

FCC SAR TEST REPORT

For

Dongguan Mingliang Electronic Technology Co., Ltd
Walkie-talkie

Model No.: ML-339

Listed Models : ML-686, ML-668, ML-336

Prepared For : Dongguan Mingliang Electronic Technology Co., Ltd
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TEST REPORT

Applicant : Dongguan Mingliang Electronic Technology Co., Ltd
Manufacturer : Dongguan Mingliang Electronic Technology Co., Ltd
Product Name : Walkie-talkie
Model No. : ML-339
Listed Models : ML-686, ML-668, ML-336
Trade Mark : N/A
Rating(s) : DC4.50V From Battery

**Test Standard(s) : IEEE Std 1528:2013; FCC 47 CFR Part 2 (2.1093:2013);
ANSI/IEEE C95.1:2005**

The device described above is tested by Shenzhen Anbotek Compliance Laboratory Limited to determine the maximum emission levels emanating from the device and the severe levels of the device can endure and its performance criterion. The measurement results are contained in this test report and Shenzhen Anbotek Compliance Laboratory Limited is assumed full of responsibility for the accuracy and completeness of these measurements. Also, this report shows that the EUT (Equipment Under Test) is technically compliant with the IEEE Std 1528:2013, FCC 47 CFR Part 2 (2.1093:2013), ANSI/IEEE C95.1:2005 requirements.

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

Date of Test

May 22, 2019-June 19, 2019

Prepared By



A handwritten signature in black ink that reads "Winkey Wang".

(Tested Engineer / Winkey Wang)

Reviewer

A handwritten signature in black ink that reads "Bobby Wang".

(Project Manager / Bobby Wang)

Approved & Authorized Signer

A handwritten signature in black ink that reads "Tom Chen".

(Manager / Tom Chen)

Version

Version No.	Date	Description
01	June 19, 2019	Original

1. Statement of Compliance

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

<Highest SAR Summary>

Mode	Channel Separation	Frequency (MHz)	Position	ISED	
				100% duty cycle	50% duty cycle
UHF	25KHz	467.6375	Face-held	0.358	0.209
UHF	25KHz	467.6375	Body-Worn	0.954	0.558

This device is in compliance with Specific Absorption Rate (SAR) for general Occupational exposure / Controlled environment limits (8.0 W/kg) specified in FCC 47 CFR part 2 (2.1093) and ANSI/IEEE C95.1-2005, and had been tested in accordance with the measurement methods and procedures specified in IEEE 1528-2013

2. General Information

2.1 Client Information

Applicant:	Dongguan Mingliang Electronic Technology Co., Ltd
Address of Applicant:	No.34, Ludong avenue, Humen town, Dongguan city, China
Manufacture:	Dongguan Mingliang Electronic Technology Co., Ltd
Address of Manufacture:	No.34, Ludong avenue, Humen town, Dongguan city, China

2.2 Testing Laboratory Information

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

2.3 Description of Equipment Under Test (EUT)

Equipment	Walkie-talkie
Brand Name	N/A
Model Name	ML-339
Listed Models	ML-686, ML-668, ML-336
Operation frequency range	462.5500 MHz –462.7250MHz, 467.5625 MHz –467.7125MHz
Tx Frequency	See NOTE table
Channel Separation	25kHz
Type of Modulation	FM
RF Rated Output power	0.5W
Power supply	DC4.50V From Battery
Exposure category:	General population
Category of device	Portable device
Remark:	
1.	The above DUT's information was declared by manufacturer. Please refer to the specifications or user's manual for more detailed description.

NOTE: Tx Frequency

Modulation Type	Test Channel	Channel Separation	Test Frequency (MHz)
Analog/FM	Ch1	25KHz	462.5625
	Ch2		462.5875
	Ch3		462.6125
	Ch4		462.6375
	Ch5		462.6625
	Ch6		462.6875
	Ch7		462.7125
	Ch8		467.5625
	Ch9		467.5875
	Ch10		467.6125
	Ch11		467.6375
	Ch12		467.6625
	Ch13		467.6875
	Ch14		467.7125
	Ch15		462.5500
	Ch16		462.5750
	Ch17		462.6000
	Ch18		462.6250
	Ch19		462.6500
	Ch20		462.6750
	Ch21		462.7000
	Ch22		462.7250

2. 4 Device Category and SAR Limits

This device belongs to portable device category because its radiating structure is allowed to be used within 20 centimeters of the body of the user. Limit for General Population/Uncontrolled exposure should be applied for this device, it is 8.0 W/kg as averaged over any 1 gram of tissue.

2. 5 Device Category and SAR Limits

This device belongs to portable device category because its radiating structure is allowed to be used within 20 centimeters of the body of the user. Limit for General Population/Uncontrolled exposure should be applied for this device, it is 8.0 W/kg as averaged over any 1 gram of tissue.

2. 6 Applied Standard

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

- FCC 47 CFR Part 2 (2.1093:2013)
- ANSI/IEEE C95.1:2005
- IEEE Std 1528:2013
- KDB 643646 D01 v01r03 (October 23, 2015): SAR Test reduction considerations for occupational PTT radio

2. 7 Environment of Test Site

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

2. 8 Test Configuration

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

3. Specific Absorption Rate (SAR)

3. 1 Introduction

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

3. 2 SAR Definition

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

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

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

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

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

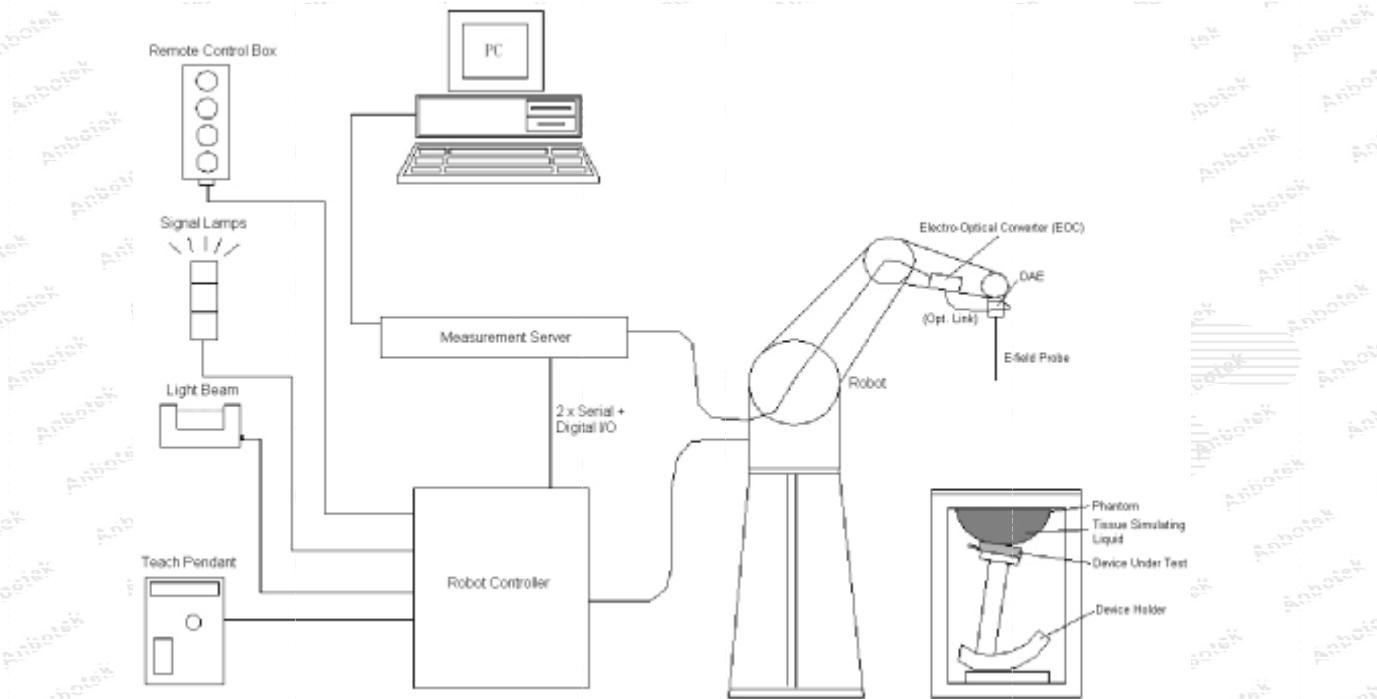
Where: C is the specific heat capacity, δT is the temperature rise and δt is the exposure duration, or related to the electrical field in the tissue by

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

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

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

4. SAR Measurement System



DASY System Configurations

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

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

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

4. 1 E-Field Probe

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

➤ E-Field Probe Specification

<EX3DV4 Probe>

Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)	 <p>Photo of EX3DV4</p>
Frequency	10 MHz to 6 GHz; Linearity: ± 0.2 dB	
Directivity	± 0.3 dB in HSL (rotation around probe axis) ± 0.5 dB in tissue material (rotation normal to probe axis)	
Dynamic Range	10 μ W/g to 100 mW/g; Linearity: ± 0.2 dB (noise: typically $< 1 \mu$ W/g)	
Dimensions	Overall length: 330 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Typical distance from probe tip to dipole centers: 1 mm	

➤ E-Field Probe Calibration

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

4. 2 Data Acquisition Electronics (DAE)

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

The input impedance of the DAE is 200MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80dB.

**Photo of DAE**

4. 3 Robot

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

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

**Photo of DASY5**

4. 4 Measurement Server

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

The measurement server performs all the real-time data evaluation for field measurements and surface

detection, controls robot movements and handles safety operations.



Photo of Server for DASY5

4. 5 Phantom

<SAM Twin Phantom>

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

The bottom plate contains three pair of bolts for locking the device holder. The device holder positions are adjusted to the standard measurement positions in the three sections. A white cover is provided to tap the phantom during off-periods to prevent water evaporation and changes in the liquid parameters. On the phantom top, three reference markers are provided to identify the phantom position with respect to the robot.

<ELI4 Phantom>

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

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

4. 6 Device Holder

The SAR in the phantom is approximately inversely proportional to the square of the distance between the source and the liquid surface. For a source at 5 mm distance, a positioning uncertainty of ± 0.5 mm would produce a SAR uncertainty of $\pm 20\%$. Accurate device positioning is therefore crucial for accurate and repeatable measurements. The positions in which the devices must be measured are defined by the standards.

The DASY device holder is designed to cope with different positions given in the standard. It has two scales for the device rotation (with respect to the body axis) and the device inclination (with respect to the line between the ear reference points). The rotation center for both scales is the ear reference point (ERP). Thus the device needs no repositioning when changing the angles.

The DASY device holder is constructed of low-loss POM material having the following dielectric parameters: relative permittivity $\epsilon = 3$ and loss tangent $\delta = 0.02$. The amount of dielectric material has been reduced in the closest vicinity of the device, since measurements have suggested that the influence of the clamp on the test results could thus be lowered.



Device Holder

4. 7 Data Storage and Evaluation

➤ Data Storage

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

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

➤ Data Evaluation

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

Probe parameters:	- Sensitivity	Norm _i , a _{i0} , a _{i1} , a _{i2}
	- Conversion factor	ConvF _i
	- Diode compression point	dcp _i
Device parameters:	- Frequency	f
	- Crest factor	cf
Media parameters:	- Conductivity	σ
	- Density	ρ

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

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

The formula for each channel can be given as:

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

with V_i = compensated signal of channel i , ($i = x, y, z$)

U_i = input signal of channel i , ($i = x, y, z$)

cf = crest factor of exciting field (DASY parameter)

dcp_i = diode compression point (DASY parameter)

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

$$\text{E-field Probes: } E_i = \sqrt{\frac{V_i}{\text{Norm}_i \cdot \text{ConvF}}}$$

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

with V_i = compensated signal of channel i , ($i = x, y, z$)

Norm_i = sensor sensitivity of channel i , ($i = x, y, z$), $\mu\text{V}/(\text{V}/\text{m})^2$ for E-field Probes

ConvF = sensitivity enhancement in solution

a_{ij} = sensor sensitivity factors for H-field probes

f = carrier frequency [GHz]

E_i = electric field strength of channel i in V/m

H_i = magnetic field strength of channel i in A/m

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

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

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

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

with SAR = local specific absorption rate in mW/g

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

σ = conductivity in [mho/m] or [$\text{Siemens}/\text{m}$]

ρ = equivalent tissue density in g/cm^3

Note that the density is set to 1, to account for actual head tissue density rather than the density of the tissue simulating liquid.

5. Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	450MHz System Validation Kit	D450V3	1079	Aug 28,2016	Aug 28,2019
SPEAG	Data Acquisition Electronics	DAE4	387	Sep 13,2018	Sep 12,2019
SPEAG	Dosimetric E-Field Probe	ES3DV3	3292	Sep 13,2018	Sep 12,2019
Agilent	ENA Series Network Analyzer	E5071C	MY46317418	May.22, 2019	May. 21, 2020
SPEAG	DAK	DAK-3.5	1226	May.22, 2019	May. 21, 2020
SPEAG	SAM Twin Phantom	QD000P40CD	1802	NCR	NCR
AR	Amplifier	ZHL-42W	QA1118004	NCR	NCR
Agilent	Power Meter	N1914A	MY50001102	Oct. 27, 2018	Oct. 26, 2019
Agilent	Power Sensor	N8481H	MY51240001	Oct. 27, 2018	Oct. 26, 2019
R&S	Spectrum Analyzer	N9020A	MY51170037	May.22, 2019	May. 21, 2020
Agilent	Signal Generation	N5182A	MY48180656	May.22, 2019	May. 21, 2020
Worken	Directional Coupler	0110A056010-10	COM5BNW1A2	May.22, 2019	May. 21, 2020

Note:

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

6. Tissue Simulating Liquids

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

The following table gives the recipes for tissue simulating liquid.

Composition of the Head Tissue Equivalent Matter

Mixture %	Frequency 450MHz
Water	38.56
Sugar	56.32
Salt	3.95
Preventol	0.10
Cellulose	1.07
Dielectric Parameters Target Value	$f=450\text{MHz } \epsilon_r=43.5 \sigma=0.87$

Composition of the Body Tissue Equivalent Matter

Mixture %	Frequency 450MHz
Water	56.16
Sugar	46.78
Salt	1.49
Preventol	0.10
Cellulose	0.47
Dielectric Parameters Target Value	$f=450\text{MHz } \epsilon_r=56.7 \sigma=0.94$

The following table shows the measuring results for simulating liquid.

Tissue Type	Measured Frequency (MHz)	Target Tissue		Measured Tissue				Liquid Temp.	Test Data
		ϵ_r	σ	ϵ_r	Dev.	σ	Dev.		
450H	450	43.50	0.87	43.68	0.41%	0.89	2.30%	22.2 degree	06/03/2019
450B	450	56.70	0.94	56.35	-0.62%	0.93	-1.06%	22.2 degree	06/04/2019

7. System Verification Procedures

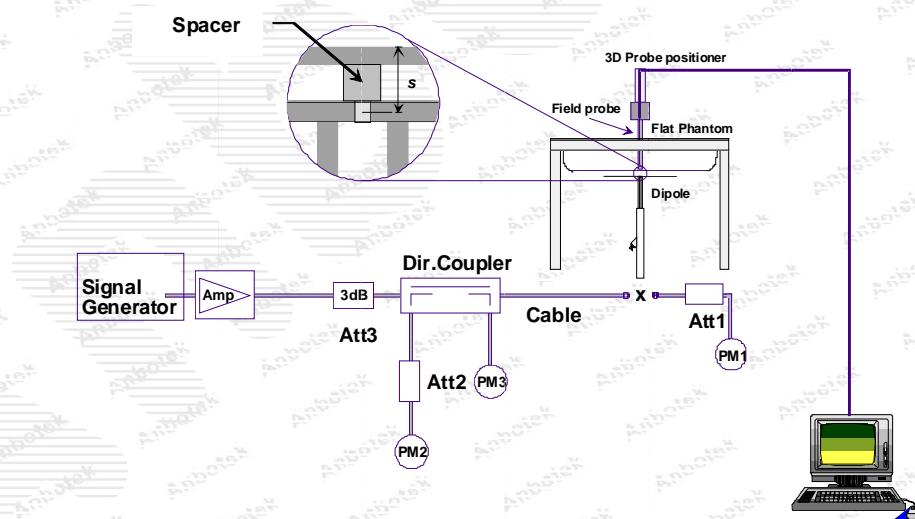
Each DASY system is equipped with one or more system validation kits. These units, together with the predefined measurement procedures within the DASY software, enable the user to conduct the system performance check and system validation. System validation kit includes a dipole, tripod holder to fix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

➤ Purpose of System Performance check

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

➤ System Setup

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



System Setup for System Evaluation

➤ Validation Results

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

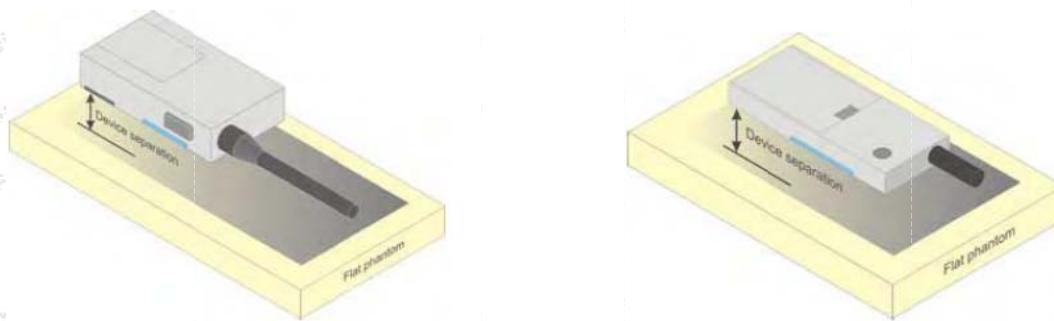
Date	Frequency (MHz)	Liquid Type	Power fed onto reference dipole (mW)	Targeted SAR (W/kg)	Measured SAR (W/kg)	Normalized SAR (W/kg)	Deviation
06/03/2019	450	Head	250	4.58	1.16	4.64	1.31%
06/04/2019	450	Body	250	4.60	1.16	4.64	0.87%

Target and Measurement SAR after Normalized

8. EUT Testing Position

8.1 Front-of-face

A typical example of a front-of-face device is a two-way radio that is held at a distance from the face of the user when transmitting. In these cases the device under test shall be positioned at the distance to the phantom surface that corresponds to the intended use as specified by the manufacturer in the user instructions (Figure 8a). If the intended use is not specified, a separation distance of 25 mm between the phantom surface and the device shall be used.



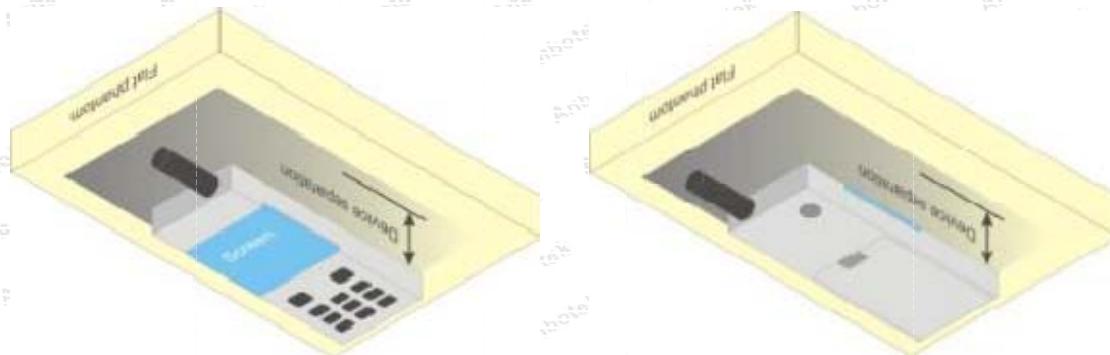
Test positions for front-of-face devices

8.2 Body Worn Position

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

Accessories for body-worn operation configurations are divided into two categories: those that do not contain metallic components and those that do contain metallic components and those that do contain metallic components. When multiple accessories that do not contain metallic components are supplied with the device, the device is tested with only the accessory that dictates the closest spacing to the body. Then multiple accessories that contain metallic components are test with the device with each accessory. If multiple accessories share an identical metallic component (i.e. the same metallic belt-chip used with

different holsters with no other metallic components) only the accessory that dictates the closest spacing to the body is tested.



Body Worn Position

9. Measurement Procedures

The measurement procedures are as follows:

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

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

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

9.1 Spatial Peak SAR Evaluation

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

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

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

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

9.2 Power Reference Measurement

The Power Reference Measurement and Power Drift Measurements are for monitoring the power drift of the device under test in the batch process. The minimum distance of probe sensors to surface determines the closest measurement point to phantom surface. This distance cannot be smaller than the distance of sensor calibration points to probe tip as defined in the probe properties.

9.3 Area Scan Procedures

The area scan is used as a fast scan in two dimensions to find the area of high field values, before doing a fine measurement around the hot spot. The sophisticated interpolation routines implemented in DASY software can find the maximum found in the scanned area, within a range of the global maximum. The range (in dB0 is specified in the standards for compliance testing. For example, a 2 dB range is required in IEEE standard 1528 and IEC 62209 standards, whereby 3 dB is a requirement when compliance is assessed in accordance with the ARIB standard (Japan), if only one zoom scan follows the area scan, then only the absolute maximum will be taken as reference. For cases where multiple maximums are detected, the number of zoom scans has to be increased accordingly.

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

	≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	5 ± 1 mm	$\frac{1}{2} \cdot \delta \cdot \ln(2) \pm 0.5$ mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location	$30^\circ \pm 1^\circ$	$20^\circ \pm 1^\circ$
	≤ 2 GHz: ≤ 15 mm $2 - 3$ GHz: ≤ 12 mm	$3 - 4$ GHz: ≤ 12 mm $4 - 6$ GHz: ≤ 10 mm
Maximum area scan spatial resolution: $\Delta x_{\text{Area}}, \Delta y_{\text{Area}}$	When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be \leq the corresponding x or y dimension of the test device with at least one measurement point on the test device.	

9.4 Zoom Scan Procedures

Zoom scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1 gram and 10 gram of simulated tissue. The zoom scan measures points (refer to table below) within a cube whose base faces are centered on the maxima found in a preceding area scan job within the same procedure. When the measurement is done, the zoom scan evaluates the averaged SAR for 1 gram and 10 gram and displays these values next to the job's label.

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

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

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

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

9.5 Volume Scan Procedures

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

9.6 Power Drift Monitoring

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

10. Conducted Power

Modulation Type	Channel Separation	Test Channel	Test Frequency (MHz)	Transmitter Power		Tune up Power
				High power level		High power level
				(dBm)	(Watts)	(Watts)
Analog / FM	25KHz	Ch4	462.6375	26.27	0.42364	0.5
		Ch11	467.6375	26.31	0.42756	0.5
		Ch19	462.6500	26.33	0.42954	0.5

Note:

1. The high power level level adjust by software, without any modification for hardware.

11. SAR Test Results Summary

General Note:

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

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

$$Max_Calc = SAR_Adju * DC * (P_max / P_cond)$$

P_max = highest power including turn up tolerance (W)

P_cond_high = highest power in conduct measured (W)

DC = Transmission mode Duty Cycle in % where applicable 50% duty cycle is applied for PTT operation

SAR_meas. = Measured SAR (W/kg)

11.1 Head SAR Results

< Analog>

Test Frequency		Mode	P_cond_high (W)	P_max	Carry Accessory	Audio Accessory	Front Surface Spacing (mm)	SAR 1g with 100% duty cycle meas. (W/kg)	SAR 1g with 50% duty cycle (W/kg)	Power Drift (dB)	Scaling Factor	Max Calc. SAR _{1-g} (W/kg)	Plot
Channel	MHz												
Ch4	462.6375	Analog	0.42364	0.5	A1	n/a	25	0.287	0.1435	0.08	1.180	0.169	1
Ch11	467.6375	Analog	0.42756	0.5			25	0.358	0.179	0.12	1.169	0.209	
Ch19	462.6500	Analog	0.42954	0.5			25	0.333	0.1665	-0.15	1.164	0.194	

Head SAR Test Considerations Note:

1. Passive body-worn and audio accessories generally do not apply to the head SAR of PTT radios. Head SAR is measured with the front surface of the radio positioned at 2.5 cm parallel to a flat phantom. A phantom shell thickness of 2 mm is required. When the front of the radio has a contour or non-uniform surface with a variation of 1.0 cm or more, the average distance of such variations is used to establish the 2.5 cm test separation from the phantom.
2. Testing antennas with the default battery:
 - A. Start by testing a PTT radio with a standard battery (default battery) that is supplied with the radio to measure the head SAR of each antenna on the highest output power channel, according to the test channels required by the number-of-test-channels formula in KDB Publication 447498 D01 and in the frequency range covered by each antenna within the operating frequency bands of the radio. When multiple standard batteries are supplied with a radio, the battery with the highest capacity is considered the default battery for making head SAR measurements.

11.2 Body-worn SAR Results

< Analog>

Test Frequency		Mode	P_cond_high (W)	P_max	Carry Accessory	Audio Accessory	Spacing (mm)	SAR 1g	SAR	Power Drift (dB)	Scaling Factor	Max Calc. SAR _{1-g} (W/kg)	Plot
Channel	MHz							with 100% duty cycle (W/Kg)	1g with 50% duty cycle (W/Kg)				
Ch4	462.6375	Analog	0.42364	0.5	BC1	AC1	0	0.862	0.431	-0.11	1.180	0.509	
Ch11	467.6375	Analog	0.42756	0.5	BC1	AC1	0	0.954	0.477	-0.08	1.169	0.558	2
Ch19	462.6500	Analog	0.42954	0.5	BC1	AC1	0	0.895	0.4475	-0.14	1.164	0.521	

Body SAR Test Considerations for Body-worn Accessories Note:

1. Body SAR is measured with the radio placed in a body-worn accessory, positioned against a flat phantom, representative of the normal operating conditions expected by users and typically with a standard default audio accessory supplied with the radio.

Since audio accessories, including any default audio accessories supplied with a radio, may be designed to operate with a subset of the combinations of antennas, batteries and body-worn accessories, when a default audio accessory does not fully support all the test configurations required in this section for body-worn accessories testing an alternative audio accessory must be selected to be the default audio accessory for body-worn accessories testing.⁹ If an alternative audio accessory cannot be identified, body-worn accessories should be tested without any audio accessory. In general, all sides of the radio that may be positioned facing the user when using a body-worn accessory must be considered for SAR compliance.

2. Testing antennas with the default battery and body-worn accessory:

Start by testing a PTT radio with the thinnest battery and a standard (default) body-worn accessory that are both supplied with the radio and, if applicable, a default audio accessory, to measure the body SAR of each antenna on the highest output power channel, according to the test channels required by the number-of-test-channels formula in KDB Publication 447498 D01 and in the frequency range covered by each antenna within the operating frequency bands of the radio. When multiple default body-worn accessories are supplied with a radio, the standard body-worn accessory expected to result in the highest SAR based on its construction and exposure conditions is considered the default body-worn accessory for making body-worn SAR measurements

12. SAR Measurement Variability

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

- 1) Repeated measurement is not required when the original highest measured SAR is < 0.80 W/kg; steps 2) through 4) do not apply.
- 2) When the original highest measured SAR is ≥ 0.80 W/kg, repeat that measurement once.
- 3) Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is ≥ 1.45 W/kg ($\sim 10\%$ from the 1-g SAR limit).
- 4) Perform a third repeated measurement only if the original, first or second repeated measurement is ≥ 1.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20 .

The same procedures should be adapted for measurements according to extremity and occupational exposure limits by applying a factor of 2.5 for extremity exposure and a factor of 5 for occupational exposure to the corresponding SAR thresholds.

Thus the following procedures are applied to determine if repeated measurements are required for occupational exposure.

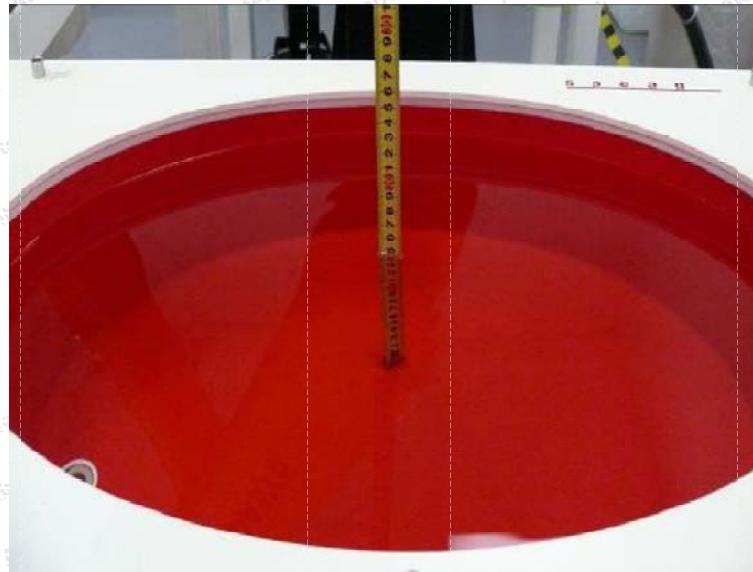
- 5) Repeated measurement is not required when the original highest measured SAR is < 4.00 W/kg; steps 6) through 8) do not apply.
- 6) When the original highest measured SAR is ≥ 4.00 W/kg, repeat that measurement once.
- 7) Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 6.00 or when the original or repeated measurement is ≥ 7.25 W/kg ($\sim 10\%$ from the 1-g SAR limit).
- 8) Perform a third repeated measurement only if the original, first or second repeated measurement is ≥ 7.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20 .

13. Measurement Uncertainty

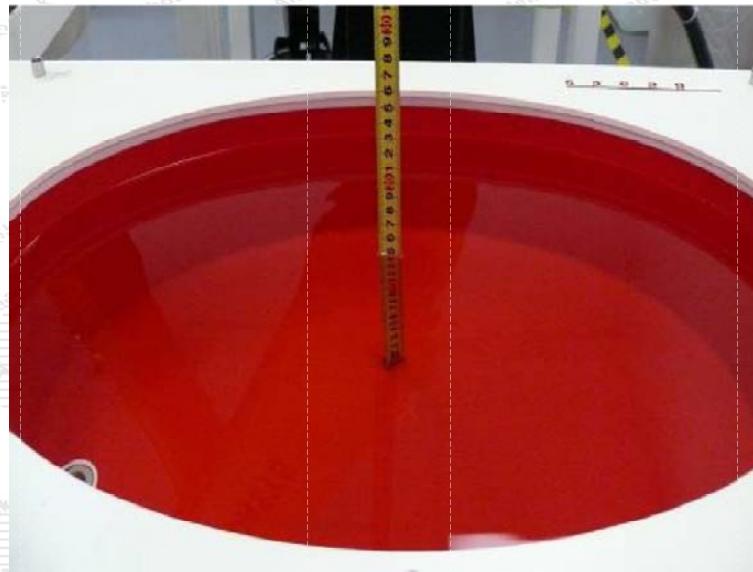
Uncertainty component	Tol. (±%)	Prob. dist.	Div.	c_i (1g)	c_i (10g)	$\frac{1g}{u_i}$ (±%)	$\frac{10g}{u_i}$ (±%)
Measurement system							
Probe calibration($k=1$)	6.1	N	1	1	1	6.1	6.1
Axial isotropy	4.7	R			$\sqrt{0.5}$	1.9	1.9
Hemispherical isotropy	9.6	R			$\sqrt{0.5}$	3.9	3.9
Boundary effect	1.0	R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

Per KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz, when the highest measured 1-g SAR within a frequency band is < 1.5 W/Kg, the extensive SAR measurement uncertainty analysis described in IEEE 1528-2013 is not required in SAR reports submitted for equipment approval.

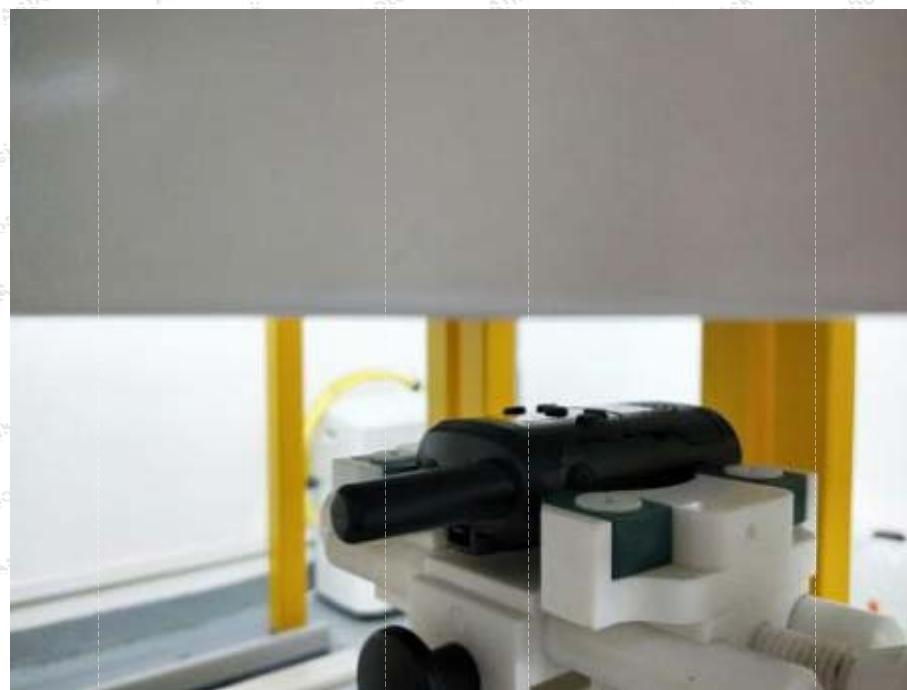
Appendix A. Test Setup Photos



Photograph of the depth in the Head Phantom (450MHz, 15.3cm)



Photograph of the depth in the Body Phantom (450MHz, 15.4cm)



Face-held, the front of the EUT towards phantom (The distance was 25mm)



Body-worn, the front of the EUT towards ground with A1, B2 and D1
(The distance was 0mm)

Appendix B. Plots of SAR System Check

System Performance Check at 450 MHz Head TSL

DUT: Dipole450 MHz; Type: D450V2; Serial: 1072

Date/Time: 06/03/2019 8:49:31 AM

Communication System: DuiJiangJi; Frequency: 450 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated): $f = 450$ MHz; $\sigma = 0.89$ S/m; $\epsilon_r = 43.68$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY5 Configuration:

Probe: ES3DV3 - SN3292; ConvF(7.12, 7.12, 7.12); Calibrated: 09/13/2018;

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn387; Calibrated: 9/13/2018

Phantom: ELI 4.0; Type: QDOVA001BA;

Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

System Performance Check at 450MHz/Area Scan (61x201x1): Interpolated grid: dx=1.50 mm, dy=1.50 mm

Maximum value of SAR (interpolated) = 1.47 mW/g

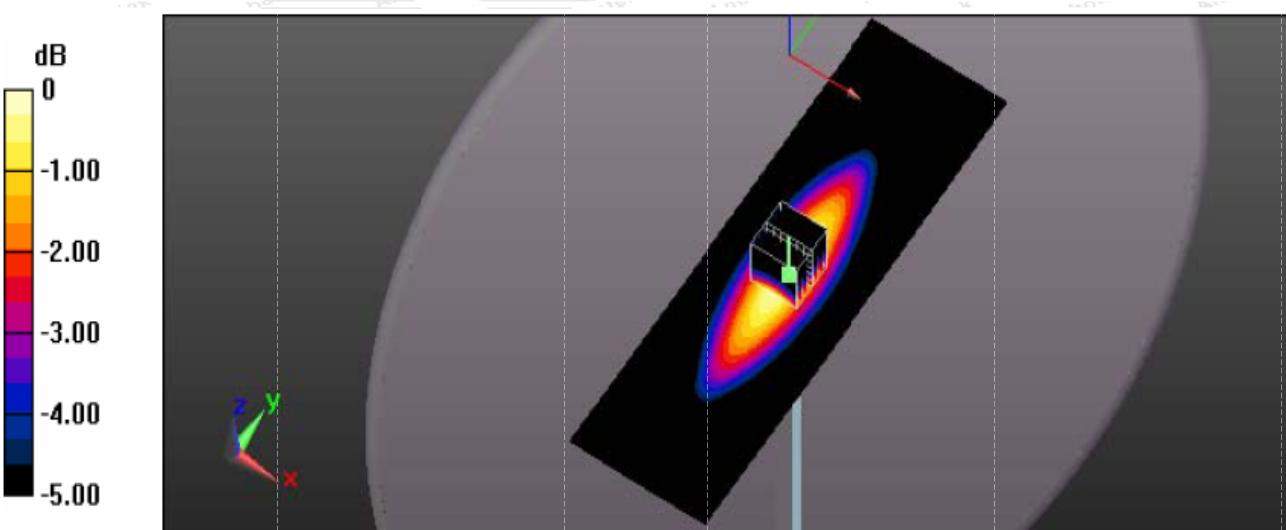
System Performance Check at 450MHz/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 41.24 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 1.72 mW/g

SAR(1 g) = 1.16 mW/g; SAR(10 g) = 0.781 mW/g

Maximum value of SAR (measured) = 1.42 mW/g



0 dB = 1.42 mW/g = 1.52 dB mW/g

System Performance Check 450MHz Head 250mW

System Performance Check at 450 MHz Body TSL

DUT: Dipole450 MHz; Type: D450V2; Serial: 1072

Date/Time: 06/04/2019 10:30:22 PM

Medium parameters used (interpolated): $f = 450$ MHz; $\sigma = 0.93$ S/m; $\epsilon_r = 56.35$; $\rho = 1000$ kg/m³

Communication System: DuiJiangJi; Frequency: 450 MHz; Duty Cycle: 1:1

Phantom section: Flat Section

DASY5 Configuration:

Probe: ES3DV3 - SN3292; ConvF(7.28, 7.28, 7.28); Calibrated: 09/13/2018;

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn387; Calibrated: 9/13/2018

Phantom: ELI 4.0; Type: QDOVA001BA;

Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

System Performance Check at 450MHz/Area Scan (61x201x1): Interpolated grid: dx=1.500 mm, dy=1.50 mm

Maximum value of SAR (interpolated) = 1.48 mW/g

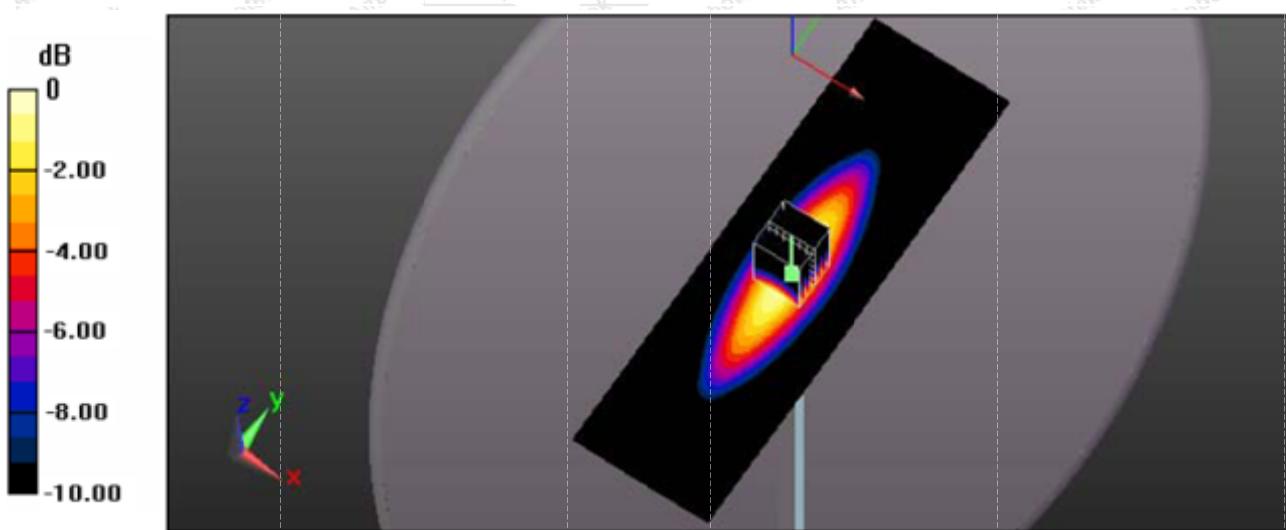
System Performance Check at 450MHz/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 40.34 V/m; Power Drift = -0.11 dB

Peak SAR (extrapolated) = 1.78 mW/g

SAR(1 g) = 1.16 mW/g; SAR(10 g) = 0.772 mW/g

Maximum value of SAR (measured) = 1.49 mW/g



0 dB = 1.49 mW/g = 1.73 dB mW/g

System Performance Check 450MHz Body 250mW

Appendix C. Plots of SAR Test Data

#1

Face Held for FM Modulation at 25 KHz Channel Separation, Front towards Phantom 467.6375MHz

Communication System: Customer System; Frequency: 467.6375 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated): $f = 467.6375$ MHz; $\sigma = 0.89$ S/m; $\epsilon_r = 43.68$; $\rho = 1000$ kg/m³

Phantom section: Head Section

DASY5 Configuration:

Probe: ES3DV3 - SN3292; ConvF(7.12, 7.12, 7.12); Calibrated: 09/13/2018;

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn387; Calibrated: 09/13/2018

Phantom: ELI 4.0; Type: QDOVA001BA;

Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

Area Scan(51x181x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm

Maximum value of SAR (interpolated) = 0.374 W/kg

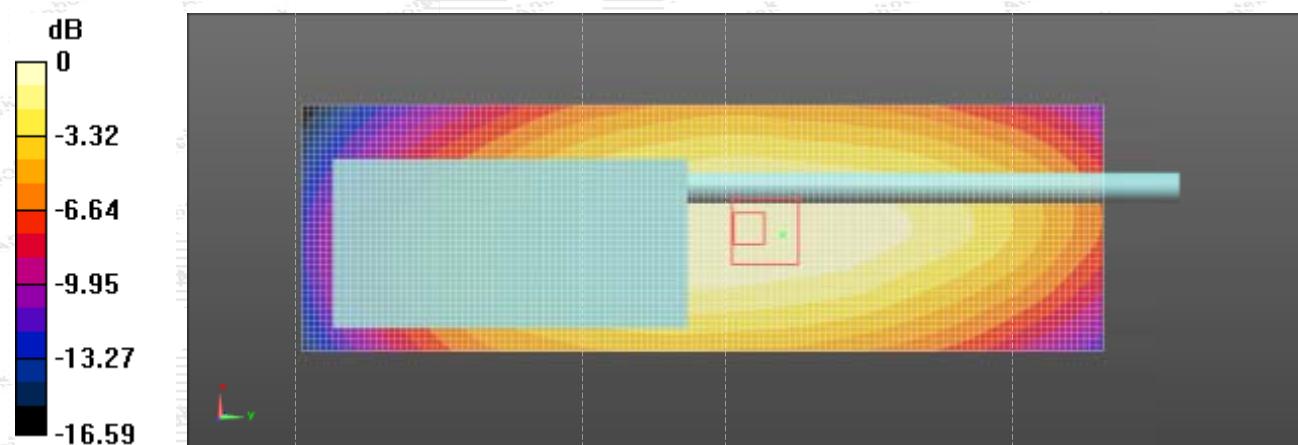
Zoom Scan (5x5x6)/Cube 0: Measurement grid: dx=7mm, dy=7mm, dz=5mm

Reference Value = 13.5442 V/m; Power Drift = 0.12dB

Peak SAR (extrapolated) = 0.389mW/g

SAR(1 g) = 0.358 mW/g; SAR(10 g) = 0.247 mW/g

Maximum value of SAR (measured) = 0.664 W/kg



Date/Time: 06/03/2019 19:21:16 AM

Figure 1: Face held for FM Modulation at 25 KHz Channel Separation Front towards Phantom 467.6375 MHz

#2

Body- Worn FM Modulation at 25 KHz Channel Separation with A1, B1, BC1, AC1, Front towards Ground 467.6375 MHz

Communication System: PTT450; Frequency: 467.6375 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated): $f = 467.6375$ MHz; $\sigma = 0.93$ S/m; $\epsilon_r = 56.35$; $\rho = 1000$ kg/m³

Phantom section : Flat Section

DASY5 Configuration:

Probe: ES3DV3 - SN3292; ConvF(7.28, 7.28, 7.28); Calibrated: 09/13/2018;

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn387; Calibrated: 09/13/2018

Phantom: ELI 4.0; Type: QDOVA001BA;

Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

Area Scan(51x181x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm

Maximum value of SAR (interpolated) = 1.45 mW/g

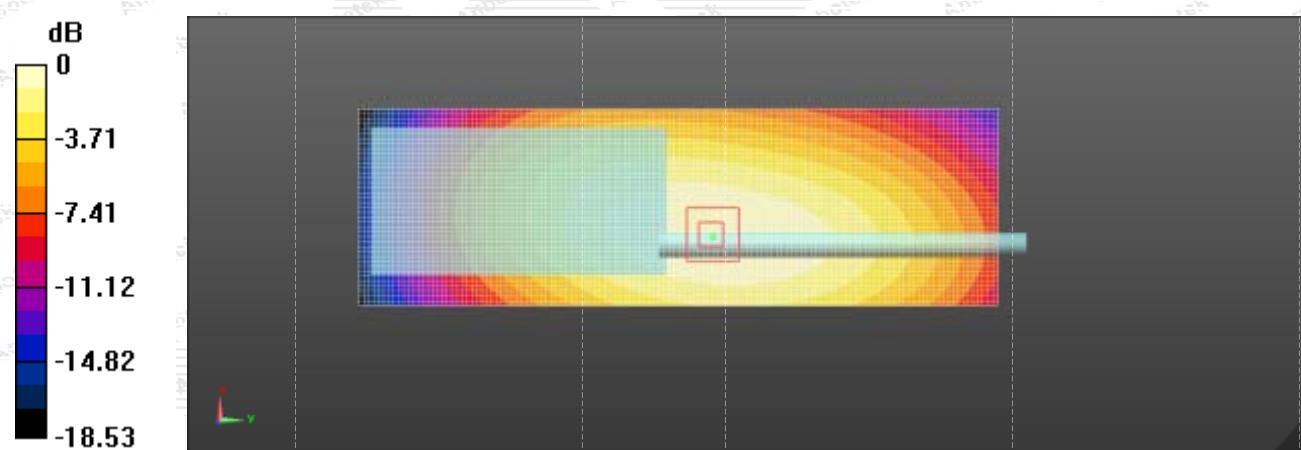
Zoom Scan (5x5x6)/Cube 0: Measurement grid: dx=7mm, dy=7mm, dz=5mm

Reference Value = 34.571 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 1.78 mW/g

SAR(1 g) = 0.954 mW/g; SAR(10 g) = 0.641 mW/g

Maximum value of SAR (measured) = 1.35 mW/g



Date/Time: 06/04/2019 19:55:13 PM

Plot 2: Body-worn for FM Modulation at 25KHz Channel Separation with A1, B1, BC1, AC1; Front towards Ground 467.6375 MHz