

SAR Compliance Test Report

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Tested device	DISHWASHER		
Related reports:	-		
Testing has been carried out in accordance with:	47CFR §2.1093 Radiofrequency Radiation Exposure Evaluation: Portable Devices FCC published RF exposure KDB procedures IEEE 1528 - 2013 IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Technique		
Documentation:	The test report must always be reproduced in full; reproduction of an excerpt only is subject to written approval of the testing laboratory		
Test Results:	The EUT complies with the requirements in respect of all parameters subject to the test. The test results relate only to devices specified in this document		
Date and signatures:	04.12.2018		
For the contents:			

Laboratory Manager

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1. SUMMARY OF SAR TEST REPORT

1.1 Test Details

Device under Test (DUT):

Product:	DISHWASHER
Manufacturer:	Arcelik
Serial Number:	2AO7BARWMo1
FCC ID Number:	2AO7AARWM01
Model:	E8P Control System with Internal Antenna Board
DUT Number:	22896
Battery Type used in testing:	-
Portable/ Mobile device	Mobile
State of the Sample	Production sample

Testing information:

Testing Performed:	23.10. 2018
Notes:	-
Document ID:	FCC SAR report_Beko_Int Antenna_ID2892_ 041218.docx
Temperature °C	22±2 / Controlled
Humidity RH%	20±20 / Controlled
Measurement performed by:	Kirsi Kyllönen

1.2 Maximum Results

The maximum reported* SAR values for Body-worn and extremity configurations is shown in a table below. The device conforms to the requirements of the standards when the maximum reported SAR value is less than or equal to the limit. The SAR limit specified in FCC 47 CFR part 2 (2.1093) for Body and Head SAR_{1g} is 1.6 W/kg and for Extremity SAR_{10g} it is 4.0 W/kg.

Equipment Class	System	Highest Reported* SAR _{1g} (W/kg) in Body-Worn Condition 0 mm separation	Highest Reported* SAR _{10g} (W/kg) for Extremity Condition 0 mm separation	Result
DTS	2.4 GHz WLAN	0.12	0.07	PASS

* Reported SAR Values are scaled to upper limit of power tuning tolerance.

1.2.1 Maximum Drift

Maximum Drift During Measurements	0.21dB*
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*Drifts >5% have been considered in the scaling factor

1.2.2 Measurement Uncertainty

Expanded Uncertainty (k=2) 95 %	23.4%
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2. DESCRIPTION OF THE DEVICE UNDER TEST (DUT)

The DUT is a dishwasher equipped with a WLAN module in the front door.

Device Category	Mobile
Exposure Environment	Uncontrolled

2.1 Supported Frequency Bands and Operational Modes

TX Frequency bands	Modes of Operation	Transmitter Frequency Range (MHz)
	2.4 GHz WLAN	2412-2462

3. OUTPUT POWER

3.1 Maximum Output Power

From a Customer;

Maximum defined output power, including tolerance of ± 1.5 dBm.

Standard	Transmission mode	Output power [dBm]		
		CH 1	CH 7	CH 13
802.11b	DSSS	19.5	19.5	19.5
802.11g	OFDM	19.5	19.5	19.5
802.11n	OFDM	19.5	19.5	19.5

3.2 Tested conducted power

Conducted output power at transmitting antenna connector;

Standard	Transmission mode	Modulation	Data rate [Mbps]	Power (dBm) Antenna 0 CH 1	Power (dBm) Antenna 0 CH 6	Power (dBm) Antenna 0 CH 11
802.11b	DSSS	BPSK	1	14.6	14.3	14.3
Standard	Transmission mode	Modulation	Data rate [Mbps]	Power (dBm) Antenna 1 CH 1	Power (dBm) Antenna 1 CH 6	Power (dBm) Antenna 1 CH 11
802.11b	DSSS	BPSK	1	14.7	14.4	14.3

4.1.1 Isotropic E-field Probe Type EX3DV4

Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Calibration	Calibration certificate in Appendix D
Frequency	10 MHz to >6 GHz (dosimetry); Linearity: ± 0.2 dB (30 MHz to 6 GHz)
Directivity	± 0.3 dB in HSL (rotation around probe axis) ± 0.5 dB in tissue material (rotation normal to probe axis)
Dynamic Range	10 μ W/g to > 100 mW/g, Linearity: ± 0.2 dB
Dimensions	Overall length: 330 mm Tip length: 10 mm Body diameter: 12 mm Tip diameter: 2.5 mm Distance from probe tip to dipole centers: 1.0 mm
Application	General dosimetry up to 6 GHz Compliance tests of mobile phones Fast automatic scanning in arbitrary phantoms

4.1.2 Eli Phantom:

The phantom used in SAR tests was an ELI phantom, manufactured by SPEAG. ELI phantom is used 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.

4.1.3 Tissue Simulants

Recommended values for the dielectric parameters of the tissue simulants are given in IEEE 1528 and FCC published RF Exposure KDB Procedures. The dielectric parameters of the used tissue simulants were within $\pm 10\%$ of the recommended values in all frequencies used. A liquid compensation algorithm was used in DASY5 with which measured peak average SAR values were corrected for the deviation of used liquid. Depth of the tissue simulant was at least 15.0 cm from the inner surface of the flat phantom.

Body 600-6000 MHz tissue simulant liquid Ingredients
Deionized Water, tween, salt

4.2 System Validation Status

Frequency [MHz]	Test System	Dipole Type / SN	Probe Type / SN	Calibrated Signal Type	DAE Unit / SN	Dielectric Constant ϵ Body tissue simulant	Conductivity σ [S/m] Body tissue simulant	Validation Done
								Body tissue simulant
2450	SAR 2	D2450V2- SN:729	EX3DV4 - SN: SN3982	CW	DAE 4 / 705	53.19	1.86	04.2018

4.3 System Check

Date	Tissue Type	Tissue Temp. [°C]	Frequency [MHz]	Input Power	Measured SAR _{1g} [W/kg]	1 W Target SAR _{1g} [W/kg]	1 W Normalized SAR _{1g} [W/kg]	Deviation 1g (%)	Plot #
23.10.2018	M600-6000	22±2	2450	100mW	5.2	53.7	52	-3.2	1

4.3.1 Tissue Simulant Verification

Date	Tissue Type	Tissue Temp. [°C]	Frequency [MHz]	Target		Measured		Deviation σ (%)	Deviation ϵ (%)
				Conductivity, σ [S/m]	Dielectric Constant ϵ	Conductivity σ [S/m]	Dielectric Constant ϵ		
23.10.2018	M600-6000	22	2450	1.95	52.7	1.89	48.3	-3.0	-8.3
23.10.2018	M600-6000	22	2412	1.91	52.8	1.86	48.3	-2.7	-8.4

5. TEST PROCEDURE

The DUT was set to transmit continuously at a maximum power level using a manufacturer specified software.

5.1 Test Positions

The DUT front door was placed below the flat phantom using an adjustable wooden support. The DUT was lifted towards the phantom until 5mm separation distance was reached for body worn configuration and 0mm separation for extremity configuration.

The area containing the transmitting antenna/module was scanned for SAR testing.

Photos of the test positions are presented in appendix A.

5.2 Scan Procedures

First, area scans were used for determination of the field distribution. Next, a zoom scan with 7x7x7 points covering a volume of 30x30x30mm was performed around the highest E-field value to determine the averaged SAR value. Power drift was determined by measuring the same point at the start of the area scan and again at the end of the zoom scan.

5.3 SAR Averaging Methods

The maximum SAR value is averaged over a cube of tissue using interpolation and extrapolation.

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

The interpolation, extrapolation and maximum search routines within Dasy47 are all based on the modified Quadratic Shepard's method (Robert J. Renka, "Multivariate Interpolation of Large Sets of Scattered Data", University of North Texas ACM Transactions on Mathematical Software, vol. 14, no. 2, June 1988, pp. 139-148).

6. MEASUREMENT UNCERTAINTY

Uncertainty Budget IEEE 1528-2013								
Error Description	Uncert. value	Prob. Dist.	Div.	(c _i) 1g	(c _i) 10g	Std. Unc. (1g)	Std. Unc. (10g)	(v _i) v _{eff}
Measurement System								
Probe Calibration	±6.0 %	N	1	1	1	±6.0 %	±6.0 %	∞
Axial Isotropy	±4.7 %	R		0.7	0.7	±1.9 %	±1.9 %	∞
Hemispherical Isotropy	±9.6 %	R	1.73	0.7	0.7	±3.9 %	±3.9 %	∞
Boundary Effects	±1.0 %	R	1.73	1	1	±0.6 %	±0.6 %	∞
Linearity	±4.7 %	R	1.73	1	1	±2.7 %	±2.7 %	∞
System Detection Limits	±1.0 %	R	1.73	1	1	±0.6 %	±0.6 %	∞
Modulation Response ^m	±2.4 %	R	1.73	1	1	±1.4 %	±1.4 %	∞
Readout Electronics	±0.3 %	N	1	1	1	±0.3 %	±0.3 %	∞
Response Time	±0.8 %	R	1.73	1	1	±0.5 %	±0.5 %	∞
Integration Time	±2.6 %	R	1.73	1	1	±1.5 %	±1.5 %	∞
RF Ambient Noise	±3.0 %	R	1.73	1	1	±1.7 %	±1.7 %	∞
RF Ambient Reflections	±3.0 %	R	1.73	1	1	±1.7 %	±1.7 %	∞
Probe Positioner	±0.4 %	R	1.73	1	1	±0.2 %	±0.2 %	∞
Probe Positioning	±2.9 %	R	1.73	1	1	±1.7 %	±1.7 %	∞
Max. SAR Eval.	±2.0 %	R	1.73	1	1	±1.2 %	±1.2 %	∞
Test Sample Related								
Device Positioning	±2.9 %	N	1	1	1	±2.9 %	±2.9 %	145
Device Holder	±3.6 %	N	1	1	1	±3.6 %	±3.6 %	5
Power Drift	±5.0 %	R	1.73	1	1	±2.9 %	±2.9 %	∞
Power Scaling	±6 %	R	1.73	1	1	±3.5 %	± 3.5%	∞
Phantom and Setup								
Phantom Uncertainty	±6.1 %	R	1.73	1	1	±3.5 %	±3.5 %	∞
SAR correction	±1.9 %	R	1.73	1	0.84	±1.1 %	±0.9 %	∞
Liquid Conductivity (mea.)	±2.5 %	R	1.73	0.78	0.71	±1.1 %	±1.0 %	∞
Liquid Permittivity (mea.)	±2.5 %	R	1.73	0.26	0.26	±0.3 %	±0.4 %	∞
Temp. unc. - Conductivity	±3.4 %	R	1.73	0.78	0.71	±1.5 %	±1.4 %	∞
Temp. unc. - Permittivity	±0.4 %	R	1.73	0.23	0.26	±0.1 %	±0.1 %	∞
Combined Std. Uncertainty						±11.7 %	±11.6 %	361
Expanded STD Uncertainty						±23.4 %	±23.3 %	

7. TEST RESULTS

7.1 Body-Worn Configuration 2.4GHz WLAN, 5 mm separation distance

Antenna	Band	Channel	Test Position	Maximum Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Duty Cycle	Measured SAR _{1g} [mW/g]	Scaling Factor	Reported SAR _{1g} [mW/g]	Plot #
0	802.11b	1	Front	19.5	14.6	0.21	1	0.024	3.09	0.07	2
1	802.11b	1	Front	19.5	14.7	0.12	1	0.017	3.02	0.05	3

7.2 Body-Worn/Extremity Configuration 2.4GHz WLAN, 0 mm separation distance

Antenna	Band	Channel	Test Position	Maximum Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Duty Cycle	Measured SAR _{1g} [mW/g]	Measured SAR _{10g} [mW/g]	Scaling Factor	Reported SAR _{1g} [mW/g]	Reported SAR _{10g} [mW/g]	Plot #
0	802.11b	1	Front	19.5	14.6	0.16	1	0.038	0.022	3.09	0.12	0.07	4
1	802.11b	1	Front	19.5	14.7	0.04	1	0.03	0.017	3.02	0.09	0.05	5

APPENDIX A: PHOTOS OF THE DUT



Body-worn Configuration, 5mm separation distance from phantom.



Body-worn/Extremity Configuration, 0mm separation distance from phantom.



Location of transmitting antenna/module. Antenna separation distance to the surface tested is 12mm. Separation distance to other edges >25 mm.



Tested device with antenna area under the phantom.

APPENDIX B: SYSTEM CHECK SCAN

Plot 1

Date/Time: 23.10.2018 12:40:41

Test Laboratory: Verkotan Oy

DUT: Dipole 2450 MHz D2450V2; Type: D2450V2; Serial: D2450V2 - SN:729

Communication System: UID 0, CW (0); Communication System Band: D2450 (2450.0 MHz); Frequency: 2450 MHz; Communication System PAR: 0 dB; PMF: 1

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.891$ S/m; $\epsilon_r = 48.311$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASYS (IEEE/IEC)

DASY Configuration:

- Probe: EX3DV4 - SN3892; ConvF(7.52, 7.52, 7.52); Calibrated: 20.4.2018;
- Sensor-Surface: 2mm (Mechanical Surface Detection), $z = 31.0$
- Electronics: DAE4 Sn756; Calibrated: 8.3.2018
- Phantom: SAR2_Phantom1_ELI; Type: QD OVA 002 AA; Serial: 29-March-2017
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration Pin=100 mW/Zoom Scan (7x9x7)/Cube 0: Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

Reference Value = 66.72 V/m; Power Drift = -0.17 dB

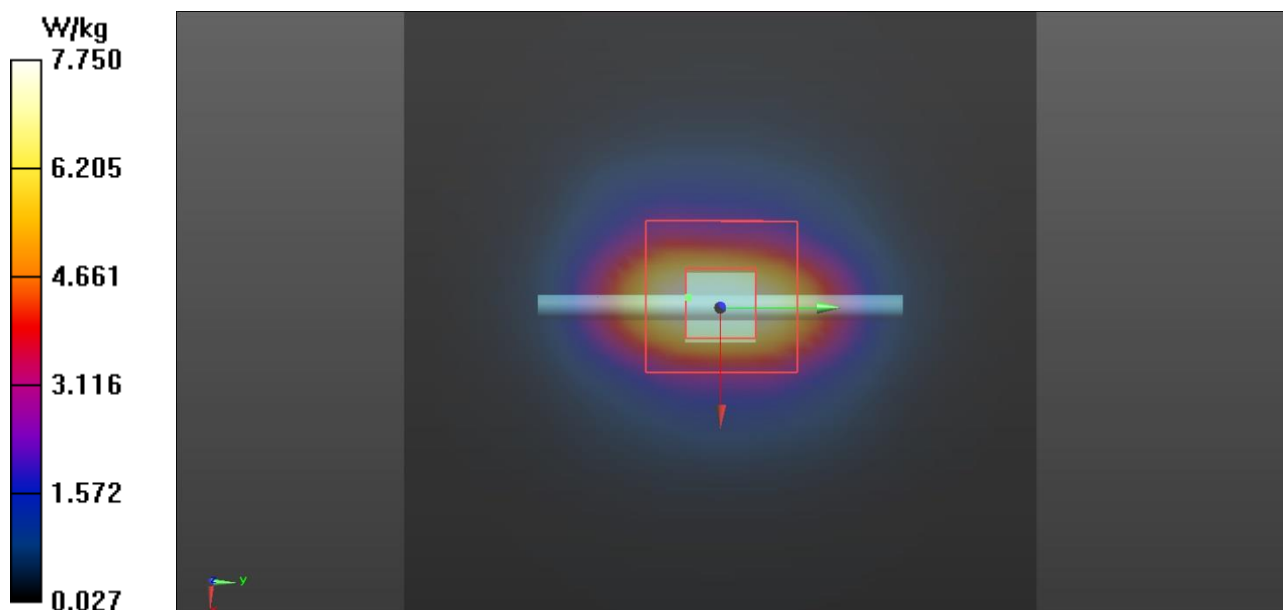
Peak SAR (extrapolated) = 10.3 W/kg

SAR(1 g) = 5.2 W/kg; SAR(10 g) = 2.45 W/kg

Maximum value of SAR (measured) = 7.75 W/kg

Configuration Pin=100 mW/Area Scan (61x61x1): Interpolated grid: $dx=1.500$ mm, $dy=1.500$ mm

Maximum value of SAR (interpolated) = 7.67 W/kg



APPENDIX C: MEASUREMENT SCANS

Plot 2

Date/Time: 23.10.2018 15:59:18

Test Laboratory: Verkotan Oy

DUT: Beko; Type: Internal Antenna 0, 5mm separation

Communication System: UID 0, WLAN 2.4 (0); Communication System Band: WLAN2.4GHz; Frequency: 2412 MHz; Communication System PAR: 0 dB; PMF: 1

Medium parameters used: $f = 2412$ MHz; $\sigma = 1.862$ S/m; $\epsilon_r = 48.335$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC)

DASY Configuration:

- Probe: EX3DV4 - SN3892; ConvF(7.52, 7.52, 7.52); Calibrated: 20.4.2018;
- Sensor-Surface: 2mm (Mechanical Surface Detection), $z = 1.0, 31.0$
- Electronics: DAE4 Sn756; Calibrated: 8.3.2018
- Phantom: SAR2_Phantom1_ELI; Type: QD OVA 002 AA; Serial: 29-March-2017
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration Beko IntAntenna0 pow11 5mm 2/Area Scan (141x241x1): Interpolated grid: $dx=1.200$ mm, $dy=1.200$ mm

Maximum value of SAR (interpolated) = 0.0325 W/kg

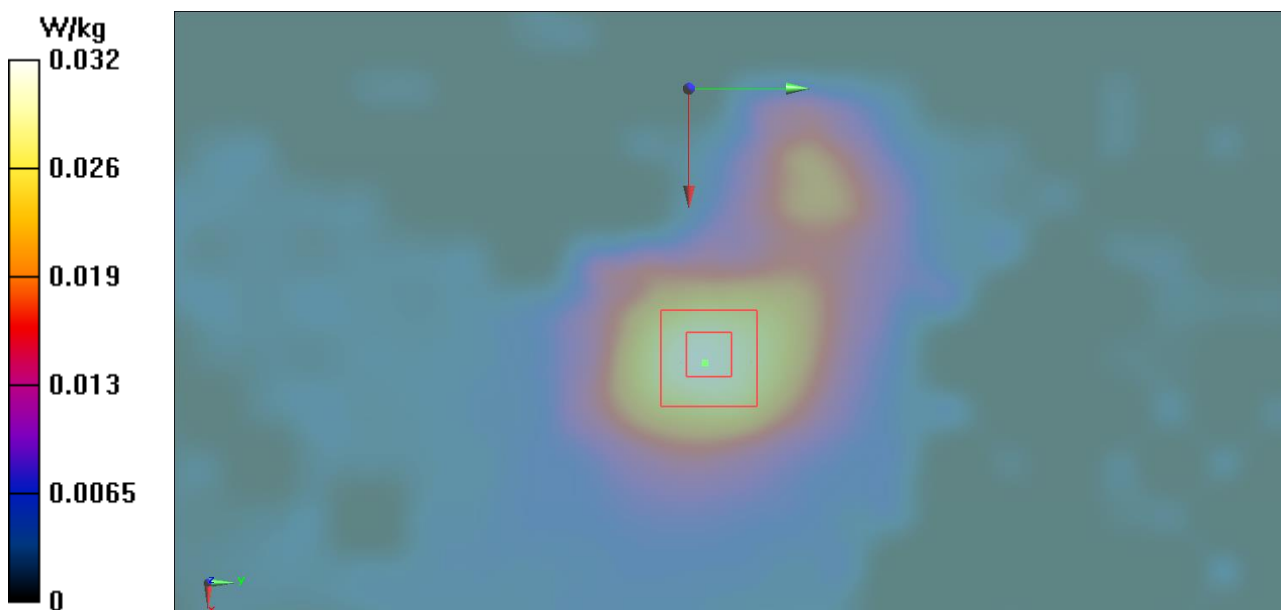
Configuration Beko IntAntenna0 pow11 5mm 2/Zoom Scan 2 (5x5x7)/Cube 0: Measurement grid: $dx=7.5$ mm, $dy=7.5$ mm, $dz=5$ mm

Reference Value = 2.990 V/m; Power Drift = 0.21 dB

Peak SAR (extrapolated) = 0.0430 W/kg

SAR(1 g) = 0.024 W/kg; SAR(10 g) = 0.015 W/kg (SAR corrected for target medium)

Maximum value of SAR (measured) = 0.0327 W/kg



Plot 3

Date/Time: 23.10.2018 16:53:03

Test Laboratory: Verkotan Oy

DUT: Beko; Type: Type: Internal Antenna 1, 5mm separation

Communication System: UID 0, WLAN 2.4 (0); Communication System Band: WLAN2.4GHz; Frequency: 2412 MHz; Communication System PAR: 0 dB; PMF: 1

Medium parameters used: $f = 2412$ MHz; $\sigma = 1.862$ S/m; $\epsilon_r = 48.335$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASYS (IEEE/IEC)

DASY Configuration:

- Probe: EX3DV4 - SN3892; ConvF(7.52, 7.52, 7.52); Calibrated: 20.4.2018;
- Sensor-Surface: 2mm (Mechanical Surface Detection), $z = 1.0, 31.0$
- Electronics: DAE4 Sn756; Calibrated: 8.3.2018
- Phantom: SAR2_Phantom1_ELI; Type: QD OVA 002 AA; Serial: 29-March-2017
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration Beko IntAntenna 1 pow11 5mm 2 2/Area Scan (141x241x1): Interpolated grid: $dx=1.200$ mm, $dy=1.200$ mm
Maximum value of SAR (interpolated) = 0.0249 W/kg

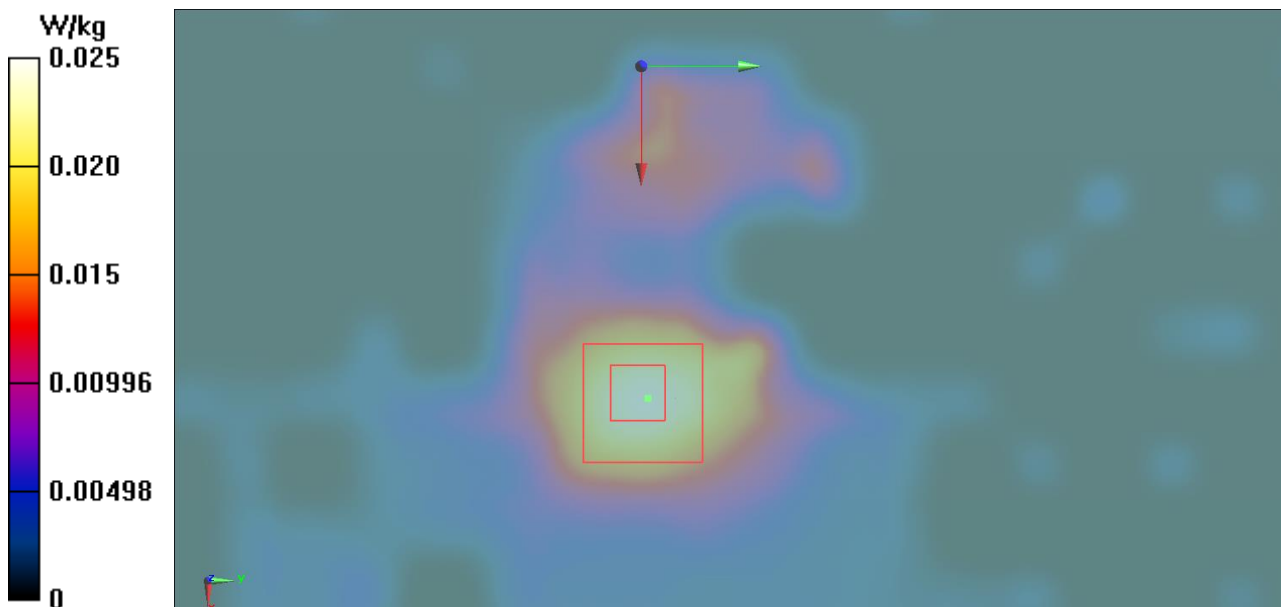
Configuration Beko IntAntenna 1 pow11 5mm 2 2/Zoom Scan 2 (5x5x7)/Cube 0: Measurement grid: $dx=7.5$ mm, $dy=7.5$ mm, $dz=5$ mm

Reference Value = 2.171 V/m; Power Drift = 0.12 dB

Peak SAR (extrapolated) = 0.0330 W/kg

SAR(1 g) = 0.017 W/kg; SAR(10 g) = 0.00937 W/kg (SAR corrected for target medium)

Maximum value of SAR (measured) = 0.0239 W/kg



Date/Time: 23.10.2018 15:43:26

Test Laboratory: Verkotan Oy

DUT: Beko; Type: Internal Antenna 0, 0mm separation

Communication System: UID 0, WLAN 2.4 (0); Communication System Band: WLAN2.4GHz; Frequency: 2412 MHz; Communication System PAR: 0 dB; PMF: 1

Medium parameters used: $f = 2412$ MHz; $\sigma = 1.862$ S/m; $\epsilon_r = 48.335$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASYS (IEEE/IEC)

DASY Configuration:

- Probe: EX3DV4 - SN3892; ConvF(7.52, 7.52, 7.52); Calibrated: 20.4.2018;
- Sensor-Surface: 2mm (Mechanical Surface Detection), $z = 31.0$
- Electronics: DAE4 Sn756; Calibrated: 8.3.2018
- Phantom: SAR2_Phantom1_ELI; Type: QD OVA 002 AA; Serial: 29-March-2017
- DASYS2 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration 3/Beko IntAntenna0 pow11 0mm/Zoom Scan 2 (5x5x7)/Cube 0: Measurement grid: $dx=7.5$ mm, $dy=7.5$ mm, $dz=5$ mm

Reference Value = 3.847 V/m; Power Drift = 0.16 dB

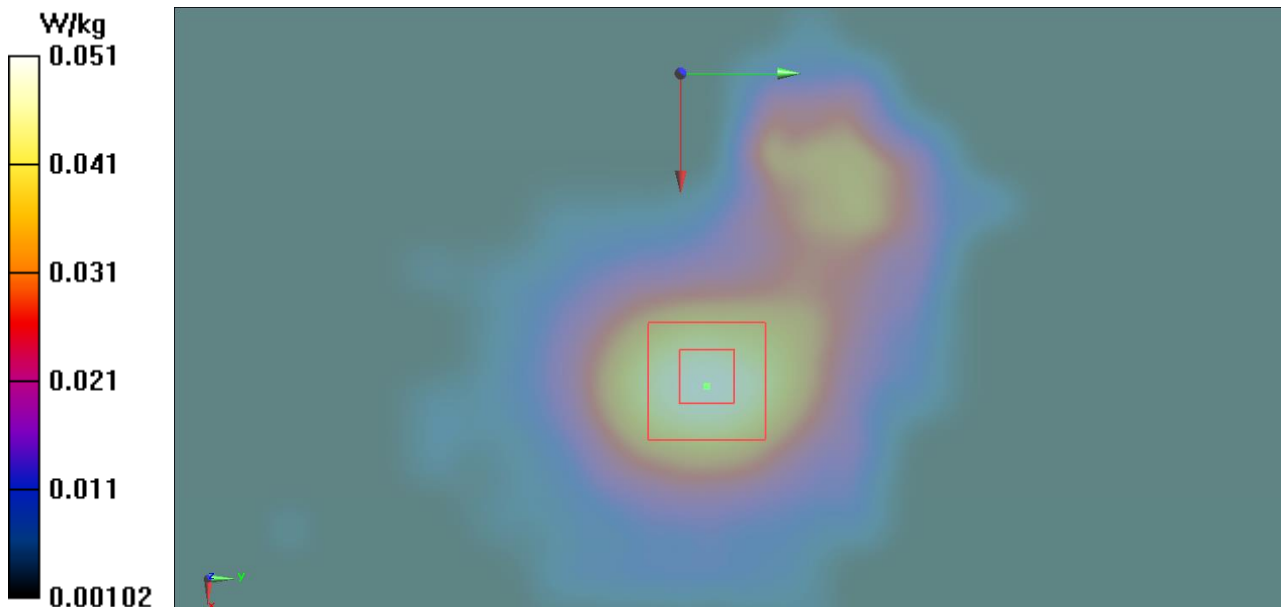
Peak SAR (extrapolated) = 0.0660 W/kg

SAR(1 g) = 0.038 W/kg; SAR(10 g) = 0.022 W/kg (SAR corrected for target medium)

Maximum value of SAR (measured) = 0.0509 W/kg

Configuration 3/Beko IntAntenna0 pow11 0mm/Area Scan (141x241x1): Interpolated grid: $dx=1.200$ mm, $dy=1.200$ mm

Maximum value of SAR (interpolated) = 0.0509 W/kg



Date/Time: 23.10.2018 18:21:23

Test Laboratory: Verkotan Oy

DUT: Beko; Type: Internal Antenna 1, 0mm separation

Communication System: UID 0, WLAN 2.4 (0); Communication System Band: WLAN2.4GHz; Frequency: 2412 MHz; Communication System PAR: 0 dB; PMF: 1

Medium parameters used: $f = 2412$ MHz; $\sigma = 1.862$ S/m; $\epsilon_r = 48.335$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASYS (IEEE/IEC)

DASY Configuration:

- Probe: EX3DV4 - SN3892; ConvF(7.52, 7.52, 7.52); Calibrated: 20.4.2018;
- Sensor-Surface: 2mm (Mechanical Surface Detection), $z = 31.0$
- Electronics: DAE4 Sn756; Calibrated: 8.3.2018
- Phantom: SAR2_Phantom1_ELI; Type: QD OVA 002 AA; Serial: 29-March-2017
- DASYS2 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration Beko IntAntenna 1 pow11 0 mm/Zoom Scan 2 (5x5x7)/Cube 0: Measurement grid: $dx=7.5$ mm, $dy=7.5$ mm, $dz=5$ mm

Reference Value = 3.115 V/m; Power Drift = 0.04 dB

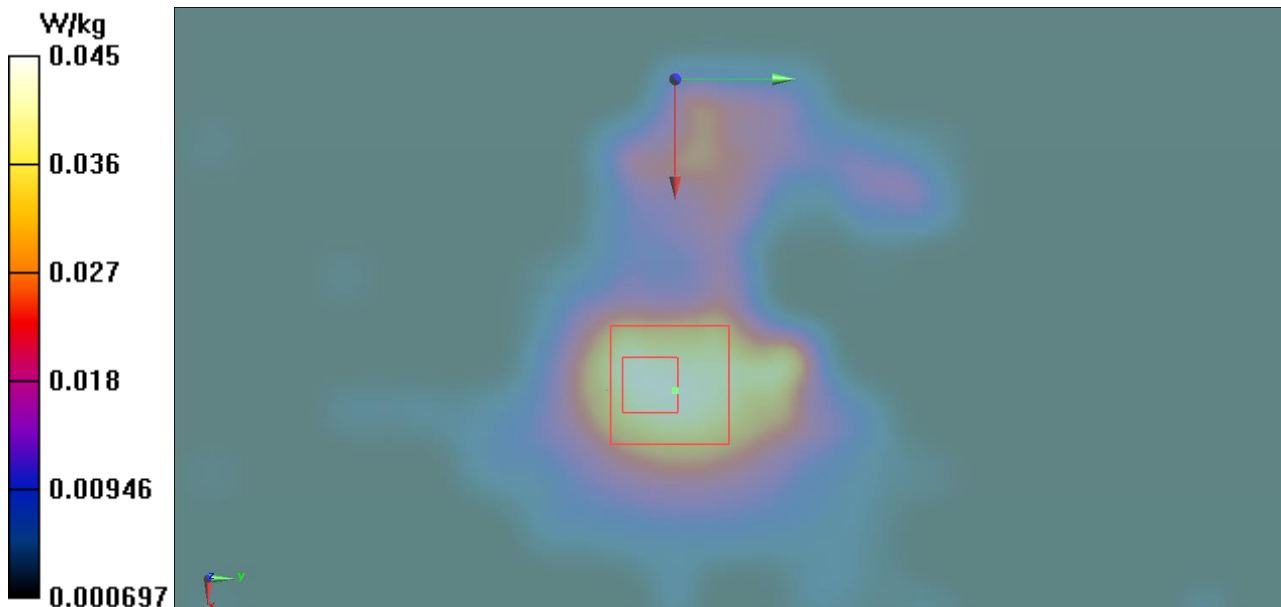
Peak SAR (extrapolated) = 0.0620 W/kg

SAR(1 g) = 0.030 W/kg; SAR(10 g) = 0.017 W/kg (SAR corrected for target medium)

Maximum value of SAR (measured) = 0.0445 W/kg

Configuration Beko IntAntenna 1 pow11 0 mm/Area Scan (141x241x1): Interpolated grid: $dx=1.200$ mm, $dy=1.200$ mm

Maximum value of SAR (interpolated) = 0.0432 W/kg



APPENDIX D: RELEVANT PAGES FROM PROBE CALIBRATION REPORTS

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



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

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA

Accreditation No.: **SCS 0108**

Client **Verkotan**

Certificate No: **EX3-3892_Apr18**

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3892**

Calibration procedure(s) **QA CAL-01.v9, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes**

Calibration date: **April 20, 2018**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature $(22 \pm 3)^{\circ}\text{C}$ and humidity $< 70\%$.

Calibration Equipment used (MATE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-18 (No. 217-02672/02673)	Apr-19
Power sensor NRP-Z91	SN: 103244	04-Apr-18 (No. 217-02672)	Apr-19
Power sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19
Reference 20 dB Attenuator	SN: S5277 (20x)	04-Apr-18 (No. 217-02682)	Apr-19
Reference Probe ES3DV2	SN: 3013	30-Dec-17 (No. ES3-3013_Dec17)	Dec-18
DAE4	SN: 660	21-Dec-17 (No. DAE4-660_Dec17)	Dec-18
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-16)	In house check: Jun-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18

	Name	Function	Signature
Calibrated by:	Leif Klysner	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	
This calibration certificate shall not be reproduced except in full without written approval of the laboratory.			

Issued: April 20, 2018

Certificate No: EX3-3892_Apr18

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:3892

Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) ^c	Relative Permittivity ^e	Conductivity (S/m) ^f	ConvF X	ConvF Y	ConvF Z	Alpha ^g	Depth ^h (mm)	Unc (k=2)
750	41.9	0.89	10.51	10.51	10.51	0.49	0.80	± 12.0 %
900	41.5	0.97	9.85	9.85	9.85	0.49	0.82	± 12.0 %
1750	40.1	1.37	8.59	8.59	8.59	0.35	0.80	± 12.0 %
1900	40.0	1.40	8.33	8.33	8.33	0.31	0.80	± 12.0 %
2450	39.2	1.80	7.46	7.46	7.46	0.30	0.85	± 12.0 %
2600	39.0	1.96	7.35	7.35	7.35	0.25	1.04	± 12.0 %

^c Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

^e At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ϵ and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^g Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

EX3DV4- SN:3892

April 20, 2018

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3892

Calibration Parameter Determined in Body Tissue Simulating Media

f (MHz) ^c	Relative Permittivity ^f	Conductivity (S/m) ^f	ConvF X	ConvF Y	ConvF Z	Alpha ^g	Depth ^g (mm)	Unc (k=2)
750	55.5	0.96	10.03	10.03	10.03	0.52	0.80	± 12.0 %
900	55.0	1.05	10.08	10.08	10.08	0.45	0.85	± 12.0 %
1750	53.4	1.49	8.21	8.21	8.21	0.38	0.85	± 12.0 %
1900	53.3	1.52	7.93	7.93	7.93	0.35	0.83	± 12.0 %
2450	52.7	1.95	7.52	7.52	7.52	0.33	0.93	± 12.0 %

^c Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

^f At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ϵ and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^g Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

APPENDIX E: RELEVANT PAGES FROM DIPOLE CALIBRATION REPORTS



SAR Reference Dipole Calibration Report

Ref : ACR.165.32.17.SATU.A

VERKOTAN LTD.
ELEKTRONIIKKATIE 17
90590, OULU, FINLAND
SAR REFERENCE DIPOLE
FREQUENCY: 2450 MHZ
SERIAL NO.: D2450V2-729

Calibrated at MVG US
2105 Barrett Park Dr. - Kennesaw, GA 30144



Calibration Date: 06/14/17

Summary:

This document presents the method and results from an accredited SAR reference dipole calibration performed in SATIMO USA using the COMOSAR test bench. All calibration results are traceable to national metrology institutions.



SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref. ACR.165.32.17.SATU.A

	<i>Name</i>	<i>Function</i>	<i>Date</i>	<i>Signature</i>
<i>Prepared by :</i>	Jérôme LUC	Product Manager	6/14/2017	<i>JS</i>
<i>Checked by :</i>	Jérôme LUC	Product Manager	6/14/2017	<i>JS</i>
<i>Approved by :</i>	Kim RUTKOWSKI	Quality Manager	6/14/2017	<i>Kim Rutkowski</i>

	<i>Customer Name</i>
<i>Distribution :</i>	Verkotan Ltd.

<i>Issue</i>	<i>Date</i>	<i>Modifications</i>
A	6/14/2017	Initial release

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SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.165.32.17.SATU.A

1950	40.0 ± 5 %		1.40 ± 5 %	
2000	40.0 ± 5 %		1.40 ± 5 %	
2100	39.8 ± 5 %		1.49 ± 5 %	
2300	39.5 ± 5 %		1.67 ± 5 %	
2450	39.2 ± 5 %	PASS	1.80 ± 5 %	PASS
2600	39.0 ± 5 %		1.96 ± 5 %	
3000	38.5 ± 5 %		2.40 ± 5 %	
3500	37.9 ± 5 %		2.91 ± 5 %	

7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

The IEEE Std. 1528 and CEI/IEC 62209 standards state that the system validation measurements should produce the SAR values shown below (for phantom thickness of 2 mm), within the uncertainty for the system validation. All SAR values are normalized to 1 W forward power. In bracket, the measured SAR is given with the used input power.

Software	OPENSAR V4
Phantom	SN 20/09 SAM71
Probe	SN 18/11 EPG122
Liquid	Head Liquid Values: ϵ_{ps}^* : 37.5 sigma : 1.80
Distance between dipole center and liquid	10.0 mm
Area scan resolution	dx=8mm/dy=8mm
Zoon Scan Resolution	dx=5mm/dy=5mm/dz=5mm
Frequency	2450 MHz
Input power	20 dBm
Liquid Temperature	21 °C
Lab Temperature	21 °C
Lab Humidity	45 %

Frequency MHz	1 g SAR (W/kg/W)		10 g SAR (W/kg/W)	
	required	measured	required	measured
300	2.85		1.94	
450	4.58		3.06	
750	8.49		5.55	
835	9.56		6.22	
900	10.9		6.99	
1450	29		16	
1500	30.5		16.8	
1640	34.2		18.4	
1750	36.4		19.3	
1800	38.4		20.1	
1900	39.7		20.5	
1950	40.5		20.9	

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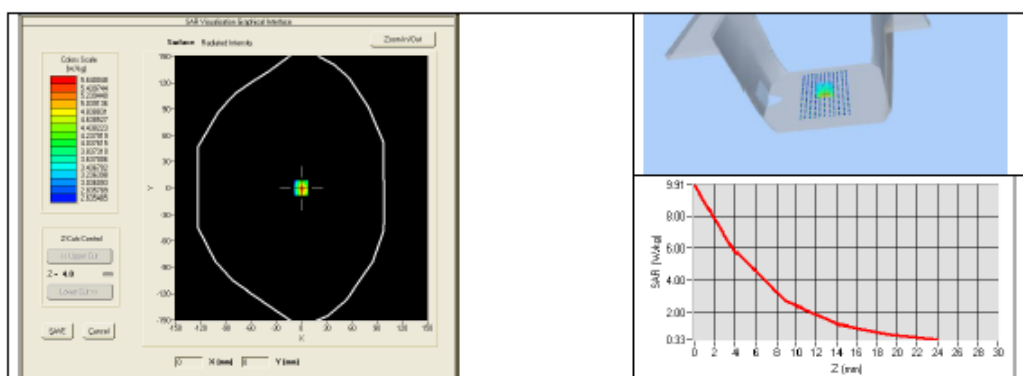
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SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref. ACR.165.32.17.SATUA

2000	41.1		21.1	
2100	43.6		21.9	
2300	48.7		23.3	
2450	52.4	53.43 (5.34)	24	24.05 (2.41)
2600	55.3		24.6	
3000	63.8		25.7	
3500	67.1		25	



7.3 BODY LIQUID MEASUREMENT

Frequency MHz	Relative permittivity (ϵ_r)		Conductivity (σ) S/m	
	required	measured	required	measured
150	61.9 $\pm$ 5 %		0.80 $\pm$ 5 %	
300	58.2 $\pm$ 5 %		0.92 $\pm$ 5 %	
450	56.7 $\pm$ 5 %		0.94 $\pm$ 5 %	
750	55.5 $\pm$ 5 %		0.96 $\pm$ 5 %	
835	55.2 $\pm$ 5 %		0.97 $\pm$ 5 %	
900	55.0 $\pm$ 5 %		1.05 $\pm$ 5 %	
915	55.0 $\pm$ 5 %		1.06 $\pm$ 5 %	
1450	54.0 $\pm$ 5 %		1.30 $\pm$ 5 %	
1610	53.8 $\pm$ 5 %		1.40 $\pm$ 5 %	
1800	53.3 $\pm$ 5 %		1.52 $\pm$ 5 %	
1900	53.3 $\pm$ 5 %		1.52 $\pm$ 5 %	
2000	53.3 $\pm$ 5 %		1.52 $\pm$ 5 %	
2100	53.2 $\pm$ 5 %		1.62 $\pm$ 5 %	
2450	52.7 $\pm$ 5 %	PASS	1.95 $\pm$ 5 %	PASS
2600	52.5 $\pm$ 5 %		2.16 $\pm$ 5 %	
3000	52.0 $\pm$ 5 %		2.73 $\pm$ 5 %	

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SAR REFERENCE DIPOLE CALIBRATION REPORT

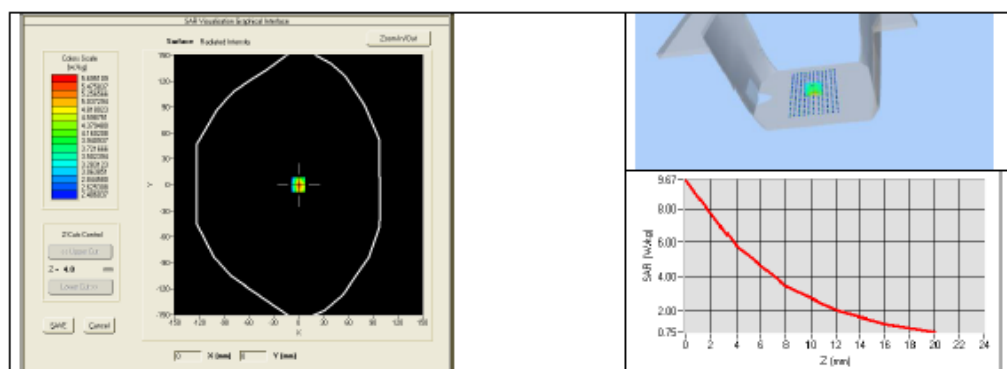
Ref: ACR.165.32.17.SATUA

3500	51.3 ±5 %		3.31 ±5 %	
5200	49.0 ±10 %		5.30 ±10 %	
5300	48.9 ±10 %		5.42 ±10 %	
5400	48.7 ±10 %		5.53 ±10 %	
5500	48.6 ±10 %		5.65 ±10 %	
5600	48.5 ±10 %		5.77 ±10 %	
5800	48.2 ±10 %		6.00 ±10 %	

7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

Software	OPENSAR V4
Phantom	SN 20/09 SAM71
Probe	SN 18/11 EPG122
Liquid	Body Liquid Values: ϵ_{ps} : 53.2 σ : 1.89
Distance between dipole center and liquid	10.0 mm
Area scan resolution	$dx=8mm/dy=8mm$
Zoon Scan Resolution	$dx=5mm/dy=5mm/dz=5mm$
Frequency	2450 MHz
Input power	20 dBm
Liquid Temperature	21 °C
Lab Temperature	21 °C
Lab Humidity	45 %

Frequency MHz	1 g SAR (W/kg/W)	10 g SAR (W/kg/W)
	measured	measured
2450	53.69 (5.37)	24.72 (2.47)



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