SAR EVALUATION REPORT

Equipment under test	GMRS/FRS 2-way Radio
Model name	T65
FCC ID // IC	MMAT65 // 3690A- T65
Applicant	Midland Radio Corporation
Manufacturer	Global Link Corporation Ltd.
Date of test(s)	2014.12.15~2014.12.16
Date of issue	2014.12.24

Issued to

Midland Radio Corporation

5900 Parretta Drive, Kansas City, Missouri United States 64120
Tel.: +1-816-241-8500 / Fax.: +1-816-241-571

Issued by

KES Co., Ltd.

C-3701, Simin-daero 365-40, Dongan-gu, Anyang-si,
Gyeonggi-do,431-716, Korea
473-29, Gayeo-ro, Yeoju-si, Gyeonggi-do, Korea
Tel.: +82-31-425-6200 / Fax: +82-31-424-0450

Test and report completed by :	**Report approval by :**
Kwang-Yeol Choo Test engineer	Jeff Do Technical manager

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1. General information

1.1. EUT description

Equipment under test	GMRS/FRS 2-way Radio
Model name	T65
Serial number	N/A
Frequency range	462.550 0 ㎒ ~ 462.725 0 ㎒(GMRS), 467.562 5 ㎒ ~ 467.712 5 ㎒(FRS)
Modulation type	FM
Exposure category	General population / Uncontrolled exposure
Body worn accessory	Belt clip and earphone
Antenna type	Integrated antenna
Power source	DC 3.6 V(Rechargeable Ni-MH Battery)

1.2. Short description of the equipment under test(EUT)

The spatial peak SAR values were assessed for systems. Battery and accessories shell be specified by the manufacturer. The EUT battery must be fully charged and checked periodically during the test to ascertain uniform power output.

1.3. Highest SAR summary

Equipment class	Frequency band	Tissue type	Reported SAR value 1g-SAR (W/kg)
GMRS/FRS	462.550 0 ㎒ ~ 467.712 5 ㎒	Head	0.430
		Body	0.578

Notes:

Face-Held Configuration

Face-held Configuration- per FCC KDB447498 page 22: “A test separation distance of 25 mm must be applied for in-front-of the face SAR test exclusion and SAR measurements.”

Body-worn Configuration

Body-worn measurements-per FCC KDB447498 page 22 “When body-worn accessory SAR testing is required, the body-worn accessory requirements in section 4.2.2 should be applied. PTT two-way radios that support held-to-ear operating mode must also be tested according to the exposure configurations required for handsets. This generally does not apply to cellphones with PTT options that have already been tested in more conservative configurations in applicable wireless modes for SAR compliance at 100% duty factor.”

1.4. Guidance applied

- IEEE 1528-2013
- FCC KDB Publication 865664 D01 v01r03- D02 v01r01 (SAR measurement up to 6 ㎓)
- FCC KDB Publication 447498 D01 v05r02 (General SAR guidance)
- FCC KDB Publication 643646 D01 v01r01 (PTT Radios)
- FCC KDB Publication 865664 D02v01r01 (SAR reporting)
- RSS-102 Issue 4 Radio Frequency Exposure Compliance of Radio communication Apparatus (All Frequency Bands)

1.5. Test conditions

Ambient temperature	(22 ± 2) ℃
Tissue simulating liquid	(22 ± 2) ℃
Humidity	(55 ± 5) % R.H.

1.6. SAR definition

Specific Absorption Rate is defined as the time derivative (rate) of the incremental energy (dU) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dV) of a given density (ρ). It is also defined as the rate of RF energy absorption per unit mass at a point in an absorbing body (see Figure 1).

$$\boxed{SAR = \frac{d}{dt}\left(\frac{dU}{dm}\right) = \frac{d}{dt}\left(\frac{dU}{\rho d\upsilon}\right)}$$

Figure 1. SAR Mathematical equation

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

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

Where:

σ = Conductivity of the tissue-simulating material (S/m)

ρ = Mass density of the tissue-simulating material (kg/㎥)

E = Total RMS electric field strength (V/m)

NOTE:

The primary factors that control rate of energy absorption were found to be the wavelength of the incident field in relations to the dimensions and geometry of the irradiated organism, the orientation of the organism in relation to the polarity of field vectors, the presence of reflecting surfaces, and whether conductive contact is made by the organism with a ground plane.

1.7. Accessories of EUT

Accessory	Description	Other
Audio Accessory	Earphone	1.2m
Body Worn Accessory	Belt clip	Standard

2. SAR measurement system

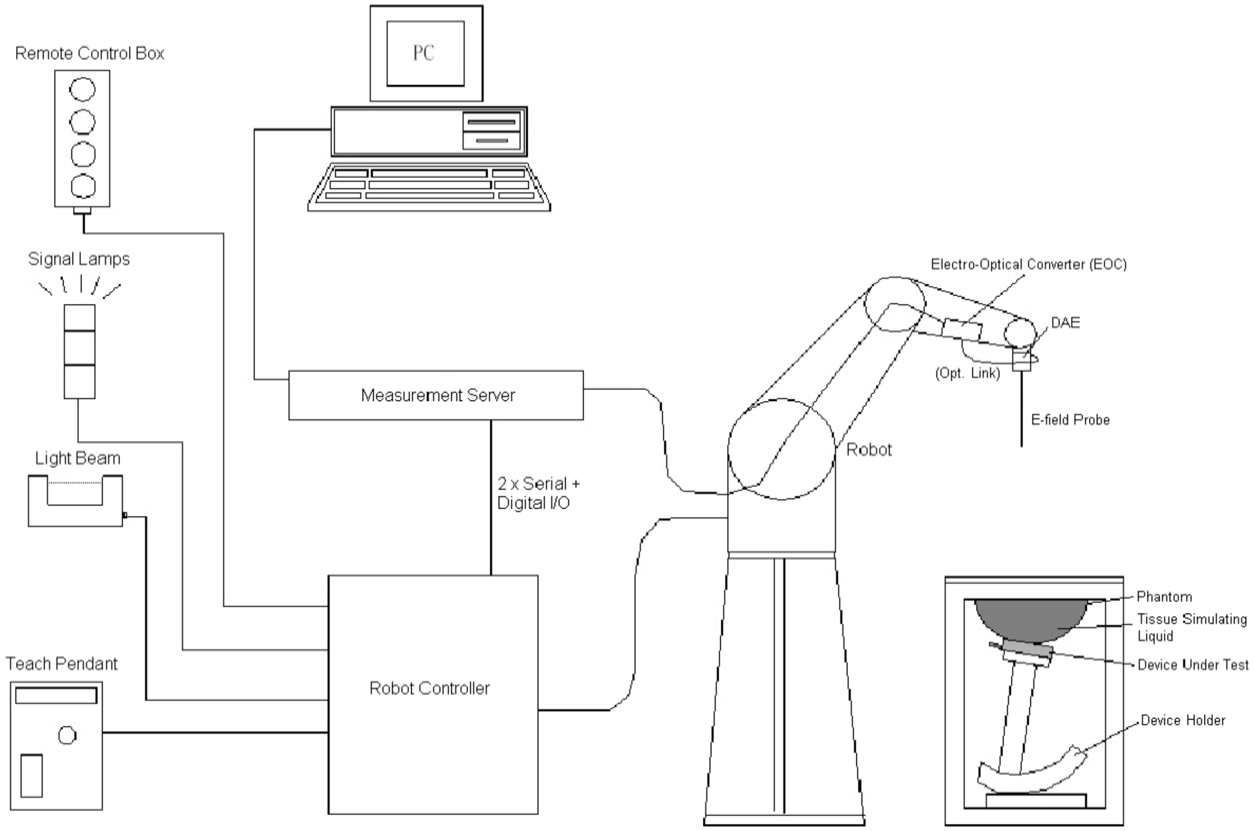

Figure 2. SPEAG DASY system configuration

The DASY system for performance compliance tests is illustrated above graphically. This system co nsists 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 s ignals
- A measurement server performs the time critical tasks such as signal filtering, control of th e 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
- Remove control with teach pendant and additional circuitry for robot safety such as warmin g lamps, etc.
- The SAM twin phantom and/or ELI phantom
- A device holder
- Tissue simulating liquid
- Dipole for evaluating the proper functioning of the system

2.1. Robot

The DASY system uses the high precision robots 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 ±0.035 mm)
- High reliability (industrial design)
- Jerk-free straight movements
- Low ELF interference (the closed metallic construction shields against motor control fields)

Figure 3. SPEAG DASY 4

2.2. Probe

The SAR measurement is conducted with the dosimetric probe. 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.

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

Figure 4. Probe

2.3. Data Acquisition Electronics (DAE)

Model	DAE4
Construction	Signal amplifier, multiplexer, A/D converter and control logic. Serial optical link for communication with DASY4/5 embedded system (fully remote controlled). Two step probe touch detector for mechanical surface detection and emergency robot stop.
Measurement Range	-100 to +300 mV (16 bit resolution and two range settings: 4 mV, 40 0mV)
Input Offset Voltage	± 0.2 ㏈ in HSL (rotation around probe axis) ± 0.3 ㏈ in tissue material (rotation normal to probe axis)
Input Bias Current	< 50 fA
Dimensions	60 x 60 x 68 mm

Figure 5. DAE

2.4. Phantoms

Model	Twin SAM
Construction	The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 and IEC 62209-1. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by teaching three points with the robot.
Material	Vinylester, glass fiber reinforced (VE-GF)
Shell Thickness	2 ± 0.2 mm (6 ± 0.2 mm at ear point)
Dimensions	Length: 1000 mm Width: 500 mm Height: adjustable feet
Filling Volume	approx. 25 liters

Figure 6. Twin SAM

Model	ELI
Construction	Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI is fully compatible with the IEC 62209-2 standard and all known tissue simulating liquids. ELI has been optimized regarding its performance and can be integrated into our standard phantom tables. A cover prevents evaporation of the liquid. Reference markings on the phantom allow installation of the complete setup, including all predefined phantom positions and measurement grids, by teaching three points. The phantom is compatible with all SPEAG dosimetric probes and dipoles.
Material	Vinylester, glass fiber reinforced (VE-GF)
Shell Thickness	2.0 ± 0.2 mm (bottom plate)
Dimensions	Major axis: 600 mm Minor axis: 400 mm
Filling Volume	approx. 30 liters

Figure 7. ELI

2.5. Device holder

Model	Mounting device	
Construction	In combination with the Twin SAM Phantom or ELI4, the Mounting Device enables the rotation of the mounted transmitter device in spherical coordinates. Rotation point is the ear opening point. Transmitter devices can be easily and accurately positioned according to IEC, IEEE, FCC or other specifications. The device holder can be locked for positioning at different phantom sections (left head, right head, flat).	
Material	POM	Figure 8. Mounting device

Model	Laptop extensions kit	
Construction	Simple but effective and easy-to-use extension for Mounting Device that facilitates the testing of larger devices according to IEC 62209-2 (e.g., laptops, cameras, etc.). It is lightweight and fits easily on the upper part of the Mounting Device in place of the phone positioner.	
Material	POM, Acrylic glass, Foam	Figure 9. Laptop extensions kit

3. SAR measurement procedure

Step 1: Power reference measurement

The power reference measurement and power reference 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. The minimum distance of probe sensors to surface is 2 ㎜. This distance cannot be smaller than the distance of sensor calibration points to probe tip as defined in the probe properties.

Step 2 and 3: Area scan & zoom scan procedures

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 1 g and 10 g cubes. The algorithm to find the cube with highest averaged SAR is divided into the following stages:

1. The extraction of the measured data (grid and values) from the zoom scan.
2. The calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters)
3. The generation of a high-resolution mesh within the measured volume
4. The interpolation of all measured values from the measurement grid to the high-resolution grid
5. The extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface
6. The calculation of the averaged SAR within masses of 1 g and 10 g.

<table>
<tr><td colspan="3"></td><td>≤ 3 GHz</td><td>> 3 GHz</td></tr>
<tr><td colspan="3">Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface</td><td>5 ± 1 mm</td><td>½·δ·ln(2) ± 0.5 mm</td></tr>
<tr><td colspan="3">Maximum probe angle from probe axis to phantom surface normal at the measurement location</td><td>30° ± 1°</td><td>20° ± 1°</td></tr>
<tr><td colspan="3" rowspan="2">Maximum area scan spatial resolution: Δx_{Area}, Δy_{Area}</td><td>≤ 2 GHz: ≤ 15 mm
2 – 3 GHz: ≤ 12 mm</td><td>3 – 4 GHz: ≤ 12 mm
4 – 6 GHz: ≤ 10 mm</td></tr>
<tr><td colspan="2">When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be ≤ the corresponding x or y dimension of the test device with at least one measurement point on the test device.</td></tr>
<tr><td colspan="3">Maximum zoom scan spatial resolution: Δx_{Zoom}, Δy_{Zoom}</td><td>≤ 2 GHz: ≤ 8 mm
2 – 3 GHz: ≤ 5 mm*</td><td>3 – 4 GHz: ≤ 5 mm*
4 – 6 GHz: ≤ 4 mm*</td></tr>
<tr><td rowspan="3">Maximum zoom scan spatial resolution, normal to phantom surface</td><td colspan="2">uniform grid: $\Delta z_{Zoom}(n)$</td><td>≤ 5 mm</td><td>3 – 4 GHz: ≤ 4 mm
4 – 5 GHz: ≤ 3 mm
5 – 6 GHz: ≤ 2 mm</td></tr>
<tr><td rowspan="2">graded grid</td><td>$\Delta z_{Zoom}(1)$: between 1st two points closest to phantom surface</td><td>≤ 4 mm</td><td>3 – 4 GHz: ≤ 3 mm
4 – 5 GHz: ≤ 2.5 mm
5 – 6 GHz: ≤ 2 mm</td></tr>
<tr><td>$\Delta z_{Zoom}(n>1)$: between subsequent points</td><td colspan="2">≤ 1.5·$\Delta z_{Zoom}(n-1)$</td></tr>
<tr><td>Minimum zoom scan volume</td><td colspan="2">x, y, z</td><td>≥ 30 mm</td><td>3 – 4 GHz: ≥ 28 mm
4 – 5 GHz: ≥ 25 mm
5 – 6 GHz: ≥ 22 mm</td></tr>
<tr><td colspan="5">Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details.
* When zoom scan is required and the reported SAR from the area scan based 1-g SAR estimation procedures of KDB 447498 is ≤ 1.4 W/kg, ≤ 8 mm, ≤ 7 mm and ≤ 5 mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.</td></tr>
</table>

Figure 10. Area and zoom scan resolutions per FCC KDB Publication 865664 D01v01r03

Step 4: Power drift measurement

The power drift measurement measures the field at the same location as the most recent power reference measurement within the same procedure, and with the same settings. The power drift measurement gives the field difference in dB from the reading conducted within the last power reference measurement. This allows a user to monitor the power drift of the device under test within a batch process. The measurement procedure is the same as Step 1.

4. Tissue simulating liquids

For the measurement of the field distribution inside the phantom with DASY, the phantom must be filled with around 25 liters of homogeneous body tissue simulating liquid. 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 in figure 11.

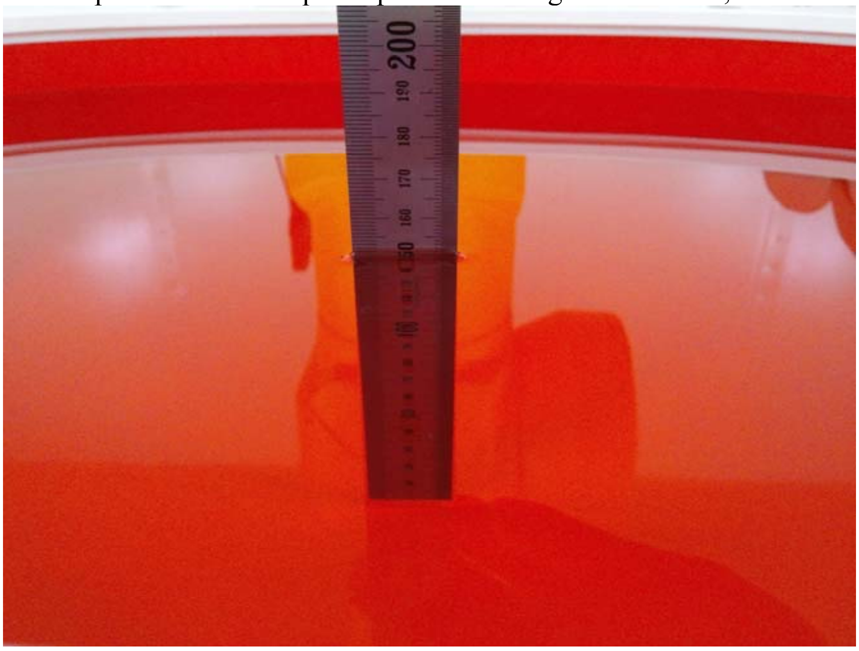

Figure 11. Liquid height photo

The dielectric parameters of the liquids were verified prior to the SAR evaluation using an Agilent dielectric probe kit and an Agilent network analyzer.

The following table shows the measuring results for simulating liquid.

Frequency (㎒)	Tissue type	Liquid temp.(°C)	Parameters	Target value	Measured value	Deviation (%)	Limit (%)	Data
450	Head	22.0	Permittivity (εr)	43.5	43.4	-0.23	±5	2014.12.15
			Conductivity (σ)	0.87	0.873	0.34	±5	2014.12.15
450	Body	22.0	Permittivity (εr)	56.7	57.4	1.23	±5	2014.12.16
			Conductivity (σ)	0.94	0.923	-1.81	±5	2014.12.16

5. System verification

5.1. Procedure

SAR measurement was prior to assessment, the system is verified to the ±10 % of the specifications at each frequency band by using the system verification kit.

- Cabling the system, using the verification kit equipment.
- Generate about 250 ㎽ input level from the signal generator to the dipole antenna.
- Dipole antenna was placed below the flat phantom.
- The measured one-gram SAR at the surface of the phantom above the dipole feed-point should be within 10 % of the target reference value.
- The results are normalized to 1 W input power.

Note;
SAR verification was performed according to the FCC KDB 865664 D01v01r03.

5.2. System verification

Frequency (㎒)	Tissue type	Probe (S/N)	Antenna (S/N)	1 W Target SAR_{1g} (W/kg)	Measured SAR_{1g} (W/kg)	1 W Normalized SAR_{1g} (W/kg)	Deviation (%)	Limit (%)	Data
450	Head	3879	1084	4.58	1.22	4.88	6.55	±10	2014.12.15
	Body	3879	1084	4.50	1.18	4.72	4.89	±10	2014.12.16

6. RF exposure limits

Uncontrolled environment

Uncontrolled environments are defined as locations where there is the exposure of individuals who have no knowledge or control of their 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.

Controlled environment

Controlled environments are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation). 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.

	Uncontrolled environment general population (W/kg) or (㎽/g)	**Controlled environment occupational (W/kg) or (㎽/g)**
Spatial peak SAR head	1.60	8.00
Spatial average SAR whole body	0.08	0.40
Spatial peak SAR hands, feet, ankles, wrists	4.00	20.00

Figure 12. RF exposure limits

7. Test results summary

7.1. RF conducted power

7.1.1. Power measurement procedures

According KDB 447498 D01 General RF Exposure Guidance v05r01Section 4.1 2) states that “Unless it is specified differently in the published RF exposure KDB procedures, these requirements also apply to test reduction and test exclusion considerations. Time-averaged maximum conducted output power applies to SAR and, as required by § 2.1091(c), time-averaged ERP applies to MPE. When an antenna port is not available on the device to support conducted power measurement, such as FRS and certain Part 15 transmitters with built-in integral antennas, the maximum output power allowed for production units should be used to determine RF exposure test exclusion and compliance.”

7.1.2. RF conducted power

Mode	Frequency (㎒)	Channel	Measured power (dBm)
GMRS	462.637 5	4	28.10
FRS	467.637 5	11	21.72

7.1.2. Target power and Tune-up limits

Mode	Frequency (㎒)	Channel	Target(dBm)	Tune-up limits(dBm)
GMRS	462.637 5	4	28.00	29.00
FRS	467.637 5	11	21.00	22.00

Note:

1. The device operates using the following maximum output power specifications. The reported SAR is measured SAR value adjusted for maximum output power tolerance.
2. Tune up tolerance is ±1.0 ㏈.

7.2. SAR results

7.2.1. SAR measurement results

Test Position	Frequency (㎒)	Channel	Tune up limit (㏈m)	Power (㏈m)	Measurement SAR_{1g}(W/kg) Duty cycle		Power drift	Scaling factor	Reported SAR_{1g}(W/kg) Duty cycle		Plot No.
					100 %	50 %			100 %	50 %	
Face	462.637 5	4	29.00	28.10	0.699	0.350	-0.084	1.23	0.860	0.430	1
	467.637 5	11	22.00	21.72	0.430	0.215	-0.203	1.07	0.459	0.229	2
Body	462.637 5	4	29.00	28.10	0.940	0.470	-0.143	1.23	1.156	0.578	3
	467.637 5	11	22.00	21.72	0.430	0.215	-0.174	1.07	0.459	0.229	4

Note:

1. The EUT is fitted with Belt Clip accessory and placed directly against a phantom (no gap) in case of Face Down side.
2. This test was conducted in reference to KDB447498 D01 and KDB643646 D01.

8. Measurement equipments

Equipment	Manufacturer	Model	Serial No.	Calibration interval	Calibration due.
Stäubli Robot Unit	Stäubli	RX90B	F02/5Q89A1/A/01	N/A	N/A
Data Acquisition Electronics	SPEAG	DAE4	1344	1year	2015.11.12
E-Field Probe	SPEAG	EX3DV4	3879	1year	2015.11.19
Electro Optical Converter	SPEAG	EOC5	N/A	N/A	N/A
2mm Oval Phantom ELI5	SPEAG	QD OVA 002 AA	1190	N/A	N/A
Dipole Antenna	SPEAG	D450V3	1084	3years	2017.11.19
S-Parameter Network Analyzer	Agilent	8753ES	MY40000210	1year	2015.07.24
Calibration Kit	Agilent	85033D	3423A02429	N/A	N/A
EPM Series Power Meter	HP	E4419B	GB37290599	1year	2015.07.23
E-Series AVG Power Sensor	HP	E9300H	MY41495967	1year	2015.07.23
E-Series AVG Power Sensor	HP	E9300H	US39215405	1year	2015.07.23
Wideband Power Sensor	R&S	NRP-Z81	1137.9009.02-101886-ds	1year	2015.01.07
RF Power Amplifier	None	RFSPA	001	1year	2015.07.23
Dual Directional Coupler	HP	778D-012	16468	1year	2015.07.23
Vector Signal Generator	R&S	SMBV100A	1407.6004K02	1year	2015.07.24
Signal Analyzer	R&S	FSV30	101389	1year	2015.04.30
LP Filter	WEINSCHEL	WLK1.0/18G-10TT	1	1year	2015.07.23
Attenuator	HP	8494B	2630A12857	1year	2015.04.30
Hygro-Thermometer	BODYCOM	BJ5478	N/A	1year	2015.07.28
Dielectric Probe Kit	Agilent	85070E	MY44300696	N/A	N/A
Software	SPEAG	DASY4 V4.7	-	N/A	N/A

9. Measurement Uncertainty

DASY4 Uncertainty budget							
Error Description	**Section in P1528**	**Uncertainty Value ± %**	**Prob. Dist.**	**Div.**	c_i **(1 g)**	$u_i(y)$ **(1 g) ± %**	v_i **or** v_{eff}
Probe Calibration	E.2.1	6.55	N	1.00	1.00	6.55	∞
Axial Isotropy	E.2.2	0.50	R	1.73	0.71	0.20	∞
Hemispherical Isotropy	E.2.2	2.60	R	1.73	0.71	1.06	∞
Boundary Effect	E.2.3	2.00	R	1.73	1.00	1.16	∞
Linearity	E.2.4	0.60	R	1.73	1.00	0.35	∞
System Detection Limits	E.2.5	1.00	R	1.73	1.00	0.58	∞
Readout Electronics	E.2.6	0.30	N	1.00	1.00	0.30	∞
Response Time	E.2.7	0.50	R	1.73	1.00	0.29	∞
Integration Time	E.2.8	2.60	R	1.73	1.00	1.50	∞
RF Ambient Noise	E.6.1	3.00	R	1.73	1.00	1.73	∞
RF Ambient Reflections	E.6.1	3.00	R	1.73	1.00	1.73	∞
Probe Positioning Mechanical Tolerance	E.6.2	0.40	R	1.73	1.00	0.23	∞
Probe Positioning With Respect to Phantom	E.6.3	2.90	R	1.73	1.00	1.67	∞
Max. SAR Eval.	E.5.2	2.00	R	1.73	1.00	1.15	∞
Test sample positioning	E.4.2	2.30	N	1.00	1.00	2.30	9
Device Holder Uncertainty	E.4.1	3.60	N	1.00	1.00	3.60	∞
SAR Drift Measurement	6.6.3	5.00	R	1.73	1.00	2.89	∞
Phantom Uncertainty	E.3.1	6.10	R	1.73	1.00	3.52	∞
Liquid Conductivity(target)	E.3.2	5.00	R	1.73	0.64	1.85	∞
Liquid Conductivity(meas.)	E.3.2	0.30	N	1.00	0.64	0.19	5
Liquid Permittivity(target)	E.3.3	5.00	R	1.73	0.60	1.73	∞
Liquid Permittivity(meas.)	E.3.3	0.01	N	1.00	0.60	0.01	5
Combined Std. Uncertainty(RSS)						± 10.19 %	10 301.933
Expanded Uncertainty						± 20.38 %	***k*** **= 2**

Appendix list
Appendix A. DASY4 report
Appendix B. Calibration certificate