

1.6 Conducted Power Values FCC

Bluetooth BR only – Average Output Power	
Frequency [MHz]	Source-base time-average power [dBm] includes Tune up tolerance 2dB
	BR (GFSK)
	DH5
2402	4.4
2441	4.5
2480	3.1
Date, Operator:	10.04.2017 , W. Treffke

1.7 Radiated Power Values ISED

Bluetooth BR only – Average Output Power	
Frequency [MHz]	Source-base time-average power [dBm] includes Tune up tolerance 2 dB
	BR (GFSK)
	DH5
2402	6.4*
2441	6.5*
2480	5.1*
Date, Operator:	12.05.2017 , B. Pudell
*includes antenna gain: +2 dB	

1.8 Standalone Operational Mode Test Exclusion for FCC

According to KDB 447498 D01 v06 for standalone SAR evaluation the test exclusion power condition is given by

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

for test separation distance $\leq 50\text{mm}$. For test separation distances $> 50\text{mm}$, the SAR test exclusion threshold is:

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

$100 \text{ MHz} < f < 1500 \text{ MHz}$

$$P_{TH}[\text{mW}] = \text{Power allowed at numeric threshold for } 50\text{mm} + (\text{test distance, mm} - 50\text{mm}) \cdot 10,$$

$1500 \text{ MHz} < f < 6 \text{ GHz}$

SAR Test Exclusion															
Mode	P [mW]	Ant.	Reg.	EUT Edge											
				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]
BT-BR	2.82	-	FCC	60.21	198	21.21	41	10.85	21	18	35	83.3	429	8.81	17
Comments: All bold Threshold values are above the limit and have to be measured															
Date, Operator:		11.05.2017 , B. Pudell													

1.9 Standalone Operational Mode Exemption limits for IC

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of ≤5 mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
≤300	71 mW	101 mW	132 mW	162 mW	193 mW
450	52 mW	70 mW	88 mW	106 mW	123 mW
835	17 mW	30 mW	42 mW	55 mW	67 mW
1900	7 mW	10 mW	18 mW	34 mW	60 mW
2450	4 mW	7 mW	15 mW	30 mW	52 mW
3500	2 mW	6 mW	16 mW	32 mW	55 mW
5800	1 mW	6 mW	15 mW	27 mW	41 mW

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of 30 mm	At separation distance of 35 mm	At separation distance of 40 mm	At separation distance of 45 mm	At separation distance of ≥50 mm
≤300	223 mW	254 mW	284 mW	315 mW	345 mW
450	141 mW	159 mW	177 mW	195 mW	213 mW
835	80 mW	92 mW	105 mW	117 mW	130 mW
1900	99 mW	153 mW	225 mW	316 mW	431 mW
2450	83 mW	123 mW	173 mW	235 mW	309 mW
3500	86 mW	124 mW	170 mW	225 mW	290 mW
5800	56 mW	71 mW	85 mW	97 mW	106 mW

SAR Test Exclusion															
Mode	P [mW]	Ant. [dBi]	Reg.	EUT Edge											
				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]
BT-BR	4.46	2	IC	60.21	311	21.21	52.1	10.85	7.0	18	15.0	83.3	311	8.81	4.0
Comments: All bold Threshold values are above the limit and have to be measured															
Date, Operator:		11.05.2017 , B. Pudell													

1.10 Supported concurrent (multi-transmitter) operating modes

No multi-transmitter evaluation

1.11 Supported use cases

Use case	Distance to human body	corresponding test configuration
EUT placed at human body	0 mm (worst case)	body-worn device

1.12 Radio Test Modes

Mode	Settings
BT-TX	Mode = TX-DH5 Modulation = GFSK Duty cycle = 77% Power level = maximum Antenna = integrated

1.13 Test Positions

Position	Description
FRONT-0MM	EUT front side directly touching the phantom.
BACK-0MM	EUT back side directly touching the phantom.
TOP-0MM	EUT top side directly touching the phantom.
BOTTOM-0MM	EUT bottom side directly touching the phantom.
LEFT-0MM	EUT left side directly touching the phantom.
RIGHT-0MM	EUT left side directly touching the phantom.

1.14 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	2016-09	2017-09
Dosimetric E-Field Probe	Schmid & Partner	EX3DV4	EF00826	2016-09	2017-09
System Validation Kit	Schmid & Partner	D300V3	EF00299	2015-09	2018-09
System Validation Kit	Schmid & Partner	D450V3	EF00300	2015-09	2018-09
System Validation Kit	Schmid & Partner	D900V2	EF00281	2015-09	2018-09
System Validation Kit	Schmid & Partner	D1800V2	EF00282	2015-09	2018-09
System Validation Kit	Schmid & Partner	D1900V2	EF00283	2015-09	2018-09
System Validation Kit	Schmid & Partner	D2450V2	EF00284	2015-09	2018-09
System Validation Kit	Schmid & Partner	D5GHZV2	EF00827	2015-10	2018-10
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	2016-08	2019-08
Power sensor	Rohde & Schwarz	NRV-Z2	EF00125	2015-09	2017-09
RF signal generator	Rohde & Schwarz	SMP 02	EF00165	2015-05	2017-05
Insertion unit	Rohde & Schwarz	URV5-Z4	EF00322	2015-10	2017-10
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	2016-06	2017-06
Network Analyzer 300 kHz to 3 GHz	Agilent	8752C	EF00140	2016-06	2017-06
Dielectric Probe Kit	Agilent	85070C	EF00291	functional test	functional test
Dielectric Probe Kit	SPEAG	DAK-3.5	EF00945	2016-09	2017-09
DAK Measurement Software	SPEAG	DAKS	EF00965	-	-
Thermometer	LKM electronic GmbH	DTM3000	EF00967	2016-11	2017-11

2 Result Summary

447498 D01 General RF Exposure Guidance, RSS-102					
Product Specific Standard Section	Requirement – Test	Reference Method	Maximum SAR [W/kg]	Result	Remarks
447498 D01 General RF Exposure Guidance RSS-102 Section 3	Single-band conformity Body	KDB Publication 447498 KDB Publication 941225 KDB Publication 865664	0.060	PASS	
447498 D01 General RF Exposure Guidance RSS-102 Section 3	Single-band conformity Limbs	KDB Publication 447498 KDB Publication 941225 KDB Publication 865664	N/A		
447498 D01 General RF Exposure Guidance RSS-102 Section 3	Multi-band conformity	KDB Publication 447498 KDB Publication 941225 KDB Publication 865664	N/A	N/R	No concurrent transmission modes
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)

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

where

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

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

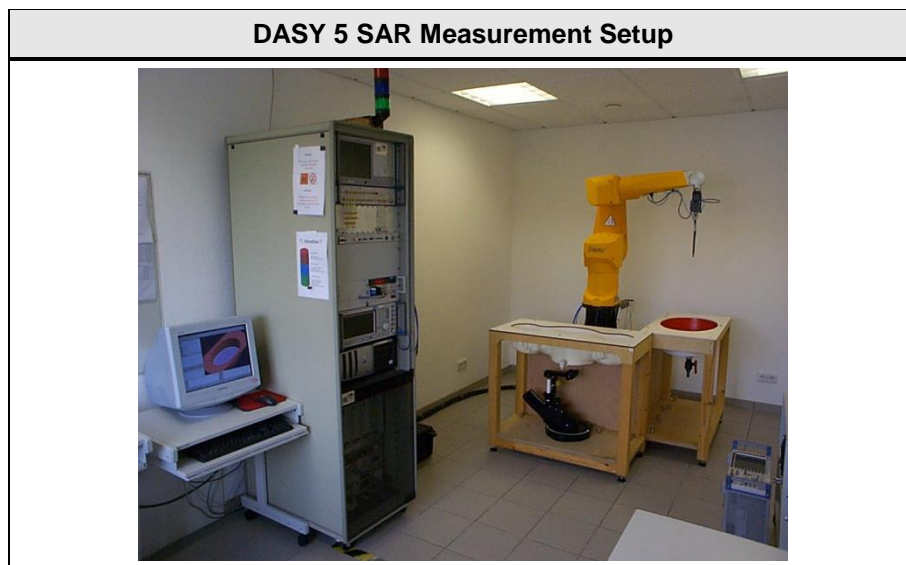
Compliance with the localized SAR limits is demonstrated using the head and trunk limit because this SAR limit is only half the limbs limit value. The values are obtained by SAR measurements according to EN 62209-2.

4 Localized SAR Measurement Equipment

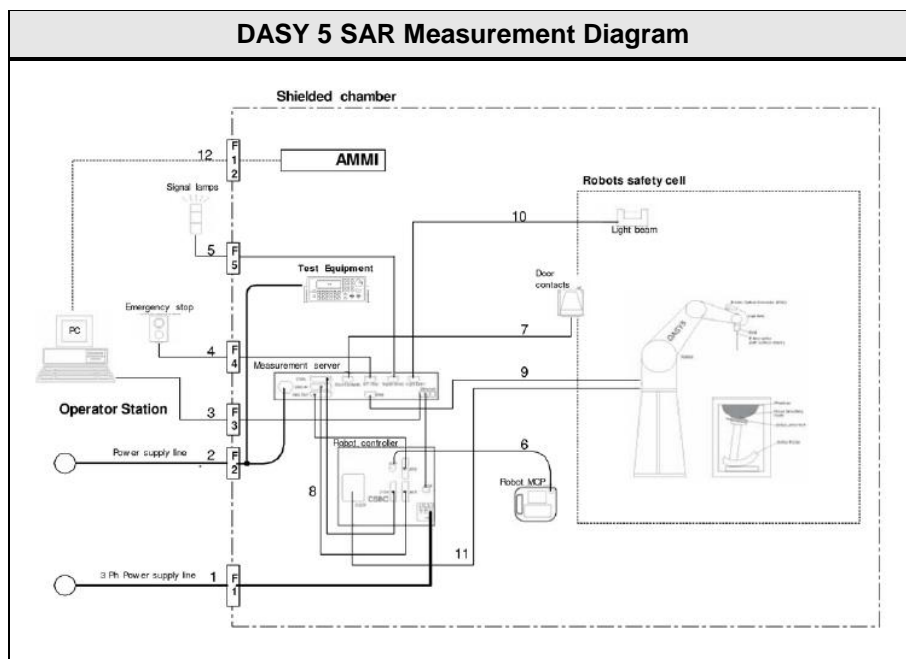
The measurements were performed with Dasy5 automated near-field scanning system comprised of high precision robot, robot controller, computer, e-field probe, probe alignment unit, phantoms, non-conductive phone positioned and software extension.

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.



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



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

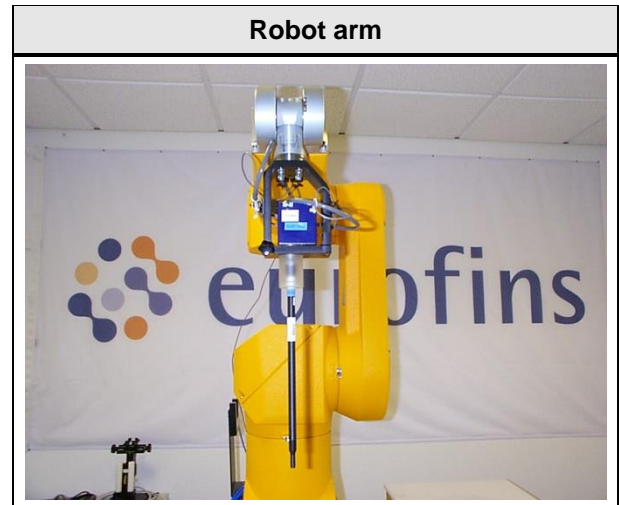
DASY5 SAR Measurement System	
Device	Description:
RX90BL	A standard high precision 6-axis robot (Stäubli RX family) with controller, teach pendant and software.
Probe Alignment Unit	A probe alignment unit which improves the (absolute) accuracy of the probe positioning.
Teach Pendant	The Manual Control 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

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:

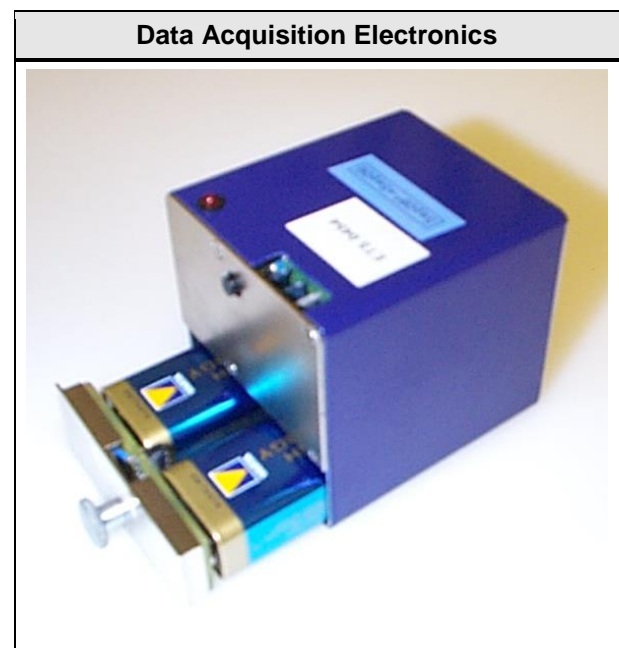
- High precision (repeatability 0.02 mm)
- High reliability (industrial design)
- Jerk-free straight movements
- Low ELF interference (the closed metallic construction shields against motor control fields)
- 6-axis controller



4.3 Data Acquisition Electronics

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 ≤ 6 GHz

Probe Specifications

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 2450, 5200, 5500, 5800

Frequency:

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

Directivity:

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

Dynamic Range:

10 μ W/g to > 100mW/g

Linearity:

± 0.2 dB

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



4.5 Test phantom and positioner

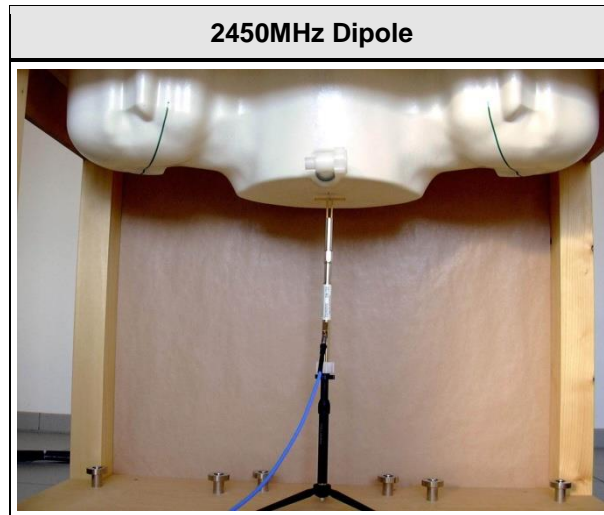
The positioner and test phantoms are manufactured by SPEAG. The test phantoms are used for all tests i.e. for both validation testing and device testing. The positioner and test phantom conforms to the requirements of EN 62209 and IEEE 1528.

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
	

4.6 System Validation Dipoles

A set of calibration dipoles (D2450V2) 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.



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, then 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:

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

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.)

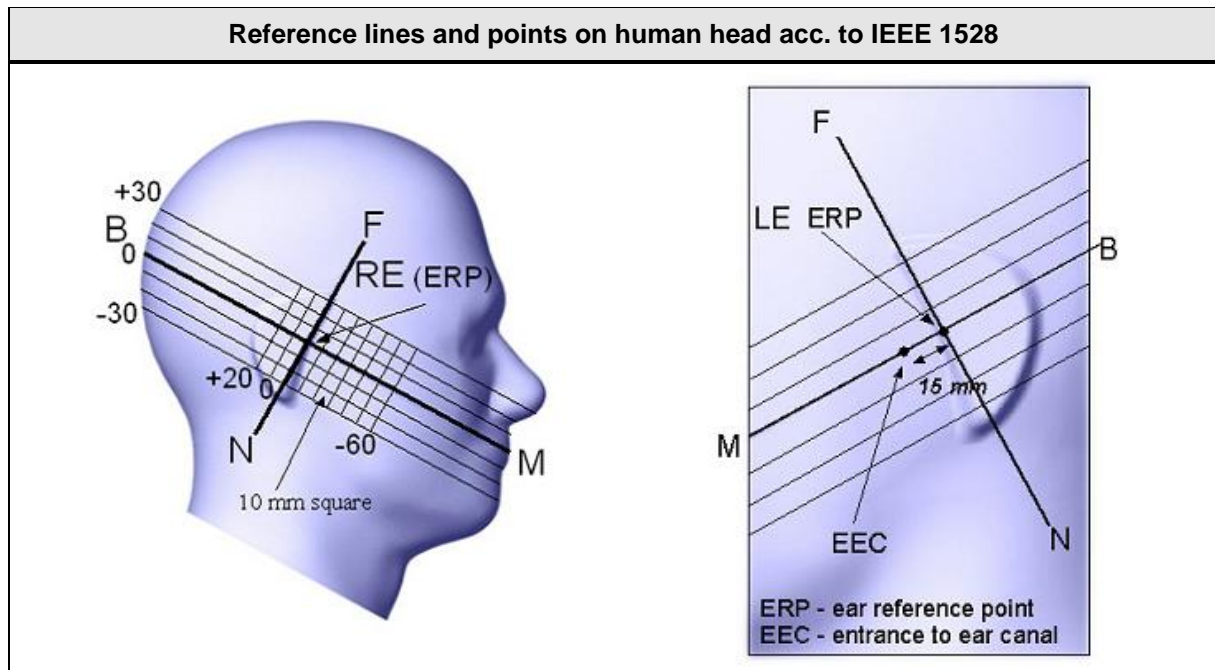
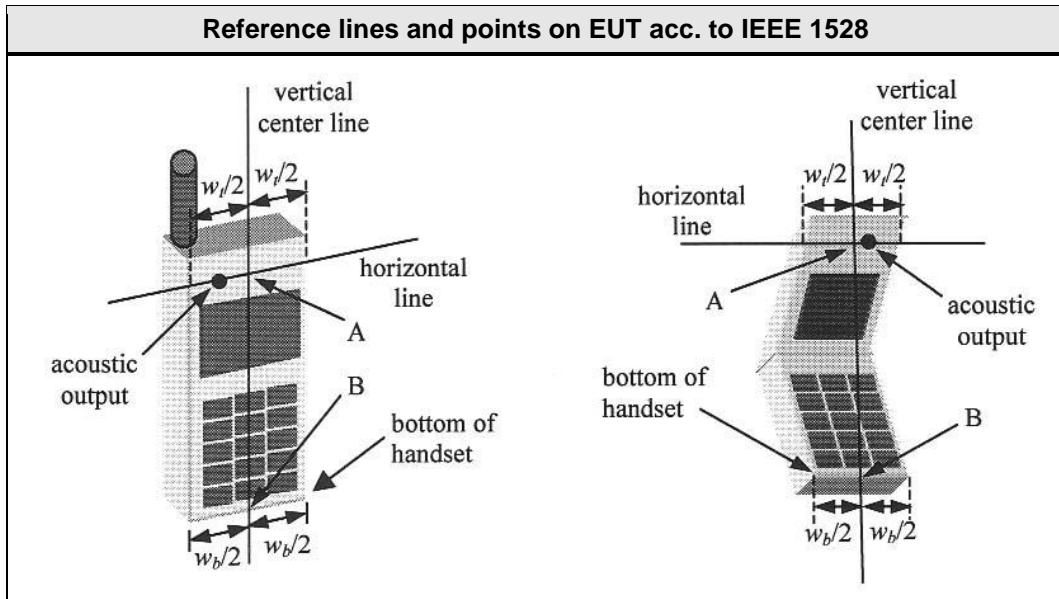
The zoom-scan volume constructed on the peak SAR position is scanned with a grid step of 5mm. The measured data are extracted and the local SAR value for each measurement point is calculated. The measured values are interpolated over a fine-mesh within the scan volume and the average SAR value over 10g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

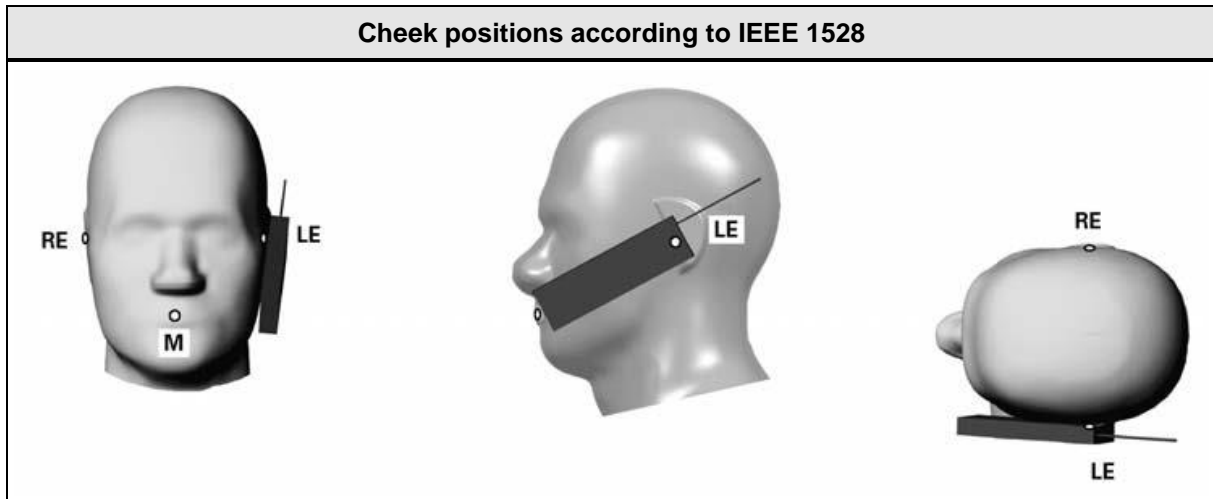
For all measurement positions of the EUT, the EUT has to be placed in a specific orientation with respect to the phantom. The orientation of the EUT relative to the phantom is defined by reference lines and points.

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



5.4 Test positions relative to the Head

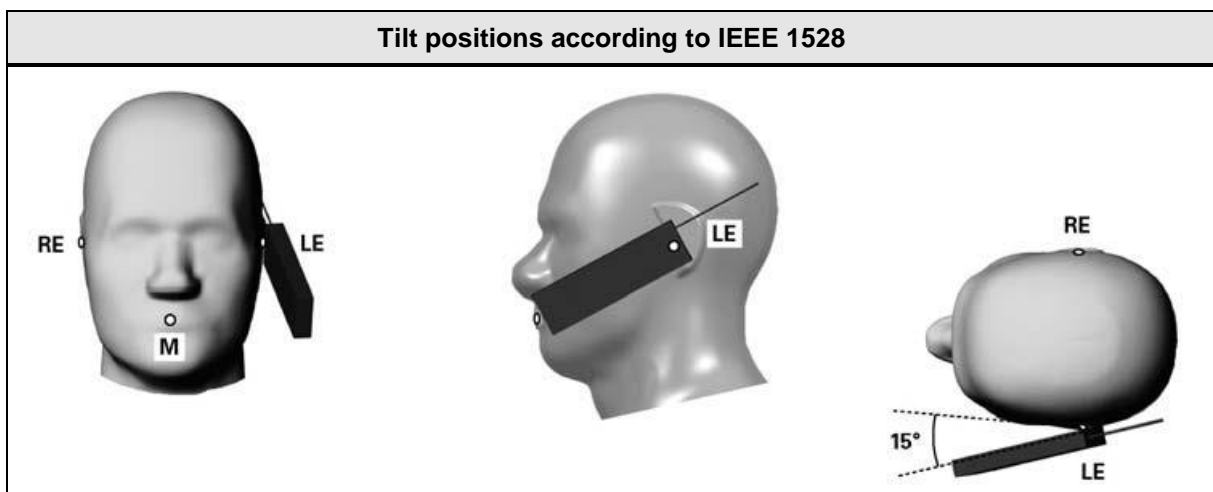
Cheek position



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.

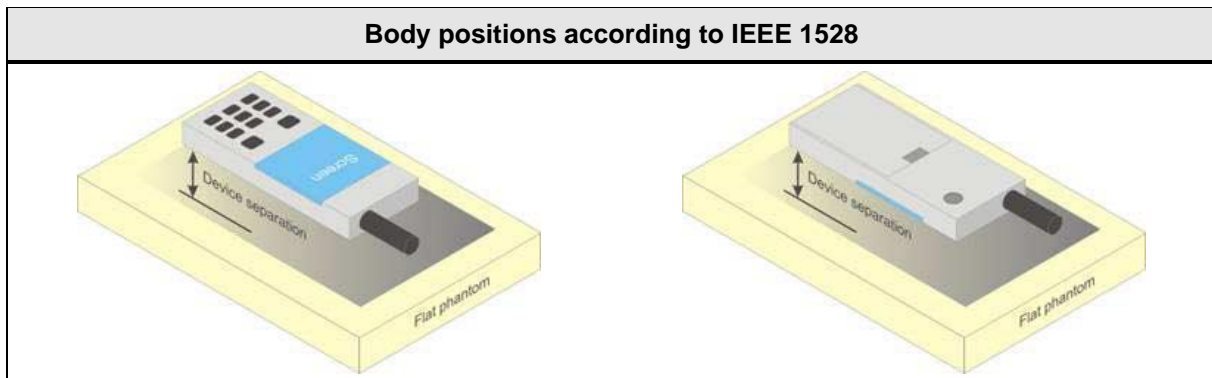
Tilt position



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



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).