port which is reserved for future applications. Please note that this expansion port does not have a standardized pinout, and therefore only devices provided by SPEAG can be connected. Devices from any other supplier could seriously damage the measurement server.

5.5.4 Device Holder for Phantom

The SAR in the phantom is approximately inversely proportional to the square of the distance between the source and the liquid surface. For a source at 5mm distance, a positioning uncertainty of ±0.5mm would produce a SAR uncertainty of ±20%. Accurate device positioning is therefore crucial for accurate and repeatable measurements. The positions in which the devices must be measured are defined by the standards.
The DASY device holder is designed to cope with the different positions given in the standard. It has two scales for device rotation (with respect to the body axis) and device inclination (with respect to the line between the ear reference points). The rotation centers for both scales are the ear reference point (ERP). Thus the device needs no repositioning when changing the angles.
The DASY device holder is constructed of low-loss POM material having the following dielectric parameters: relative permittivity=3 and loss tangent=0.02. The amount of dielectric material has been reduced in the closest vicinity of the device, since measurements have suggested that the influence of the clamp on the test results could thus be lowered.
<Laptop Extension Kit>
The extension is lightweight and made of POM, acrylic glass and foam. It fits easily on the upper part of the Mounting Device in place of the phone positioner. The extension is fully compatible with the Twin-SAM and ELI phantoms.

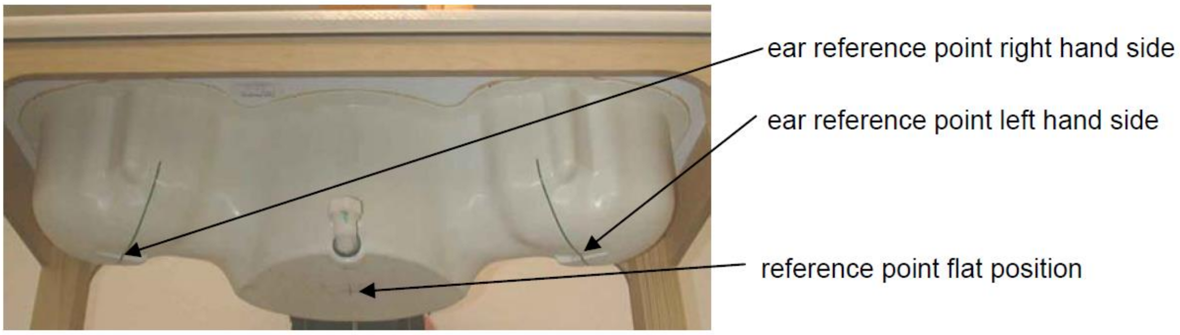


5.5.5 Phantom Description

SAM Twin Phantom

Shell Thickness	2mm +/- 0.2 mm; The ear region: 6mm	
Filling Volume	Approximately 25 liters	
Dimensions	Length:1000mm; Width:500mm; Height: adjustable feet	
Measurement Areas	Left hand Right hand Flat phantom	
The bottom plate contains three pairs of bolts for locking the device holder. The device holder positions are adjusted to the standard measurement positions in the three sections. A white cover is provided to cover the phantom during off-periods to prevent water evaporation and changes in the liquid parameters. Free space scans of devices on top of this phantom cover are possible. Three reference marks are provided on the phantom counter. These reference marks are used to teach the absolute phantom position relative to the robot.		

The following figure shows the definition of reference point:



ELI4 Phantom

Shell Thickness	2mm +/- 0.2 mm	
Filling Volume	Approximately 30 liters	
Dimensions	Major axis:600mm; Minor axis:400mm;	
Measurement Areas	Flat phantom	
The ELI4 phantom is intended for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30MHz to 6GHz. ELI4 is fully compatible with the latest draft of the standard IEC 62209-2 and all known tissue simulating liquids.		

The phantom shell material is resistant to all ingredients used in the tissue-equivalent liquid recipes.
The shell of the phantom including ear spacers is constructed from low permittivity and low loss material, with a relative permittivity ≤5 and a loss tangent ≤0.05.

5.6 Scanning Procedure

The DASY5 installation includes predefined files with recommended procedures for measurements and validation. They are read-only document files and destined as fully defined but unmeasured masks. All test positions (head or body-worn) are tested with the same configuration of test steps differing only in the grid definition for the different test positions.

The “reference” and “drift” measurements are located at the beginning and end of the batch process. They measure the field drift at one single point in the liquid over the complete procedure. The indicated drift is mainly the variation of the DUT’s output power and should vary max. ± 5 %.

The “surface check” measurement tests the optical surface detection system of the DASY5 system by repeatedly detecting the surface with the optical and mechanical surface detector and comparing the results. The output gives the detecting heights of both systems, the difference between the two systems and the standard deviation of the detection repeatability. Air bubbles or refraction in the liquid due to separation of the sugar-water mixture gives poor repeatability (above ± 0.1mm). To prevent wrong results tests are only executed when the liquid is free of air bubbles. The difference between the optical surface detection and the actual surface depends on the probe and is specified with each probe. (It does not depend on the surface reflectivity or the probe angle to the surface within ± 30°.)

Area Scan

The Area Scan is used as a fast scan in two dimensions to find the area of high field values before running a detailed measurement around the hot spot. Before starting the area scan a grid spacing is set according to FCC KDB Publication 865664. During scan the distance of the probe to the phantom remains unchanged. After finishing area scan, the field maxima within a range of 2 dB will be ascertained.

Zoom Scan

After the maximum interpolated values were calculated between the points in the cube, the SAR was averaged over the spatial volume (1g or 10g) using a 3D-Spline interpolation algorithm. The 3D-spline is composed of three one-dimensional splines with the “Not a knot” condition (in x, y, and z directions). The volume was then integrated with the trapezoidal algorithm.

Spatial Peak Detection

The procedure for spatial peak SAR evaluation has been implemented and can determine values of masses of 1g and 10g, as well as for user-specific masses. The DASY5 system allows evaluations that combine measured data and robot positions, such as:

• maximum search
• extrapolation
• boundary correction
• peak search for averaged SAR

During a maximum search, global and local maxima searches are automatically performed in 2-D after each Area Scan measurement with at least 6 measurement points. It is based on the evaluation of the local SAR gradient calculated by the Quadratic Shepard’s method. The algorithm will find the global maximum and all local maxima within -2 dB of the global maxima for all SAR distributions.

Extrapolation routines are used to obtain SAR values between the lowest measurement points and the inner phantom surface. The extrapolation distance is determined by the surface detection distance and the probe sensor offset. Several measurements at different distances are necessary for the extrapolation. Extrapolation routines require at least 10 measurement points in 3-D space.

They are used in the Zoom Scan to obtain SAR values between the lowest measurement points and the inner phantom surface. The routine uses the modified Quadratic Shepard’s method for extrapolation.

A Z-axis scan measures the total SAR value at the x-and y-position of the maximum SAR value found during the cube scan. The probe is moved away in z-direction from the bottom of the SAM phantom in 5mm steps.

Area and Zoom Scan Resolutions per FCC KDB Publication 865664 D01

Frequency	Maximum Area Scan Resolution (mm) (Δxarea, Δyarea)	Maximum Zoom Scan Resolution (mm) (Δxzoom, Δyzoom)	Maximum Zoom Scan Spatial Resolution (mm) Δzzoom(n)	Minimum Zoom Scan Volume (mm) (x,y,z)
≤2 GHz	≤15	≤8	≤5	≥30
2-3 GHz	≤12	≤5	≤5	≥30
3-4 GHz	≤12	≤5	≤4	≥28
4-5 GHz	≤10	≤4	≤3	≥25
5-6 GHz	≤10	≤4	≤2	≥22

5.7 Data Storage and Evaluation

5.7.1 Data Storage

The DASY5 software stores the acquired data from the data acquisition electronics as raw data (in microvolt readings from the probe sensors), together with all necessary software parameters for the data evaluation (probe calibration data, liquid parameters and device frequency and modulation data) in measurement files with the extension ".DAE4". The software evaluates the desired unit and format for output each time the data is visualized or exported. This allows verification of the complete software setup even after the measurement and allows correction of incorrect parameter settings. For example, if a measurement has been performed with a wrong crest factor parameter in the device set up, the parameter can be corrected afterwards and the data can be re-evaluated.
The measured data can be visualized or exported in different units or formats, depending on the selected probe type ([V/m], [A/m], [°C], [mW/g], [mW/cm²], [dBrel], etc.). Some of these units are not available in certain situations or show meaningless results, e.g., a SAR output in a loss less media will always be zero. Raw data can also be exported to perform the evaluation with other software packages.

5.7.2 Data Evaluation by SEMCAD

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

Probe parameters: - Sensitivity $Norm_i$, a_{i0}, a_{i1}, a_{i2}

- Conversion factor $ConvF_i$

- Diode compression point Dcp_i

Device parameters: - Frequency f

- Crest factor cf

Media parameters: - Conductivity
- Density

These parameters must be set correctly in the software. They can be found in the component documents or they can be imported into the software from the configuration files issued for the DASY5 components. In the direct measuring mode of the multimeter option, the parameters of the actual system setup are used. In the scan visualization and export modes, the parameters stored in the corresponding document files are used.

The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics.

If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power. The formula for each channel can be given as:

$\mathbf{V_i = U_i + U_i^2 \cdot c\,f / dcp_i}$

With $\mathbf{V_i}$ = compensated signal of channel i (i = x, y, z)

$\mathbf{U_i}$ = input signal of channel i (i = x, y, z)

cf = crest factor of exciting field (DASY parameter)

$\mathbf{dcp_i}$ = diode compression point (DASY parameter)

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

evaluated:

E-field probes: $\mathbf{E_i = (V_i / Norm_i \cdot ConvF)^{1/2}}$

H-field probes: $\mathbf{H_i = (V_i)^{1/2} \cdot (a_{i0} + a_{i1}\,f + a_{i2}f^2) / f}$

With $\mathbf{V_i}$ = compensated signal of channel i (i = x, y, z)

$\mathbf{Norm_i}$ = sensor sensitivity of channel i (i = x, y, z)

[mV/(V/m)2] for E-field Probes

ConvF = sensitivity enhancement in solution

$\mathbf{a_{ij}}$ **=** sensor sensitivity factors for H-field probes

f = carrier frequency [GHz]

$\mathbf{E_i}$ = electric field strength of channel i in V/m

$\mathbf{H_i}$ = magnetic field strength of channel i in A/m

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

$\mathbf{E_{tot} = (E_x^2 + E_Y^2 + E_z^2)^{1/2}}$

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

$\mathbf{SAR = (E_{tot})\ 2 \cdot \sigma / (\rho \cdot 1000)}$

with **SAR** = local specific absorption rate in mW/g

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

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

= equivalent tissue density in g/cm^3

Note that the density is normally set to 1 (or 1.06), to account for actual brain density rather than the density of the simulation liquid. The power flow density is calculated assuming the excitation field to be a free space field.

$\mathbf{P_{pwe} = E_{tot}^2 / 3770}$ **or** $\mathbf{P_{pwe} = H_{tot}^2 \cdot 37.7}$

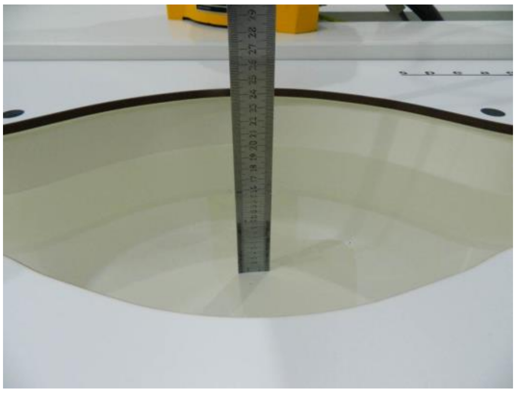
with $\mathbf{P_{pwe}}$ = equivalent power density of a plane wave in mW/cm^2

$\mathbf{E_{tot}}$ = total electric field strength in V/m; $\mathbf{H_{tot}}$ = total magnetic field strength in A/m

6. Tissue Simulating Liquids

6.1 Composition of Tissue Simulating Liquid

For the measurement of the field distribution inside the SAM phantom with SMTIMO, the phantom must be filled with around 25 liters of homogeneous body tissue simulating liquid. For head SAR testing, the liquid height from the ear reference point (ERP) of the phantom to the liquid top surface is larger than 15 cm. For body SAR testing, the liquid height from the center of the flat phantom to the liquid top surface is larger than 15 cm. Please see the following photos for the liquid height.



Liquid Height for Head SAR

Liquid Height for Body SAR

The Composition of Tissue Simulating Liquid

Frequency (MHz)	Water (%)	Salt (%)	Sugar (%)	HEC (%)	Preventol (%)	DGBE (%)
Head						
2450	62.7	0.5	0	0	0	36.8
Body						
2450	73.2	0.04	0	0	0	26.7

6.2 Tissue Dielectric Parameters for Head and Body Phantoms

The head tissue dielectric parameters recommended by the IEEE SCC-34/SC-2 in P1528 have been incorporated in the following table. These head parameters are derived from planar layer models simulating the highest expected SAR for the dielectric properties and tissue thickness variations in a human head. Other head and body tissue parameters that have not been specified in P1528 are derived from the tissue dielectric parameters computed from the 4-Cole-Cole equations described in Reference [12] and extrapolated according to the head parameters specified in P1528.

Target Frequency (MHz)	Head		Body	
	Conductivity (σ)	Permittivity (ε_r)	Conductivity (σ)	Permittivity (ε_r)
150	0.76	52.3	0.80	61.9
300	0.87	45.3	0.92	58.2
450	0.87	43.5	0.94	56.7
750	0.89	41.9	0.96	55.5
835	0.90	41.5	0.97	55.2
900	0.97	41.5	1.05	55.0
915	0.98	41.5	1.06	55.0
1450	1.20	40.5	1.30	54.0
1610	1.29	40.3	1.40	53.8
1800-2000	1.40	40.0	1.52	53.3
2450	1.80	39.2	1.95	52.7

3000	2.40	38.5	2.73	52.0
5800	5.27	35.3	6.00	48.2

6.3 Tissue Calibration Result

The dielectric parameters of the liquids were verified prior to the SAR evaluation using COMOSAR Dielectric Probe Kit and an Agilent Network Analyzer.

Calibration Result for Dielectric Parameters of Tissue Simulating Liquid:

Head Tissue Simulating Liquid									
Freq. MHz.	Temp. (℃)	Conductivity			Permittivity			Limit (%)	Date
		Reading (σ)	Target (σ)	Delta (%)	Reading (εr)	Target (εr)	Delta (%)		
2450	22.5	1.81	1.80	0.56	37.40	39.20	-4.59	±5	01.07.2017

Body Tissue Simulating Liquid									
Freq. MHz.	Temp. (℃)	Conductivity			Permittivity			Limit (%)	Date
		Reading (σ)	Target (σ)	Delta (%)	Reading (εr)	Target (εr)	Delta (%)		
2450	21.3	2.03	1.95	4.10	52.96	52.70	0.49	±5	03.07.2017

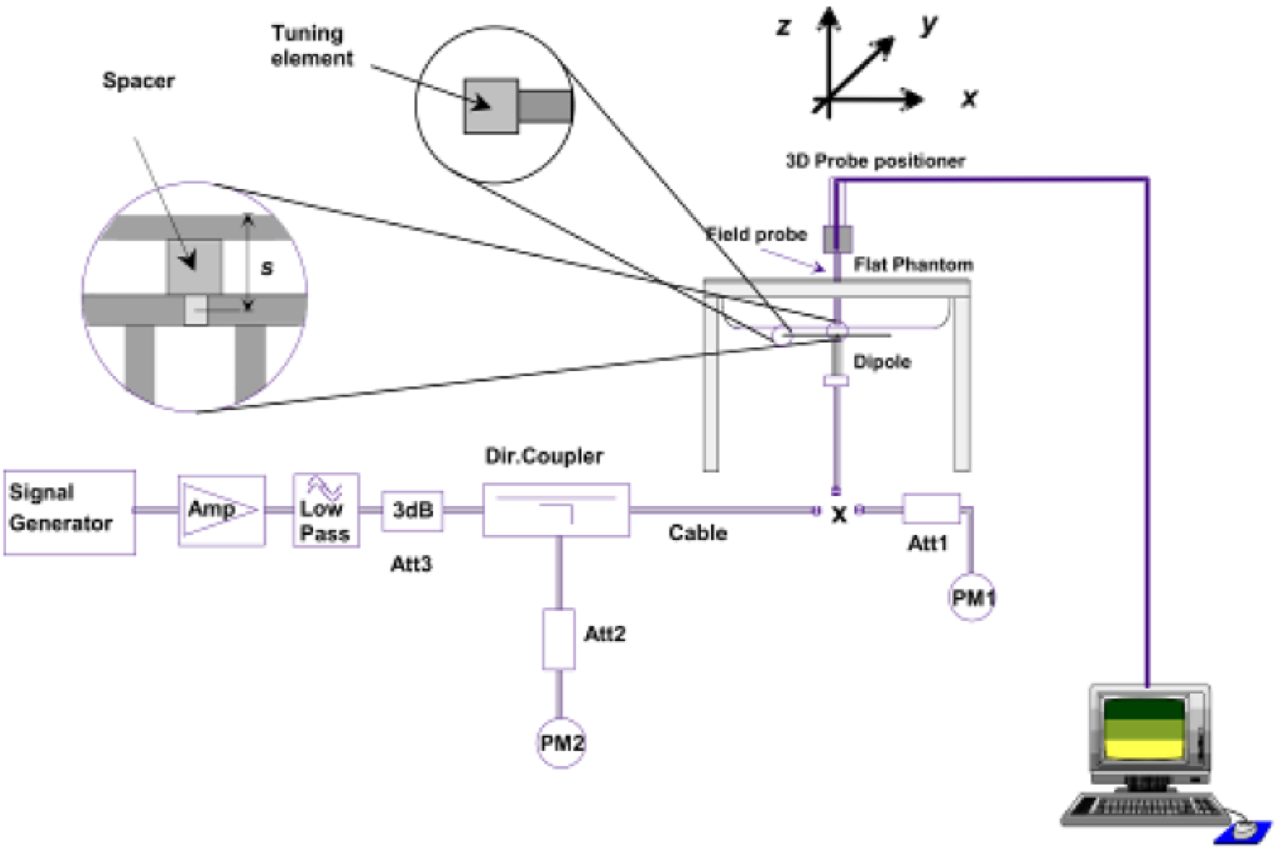
7. SAR Measurement Evaluation

7.1 Purpose of System Performance Check

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

7.2 System Setup

In the simplified setup for system evaluation, the EUT is replaced by a calibrated dipole and the power source is replaced by a continuous wave which comes from a signal generator at frequency 835 MHz and 1900 MHz. The calibrated dipole must be placed beneath the flat phantom section of the SAM twin phantom with the correct distance holder. The distance holder should touch the phantom surface with a light pressure at the reference marking and be oriented parallel to the long side of the phantom.



System Verification Setup Block Diagram

Setup Photo of Dipole Antenna

The output power on dipole port must be calibrated to 24 dBm (250 mW) before dipole is connected.

7.3 System Check

The system check is performed for verifying the accuracy of the complete measurement system and performance of the software. The system check is perforemed with tissue equivalent material according to IEEE P1528 (decribed above). The following tablet shows system check results for the frequency band and tissue luquid used during the tests.

Frequency MHz	Liquid Temp.	Input Power (mW)	Targeted SAR_{1g} (W/kg)	Measured SAR_{1g} (W/kg)	Normalized SAR_{1g} (W/kg)	Deviation (With in +/- 10%)
Head (Date: 01.07.2017)						
2450	21.5	250	52.3	13.3	53.2	1.72
Body (Date: 03.07.2017)						
2450	21.4	250	51.2	12.4	49.6	-3.13

System Check Results of Targeted and Measurement SAR

8. EUT Testing Position

The DUT is tested using a Wireless communications tester as controller unit to set test channels and maximum output power to the DUT, as well as for measuring the conducted peak power.

8.1 Test Positions Configuration

8.1.1 General considerations

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

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

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

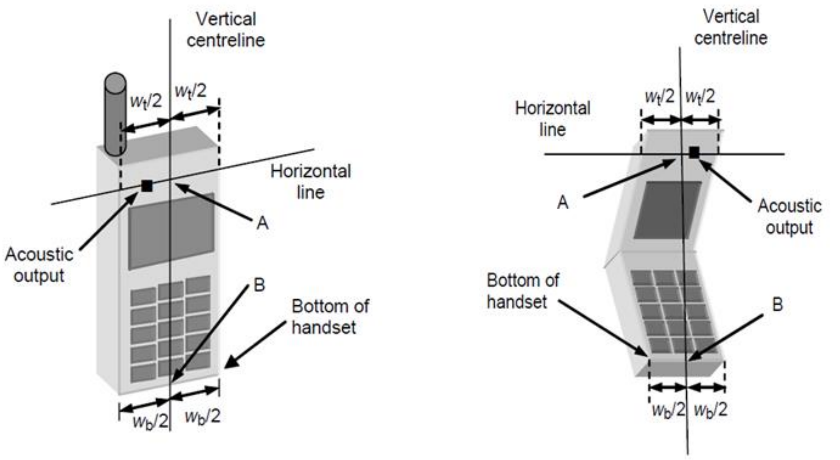


Illustration for Hand Vertical Center & Horizontal Line Reference Points

Note
wt Width of the handset at the level of the acoustic output
wb Width of the bottom of the handset
A Midpoint of the width wt of the handset at the level of the acoustic output
B Midpoint of the width wb of the bottom of the handset

8.1.2 Cheek Position

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

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

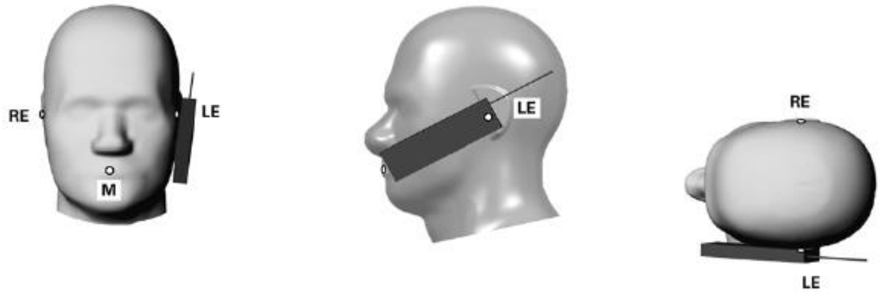


Illustration for Cheek Position

8.1.3 Tilted Position

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

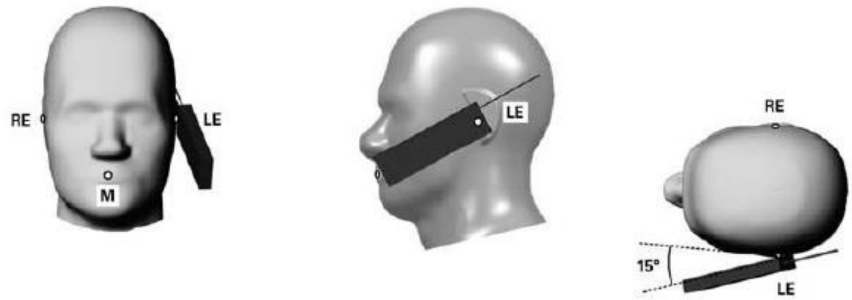


Illustration for Tilted Position

8.1.4 Body Worn Position

Body-worn operating configurations are tested with the holder attached to the device and positioned against a flat phantom with test separation distance of 0mm in a normal user configuration. Devices that are designed to operate in front of a person’s face, as in oush-to-tak configurations, are tested for SAR compliance with the front of the device positioned to face the flat phantom in head liquid. For devices that are carried next to the body such as a shoulder, waist or chest-worn transmitters, SAR comlicance is tested with the accessories, including headsets and microphones, attached to the device and positioned against a flat phantom in a normal use configuration.

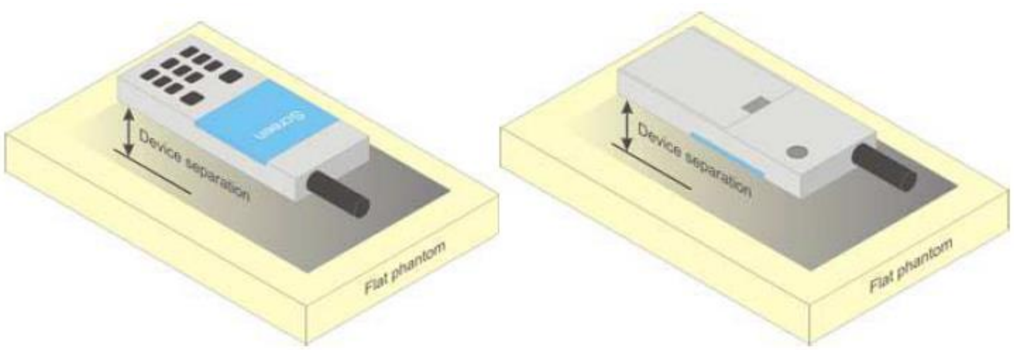
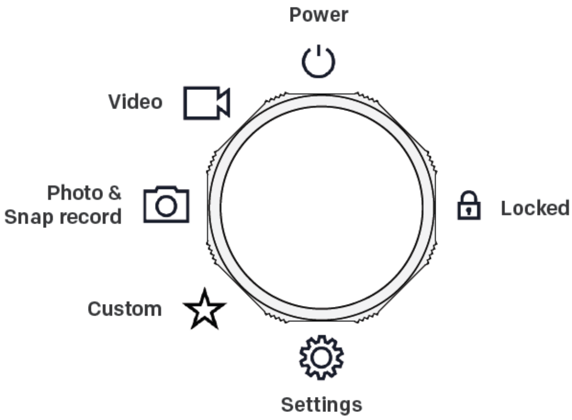


Illustration for Body Worn Position

8.2 EUT Antenna Position and accessories

Block Diagram for EUT Antenna Position

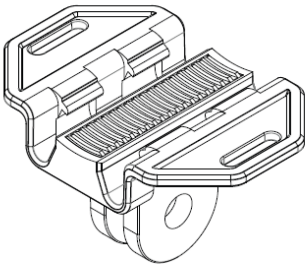


8 Track sides of EUT

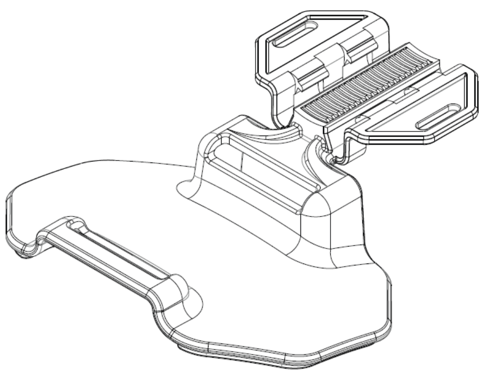
(Note: Track side 1 is the side that power indicator on it, and track side 1 to track side 8 in the clockwise direction)

8.2.1 Accessories

There are two mounts provided by manufacturer, the universal mount and the mask mount containing metallic componenets. The universal mount enables the users to use most of the existing accessories on the market, the mask mount is designed to fit all regular diving masks.



Universal Mount



Mask Mount

8.2.2 EUT Testing Position

Head (flat phantom) / Body-worn mode SAR assessments are required for this device. This EUT was tested in different positions for different SAR test modes, more information as below:

Test position	Head SAR tests (Flat Phantom)	Body-worn SAR tests
Front Surface	N/A	N/A
Back Surface	N/A	Yes
Track Side 1	Yes	Yes
Track Side 2	Yes	Yes
Track Side 3	Yes	Yes
Track Side 4	Yes	Yes
Track Side 5	Yes	Yes
Track Side 6	Yes	Yes
Track Side 7	Yes	Yes
Track Side 8	Yes	Yes

Remark: the max power including tune-up tolerance is 15.5dBm=35.8mW of this device, and Per KDB 447498 D01 General RF Exposure Guidance v06 section 4.3.1, and the distance from front surface to the antenna is greater than 18.4mm, hence the front surface is satisfy with the SAR test exclusion.

9. Measurement Results

9.1 Conducted Power

2.4GHz WLAN - Maximum Average Conducted Power				
Test Mode	Data Rate	Channel No.	Frequency (MHz)	Average Conducted Power (dBm)
802.11b	1Mbps	CH 01	2412	15.06
		CH 06	2437	14.89
		CH 11	2462	**15.11**
802.11g	6Mbps	CH 01	2412	10.81
		CH 06	2437	11.01
		CH 11	2462	11.37
802.11n (20MHz)	MCS0	CH 01	2412	10.73
		CH 06	2437	11.02
		CH 11	2462	11.22

Remark:
1. Per KDB 248227 D01 v02r02, choose the highest output power channel to test SAR and determine further SAR exclusion.
2. SAR is not required for 802.11g/n when
a) KDB Publication 447498 D01 SAR test exclusion applies to the OFDM configuration.
b) The highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg.
3. Each channel should be tested at the lowest data rate, and repeated SAR measurement is required only when the measured SAR is ≥ 0.8 W/kg.
4. When the reported SAR is > 0.8 W/kg, SAR is required for that exposure configuration using the next highest measured output power channel. When any reported SAR is > 1.2 W/kg, SAR is required for the third channel; i.e., all channels require testing.

Bluetooth - Maximum Average Power				
Frequency (MHz)	Data Rate	Channel No.	Average Conducted Power	
			(dBm)	(mW)
2402	1.0 Mbps	0	8.05	6.38
2441	1.0 Mbps	39	**8.15**	**6.53**
2480	1.0 Mbps	78	8.11	6.47
2402	2.0 Mbps	0	4.11	2.77
2441	2.0 Mbps	39	4.14	2.59
2480	2.0 Mbps	78	4.06	2.55
2402	3.0 Mbps	0	4.01	2.52
2441	3.0 Mbps	39	4.04	2.54
2480	3.0 Mbps	78	3.95	2.48
For Bluetooth BLE				
2402	1.0 Mbps	0	6.11	4.08
2440	1.0 Mbps	19	6.25	4.22
2480	1.0 Mbps	39	7.78	6.00

Figure of Bluetooth Transmission Plot

Bluetooth Duty Cycle Calculation:

$$Dutycycle = pulse\frac{width}{period}*100\% = \frac{2.887ms}{3.7565ms}*100\% = 76.9\%$$

Remark:
1. Each channel should be tested at the lowest data rate, and repeated SAR measurement is required only when the measured SAR is ≥ 0.8 W/kg.
2. When the reported SAR is > 0.8 W/kg, SAR is required for that exposure configuration using the next highest measured output power channel. When any reported SAR is > 1.2 W/kg, SAR is required for the third channel; i.e., all channels require testing.

9.2 Test Results for Standalone SAR Test

9.2.1 Head SAR – Flat Phantom with 0 mm test distance

2.4GHz WLAN – Head SAR Test										
Plot No.	Mode	Test Position	Frequency		Output Power (dBm)	Max. Tune-up power (dBm)	Power Drift (dB)	Scaling Factor (Power)	SAR1g (W/kg)	Reported SAR1g (W/kg)
			CH No.	MHz						
/	802.11 b	Track side 1	11	2462	15.11	15.50	0.13	1.086	0.062	0.067
/	802.11 b	Track side 2	11	2462	15.11	15.50	0.17	1.086	0.057	0.062
/	802.11 b	Track side 3	11	2462	15.11	15.50	0.21	1.086	0.077	0.084
Yes	802.11 b	Track side 4	11	2462	15.11	15.50	-0.14	1.086	0.092	**0.100**
/	802.11 b	Track side 5	11	2462	15.11	15.50	-0.17	1.086	0.083	0.090
/	802.11 b	Track side 6	11	2462	15.11	15.50	0.12	1.086	0.080	0.087
/	802.11 b	Track side 7	11	2462	15.11	15.50	0.21	1.086	0.043	0.047
/	802.11 b	Track side 8	11	2462	15.11	15.50	0.05	1.086	0.053	0.058
/	802.11 b	Track side 4 with Mask Mount	11	2462	15.11	15.50	-0.11	1.086	0.089	0.097

Bluetooth – Head SAR Test												
Plot No.	Mode	Test Position	Frequency		Output Power (dBm)	Max. Tune-up power (dBm)	Power Drift (dB)	Duty Cycle (%)	Scaling Factor (Power)	Scaling Factor (Duty Cycle)	SAR1g (W/kg)	Reported SAR1g (W/kg)
			CH No.	MHz								
/	BT	Track side 1	39	2441	8.15	8.50	0.18	76.9	1.083	1.300	0.070	0.099
/	BT	Track side 2	39	2441	8.15	8.50	0.11	76.9	1.083	1.300	0.085	0.120
/	BT	Track side 3	39	2441	8.15	8.50	0.09	76.9	1.083	1.300	0.075	0.106
Yes	BT	Track side 4	39	2441	8.15	8.50	-0.12	76.9	1.083	1.300	0.089	**0.125**
/	BT	Track side 5	39	2441	8.15	8.50	0.25	76.9	1.083	1.300	0.061	0.086
/	BT	Track side 6	39	2441	8.15	8.50	0.22	76.9	1.083	1.300	0.065	0.092
/	BT	Track side 7	39	2441	8.15	8.50	0.17	76.9	1.083	1.300	0.068	0.096
/	BT	Track side 8	39	2441	8.15	8.50	-0.18	76.9	1.083	1.300	0.053	0.075
/	BT	Track side 4 with Mask Mount	39	2441	8.15	8.50	-0.14	76.9	1.083	1.300	0.087	0.122

Remark:
1. Per KDB 447498 D01 v06, if the highest output channel SAR for each exposure position ≤ 0.8 W/kg other channels SAR tests are not necessary.
2. Repeated measurement is not required when the original highest measured SAR is < 0.80 W/kg.

9.2.2 Body-worn SAR – with 0 mm test distance

2.4GHz WLAN – Body SAR Test										
Plot No.	Mode	Test Position	Frequency		Output Power (dBm)	Max. Tune-up power (dBm)	Power Drift (dB)	Scaling Factor (Power)	SAR1g (W/kg)	Reported SAR1g (W/kg)
			CH No.	MHz						
/	802.11 b	Track side 1	11	2462	15.11	15.50	0.12	1.086	0.058	0.063
/	802.11 b	Track side 2	11	2462	15.11	15.50	0.21	1.086	0.063	0.068
/	802.11 b	Track side 3	11	2462	15.11	15.50	0.44	1.086	0.061	0.066
/	802.11 b	Track side 4	11	2462	15.11	15.50	0.31	1.086	0.098	0.106
/	802.11 b	Track side 5	11	2462	15.11	15.50	0.25	1.086	0.073	0.079
/	802.11 b	Track side 6	11	2462	15.11	15.50	0.17	1.086	0.053	0.058
/	802.11 b	Track side 7	11	2462	15.11	15.50	-0.17	1.086	0.048	0.052
/	802.11 b	Track side 8	11	2462	15.11	15.50	-0.09	1.086	0.056	0.061
Yes	802.11 b	Back Surface	11	2462	15.11	15.50	0.15	1.086	0.141	**0.153**
/	802.11 b	Back Surface with Universal Mount	11	2462	15.11	15.50	0.23	1.086	0.136	0.148

Bluetooth – Body SAR Test												
Plot No.	Mode	Test Position	Frequency		Output Power (dBm)	Max. Tune-up power (dBm)	Power Drift (dB)	Duty Cycle (%)	Scaling Factor (Power)	Scaling Factor (Duty Cycle)	SAR1g (W/kg)	Reported SAR1g (W/kg)
			CH No.	MHz								
/	BT	Track side 1	39	2441	8.15	8.50	-0.12	76.9	1.083	1.300	0.068	0.096
/	BT	Track side 2	39	2441	8.15	8.50	-0.18	76.9	1.083	1.300	0.058	0.082
/	BT	Track side 3	39	2441	8.15	8.50	0.17	76.9	1.083	1.300	0.074	0.104
/	BT	Track side 4	39	2441	8.15	8.50	0.25	76.9	1.083	1.300	0.087	0.122
/	BT	Track side 5	39	2441	8.15	8.50	-0.09	76.9	1.083	1.300	0.063	0.089
/	BT	Track side 6	39	2441	8.15	8.50	0.31	76.9	1.083	1.300	0.048	0.068
/	BT	Track side 7	39	2441	8.15	8.50	-0.08	76.9	1.083	1.300	0.051	0.072
/	BT	Track side 8	39	2441	8.15	8.50	0.31	76.9	1.083	1.300	0.079	0.111
Yes	BT	Back Surface	39	2441	8.15	8.50	0.28	76.9	1.083	1.300	0.101	**0.142**
/	BT	Back Surface with Universal Mount	39	2441	8.15	8.50	0.11	76.9	1.083	1.300	0.098	0.138

Remark:
1. The eyelet of EUT was cut when preformed the body-worn SAR testing for the conservative consideration.
2. Per KDB 447498 D01 v06, if the highest output channel SAR for each exposure position ≤ 0.8 W/kg other channels SAR tests are not necessary.
3. Repeated measurement is not required when the original highest measured SAR is < 0.80 W/kg.

9.3 Simultaneous Transmission SAR Analysis

Since the 2.4GHz and Bluetooth use the same one ant and cann’t transmit simultaneously, hence the simultaneous transmission SAR is not applicable.

10. Measurement Uncertainty

The component of uncertainly may generally be categorized according to the methods used to evaluate them. The evaluation of uncertainly by the statistical analysis of a series of observations is termed a Type An evaluation of uncertainty. The evaluation of uncertainty by means other than the statistical analysis of a series of observation is termed a Type B evaluation of uncertainty. Each component of uncertainty, however evaluated, is represented by an estimated standard deviation, termed standard uncertainty, which is determined by the positive square root of the estimated variance.

A Type A evaluation of standard uncertainty may be based on any valid statistical method for treating data. This includes calculating the standard deviation of the mean of a series of independent observations; using the method of least squares to fit a curve to the data in order to estimate the parameter of the curve and their standard deviations; or carrying out an analysis of variance in order to identify and quantify random effects in certain kinds of measurement.

A type B evaluation of standard uncertainty is typically based on scientific judgment using all of the relevant information available. These may include previous measurement data, experience, and knowledge of the behavior and properties of relevant materials and instruments, manufacture's specification, data provided in calibration reports and uncertainties assigned to reference data taken from handbooks. Broadly speaking, the uncertainty is either obtained from an outdoor source or obtained from an assumed distribution, such as the normal distribution, rectangular or triangular distributions indicated in table below.

Uncertainty Distributions	Normal	Rectangluar	Triangular	U-Shape
Multi-plying Factor[(a)]	1/K[(b)]	1/√3	1/√6	1/√2

(a) standard uncertainty is determined as the product of the multiplying factor and the estimated range of variations in the measured quantity
(b) K is the coverage factor

The combined standard uncertainty of the measurement result represents the estimated standard deviation of the result. It is obtained by combining the individual standard uncertainties of both Type A and Type B evaluation using the usual "root-sum-squares" (RSS) methods of combining standard deviations by taking the positive square root of the estimated variances.

Expanded uncertainty is a measure of uncertainty that defines an interval about the measurement result within which the measured value is confidently believed to lie. It is obtained by multiplying the combined standard uncertainty by a coverage factor. Typically, the coverage factor ranges from 2 to 3. Using a coverage factor allows the true value of a measured quantity to be specified with a defined probability within the specified uncertainty range. For purpose of this document, a coverage factor two is used, which corresponds to confidence interval of about 95 %. The DASY uncertainty Budget is shown in the following tables.

No.	Description	Type	Uncertainty Value(%)	Probably Distribution	Div.	(Ci) 1g	(Ci) 10g	Std. Unc. (1g)	Std. Unc. (10g)	Degree of freedom
Measurement system										
1	Probe calibration	B	6	N	1	1	1	6	6	∞
2	Isotropy	B	3.0	R	$\sqrt{3}$	0.7	0.7	1.2	1.2	∞
3	Boundary effect	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
4	Linearity	B	4.7	R	$\sqrt{3}$	1	1	2.7	2.7	∞
5	Detection limit	B	1.0	N	1	1	1	0.6	0.6	∞
6	Readout electronics	B	0.3	R	$\sqrt{3}$	1	1	0.3	0.3	∞
7	Response time	B	0.8	R	$\sqrt{3}$	1	1	0.5	0.5	∞
8	Integration time	B	2.6	R	$\sqrt{3}$	1	1	1.5	1.5	∞
9	RF ambient conditions-noise	B	0	R	$\sqrt{3}$	1	1	0	0	∞
10	RF ambient conditions-reflection	B	0	R	$\sqrt{3}$	1	1	0	0	∞
11	Probe positioned mech. restrictions	B	0.4	R	$\sqrt{3}$	1	1	0.2	0.2	∞
12	Probe positioning with respect to phantom shell	B	2.9	R	$\sqrt{3}$	1	1	1.7	1.7	∞
13	Post-processing	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
Test sample related										
14	Test sample positioning	A	3.3	N	1	1	1	3.3	3.3	71
15	Device holder uncertainty	A	3.4	N	1	1	1	3.4	3.4	5
16	Drift of output power	B	3.0	R	$\sqrt{3}$	1	1	1.7	1.7	∞
Phantom and set-up										
17	Phantom uncertainty	B	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	∞
18	Liquid conductivity (target)	B	5.0	R	$\sqrt{3}$	0.64	0.43	1.8	1.2	∞
19	Liquid conductivity (meas.)	A	2.06	N	1	0.64	0.43	1.32	0.89	43
20	Liquid permittivity (target)	B	5.0	R	$\sqrt{3}$	0.6	0.49	1.7	1.4	∞
21	Liquid permittivity (meas.)	A	1.6	N	1	0.6	0.49	1.0	0.8	521
continue										
Combined standard uncertainty		$u_c^{'} = \sqrt{\sum_{i=1}^{21} c_i^2 u_i^2}$						9.20	9.07	257
Expanded uncertainty (confidence interval of 95 %)		$u_e = 2u_c$						18.40	18.14	\

Uncertainty Budget for frequency range 300 MHz to 3 GHz

No.	Description	Type	Uncertainty Value(%)	Probably Distribution	Div.	(Ci) 1g	(Ci) 10g	Std. Unc. (1g)	Std. Unc. (10g)	Degree of freedom
Measurement system										
1	Probe calibration	B	6.6	N	1	1	1	6.6	6.6	∞
2	Isotropy	B	3.0	R	$\sqrt{3}$	0.7	0.7	1.2	1.2	∞
3	Boundary effect	B	2.0	R	$\sqrt{3}$	1	1	1.2	1.2	∞
4	Linearity	B	4.7	R	$\sqrt{3}$	1	1	2.7	2.7	∞
5	Detection limit	B	1.0	N	1	1	1	0.6	0.6	∞
6	Readout electronics	B	0.3	R	$\sqrt{3}$	1	1	0.3	0.3	∞
7	Response time	B	0.8	R	$\sqrt{3}$	1	1	0.5	0.5	∞
8	Integration time	B	2.6	R	$\sqrt{3}$	1	1	1.5	1.5	∞
9	RF ambient conditions-noise	B	3.0	R	$\sqrt{3}$	1	1	1.7	1.7	∞
10	RF ambient conditions-reflection	B	3.0	R	$\sqrt{3}$	1	1	1.7	1.7	∞
11	Probe positioned mech. restrictions	B	0.8	R	$\sqrt{3}$	1	1	0.5	0.5	∞
12	Probe positioning with respect to phantom shell	B	4.7	R	$\sqrt{3}$	1	1	2.7	2.7	∞
13	Post-processing	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
Test sample related										
14	Test sample positioning	A	3.3	N	1	1	1	3.3	3.3	71
15	Device holder uncertainty	A	3.6	N	1	1	1	3.6	3.6	5
16	Drift of output power	B	3.0	R	$\sqrt{3}$	1	1	1.7	1.7	∞
Phantom and set-up										
17	Phantom uncertainty	B	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	∞
18	Liquid conductivity (target)	B	5.0	R	$\sqrt{3}$	0.64	0.43	1.8	1.2	∞
19	Liquid conductivity (meas.)	A	2.5	N	1	0.64	0.43	1.6	1.1	43
20	Liquid permittivity (target)	B	5.0	R	$\sqrt{3}$	0.6	0.49	1.7	1.4	∞
21	Liquid permittivity (meas.)	A	2.5	N	1	0.6	0.49	1.5	1.2	520
continue										
Combined standard uncertainty		$u_c' = \sqrt{\sum_{i=1}^{21} c_i^2 u_i^2}$						10.23	10.08	256
Expanded uncertainty (confidence interval of 95 %)		$u_e = 2u_c$						20.46	20.16	\

Uncertainty Budget for frequency range 3 GHz to 6 GHz

---END---