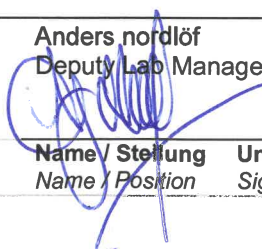


Prüfbericht-Nr.: 60233384-003 <i>Test Report No.:</i>		Auftrags-Nr.: 23870160 <i>Order No.:</i>		Seite 1 von 36 Page 1 of 36	
Kunden Referenz-Nr.: - <i>Client Reference No.:</i>		Auftragsdatum 2019-03-05 <i>Order date:</i>			
Auftraggeber: <i>Client:</i>		Brüel & Kjær Sound & Vibration Measurement A/S Skodsborgvej 307, 2850 Nærum Denmark			
Prüfgegenstand: <i>Test item:</i>		Sound Level Meter 2245 2ASFB-2245-1			
Bezeichnung / Typ-Nr.: - <i>Identification / Type No.:</i>					
Auftrags-Inhalt: <i>Order content:</i>		SAR Testing			
Prüfgrundlage: <i>Test specification:</i>		FCC 47 CFR Part 2 (2.1093) IEEE 1528:2013			
Wareneingangsdatum: 2019-03-06 <i>Date of receipt:</i>					
Prüfmuster-Nr.: A000224896-001 <i>Test sample No.:</i>					
Prüfzeitraum: 2019-03-15 to 2019-03-27 <i>Testing period:</i>					
Ort der Prüfung: Lund, Sweden <i>Place of testing:</i>					
Prüflaboratorium: TÜV Rheinland Sweden <i>Testing laboratory:</i>					
Prüfergebnis: PASS <i>Test results:</i>					
Geprüft von <i>Tested by:</i>		Kontrolliert von <i>Reviewed by:</i>			
Niall Forrester Technical Expert		Anders nordlöf Deputy Lab Manager			
2019-04-15 		2019-06-24 			
Datum <i>Date</i>	Name / Stellung <i>Name / Position</i>	Unterschrift <i>Signature</i>	Datum <i>Date</i>	Name / Stellung <i>Name / Position</i>	Unterschrift <i>Signature</i>
Sontiges / <i>Other:</i>					
Dieser Prüfbericht bezieht sich nur auf das o.g. Prüfmuster und darf ohne Genehmigung der Prüfstelle nicht auszugsweise vervielfältigt werden. Dieser Bericht berechtigt nicht zur Verwendung eines Prüfzeichens. <i>This test report only relates to the a. m. test sample. Without permission of the test center this test report is not permitted to be duplicated in extracts. This test report does not entitle to carry any test or accreditation mark/logo</i>					

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APPENDIX A:	Photographs of Device Placement Against the SAR Phantom
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APPENDIX C:	Equipment Calibration Certificates
APPENDIX D:	Diagram Showing Antenna Positions

1. Statement of Compliance

The highest reported SAR values for the device of type "B&K 2245" / 2ASFB-2245-1 were below the limits of

- 1.6 W/kg (averaged over 1g of tissue) for a body-worn use, and
- 4.0 W/kg (averaged over 10g of tissue) for hand-held use

The device is therefore in compliance with the SAR requirements set out in FCC 47 CFR Part 2 (2.1093) for a device intended for use by the General Population

Testing was carried out in accordance with the specifications listed in section 6.1 of this report

2. Application Details

Company Name:	Brüel & Kjær Sound & Vibration Measurement A/S
Address:	Skodsborgvej 307
	2850 Nærum
	Denmark
Company Telephone:	+45 77 412000
Contact Name:	Lisbeth Reindel
Contact e-mail:	lisbeth.reindel@bksv.com
Contact Telephone:	+45 77 412386
Requested Testing:	SAR Testing
Application Date:	2019-03-05

3. Test Result Summary

Equipment Class	Exposure Condition	Air Interface	Maximum SAR* (W/kg)	Result
DTS	Body (General Population / Uncontrolled)	WLAN 2.4 GHz*	0.62 W/kg (1g)	PASS
		Bluetooth	0.04 W/kg (1g)	PASS
		Simultaneous	0.89 W/kg (1g)	PASS
DTS	Extremities (General Population / Uncontrolled)	WLAN 2.4 GHz*	0.28 W/kg (10g)	PASS
		Bluetooth	N/A	N/A
		Simultaneous	0.42 W/kg (10g)	PASS

*Maximum SAR values listed include the following:

- WLAN 2.4 GHz (worst case for single antenna)
- Bluetooth (single antenna only, no dual antenna capability)
- Simultaneous: WLAN 2.4GHz (Main and Aux antenna transmitting simultaneously)

The device cannot transmit in WLAN 2.4GHz mode and Bluetooth mode simultaneously. See section 5.5

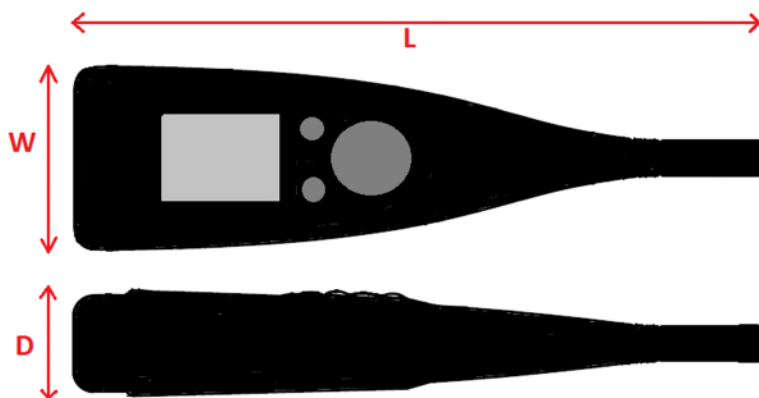
4. Laboratory Information

Laboratory Name:	TÜV Rheinland Sweden AB
Address:	Mobilvägen 10 22362 Lund Sweden
Telephone:	+46 46 272 5746
Testing Location:	As Above

5. Product Information

5.1. Product Description

Make and Model:	Brüel & Kjær Sound Level Meter 2245
Manufacturer:	Brüel & Kjær Sound & Vibration Measurement A/S
FCC ID:	2ASFB-2245-1
Description:	Hand-held sound level meter with WLAN and Bluetooth
Exposure Type:	☒ General Population / Uncontrolled ☐ Occupational / Controlled
Exposure Conditions:	☐ Next to the Ear ☐ Body Worn ☒ Next to the Body ☒ Limb ☐ Personal Wireless Router (Hotspot) ☐ Other:
Notes:	-



Device Dimensions	
Length (L)	26.12 cm
Width (W)	7.02 cm
Depth (D)	4.02 cm

Note: this diagram is not to scale and is not intended to be an accurate representation of the shape of the DUT

5.2. Test Sample Identification

Unique ID Serial No.	H/W Version:	Software Version:	Used For:	Date of Receipt:	Configuration & Condition:
A000224896-001	0.6	0.6.0.1324	SAR & Conducted Power measurements	2019-03-06	Production Equivalent Prototype (Working)

5.3. Air Interface Support

Air Interface:	Device Classes & Capabilities:	Modulation Type(s)	Band	Frequency Range: (MHz)	Tested
WLAN 2.4 GHz	802.11b/g/n	DSSS OFDM	2.4 GHz	2412 - 2462	YES
Bluetooth	BDR/EDR/BLE	GFSK $\pi/4$ -DQPSK 8DPSK	2.4 GHz	2402 - 2480	YES

5.4. Antenna Information

Antenna:	Antenna Type:	Frequency Range: (MHz)	Notes:
Main Antenna	Nanoblade	2.4GHz – 2.5GHz	WLAN 2.4GHz only
Aux Antenna	Nanoblade	2.4GHz – 2.5GHz	WLAN 2.4 GHz & Bluetooth

The “Main” antenna is used for WLAN 2.4 GHz only.

The “Aux” antenna can transmit either WLAN 2.4GHz or Bluetooth signals.

5.5. Simultaneous Transmission Configurations

Possible Simultaneous Transmission Combinations		Main Antenna	Aux Antenna	
		WLAN 2.4 GHz	WLAN 2.4GHz	Bluetooth
Main Antenna	WLAN 2.4 GHz	-	YES	NO
Aux Antenna	WLAN 2.4 GHz	-	-	NO
	Bluetooth	-	-	-

Note that in WLAN 2.4GHz mode, the device transmits identical signals (with the same frequency and modulation) on the “Main” and “Aux” antennas.

In Bluetooth mode, the device transmits only on the Aux antenna.

The device cannot transmit in WLAN 2.4GHz mode and Bluetooth mode simultaneously

5.6. Power Reduction and Special Operational Features

No power reduction features or other operational features relevant to SAR testing are supported by the device.

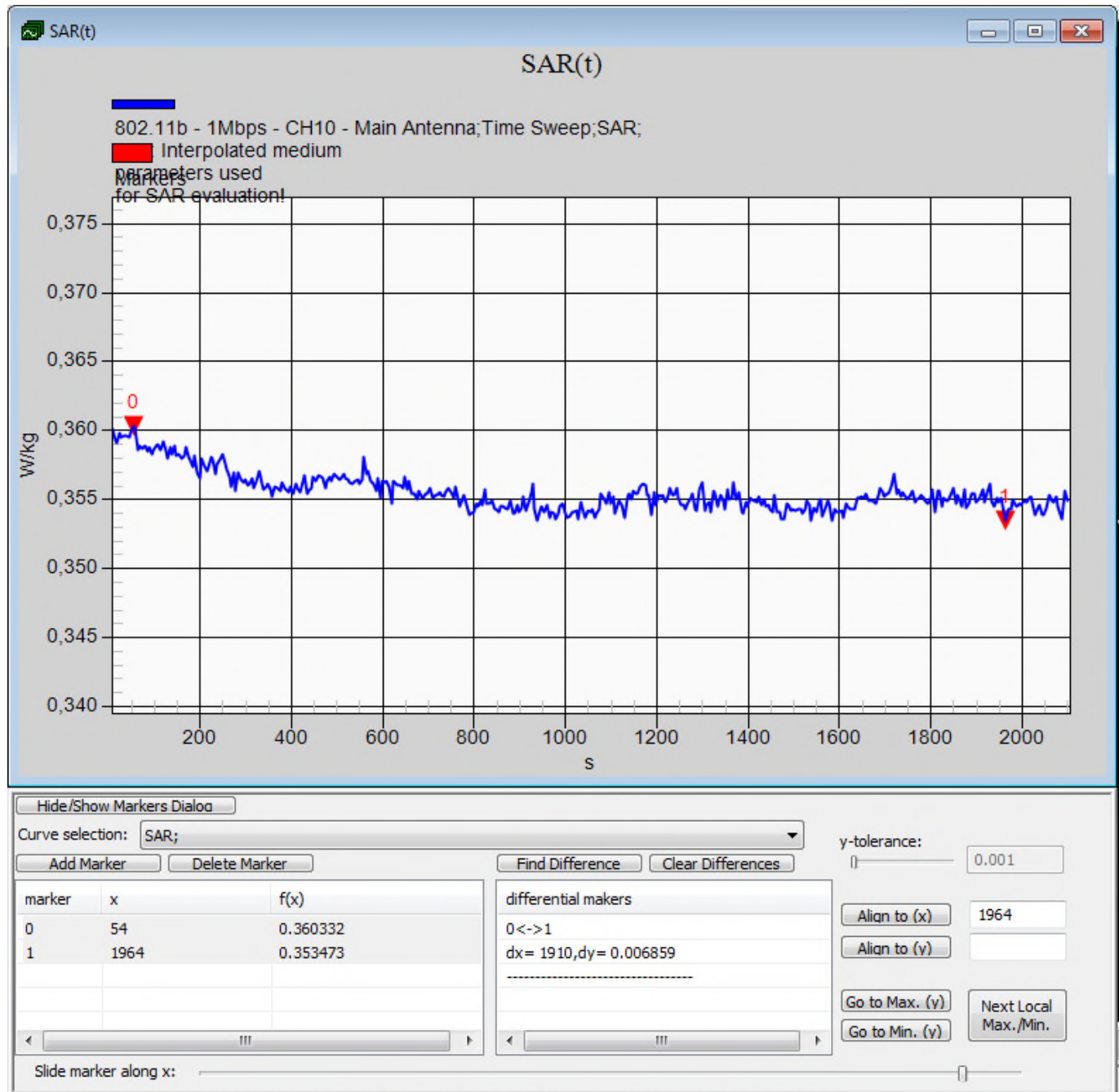
5.7. SAR Drift Considerations

Tests were conducted for each wireless technology to measure the effect of variations in output power over time. The device was positioned under the SAR phantom in the same way as for SAR testing, and SAR measurements were repeated at one second intervals at a fixed point inside the phantom. Measurements were repeated for a total of 2100 seconds (35 minutes) to cover the duration of a full SAR test (Area Scan and Zoom Scan). Graphs for these tests are included below, together with calculations

In the case of WLAN 2.4GHz, the variation was less than 5%, so the normal reference measurements at the start and end of the test were considered sufficient.

In the case of Bluetooth transmissions, the variation was higher than 5% and less than 10%, so an additional scaling factor has been included (i.e. the variation is considered as a systematic offset) as described in IEEE 1528:2013 section E.2.9. This factor has been combined with the scaling factor based on measured conducted output power, shown in section 5.8

SAR Drift for WLAN 2.4GHz



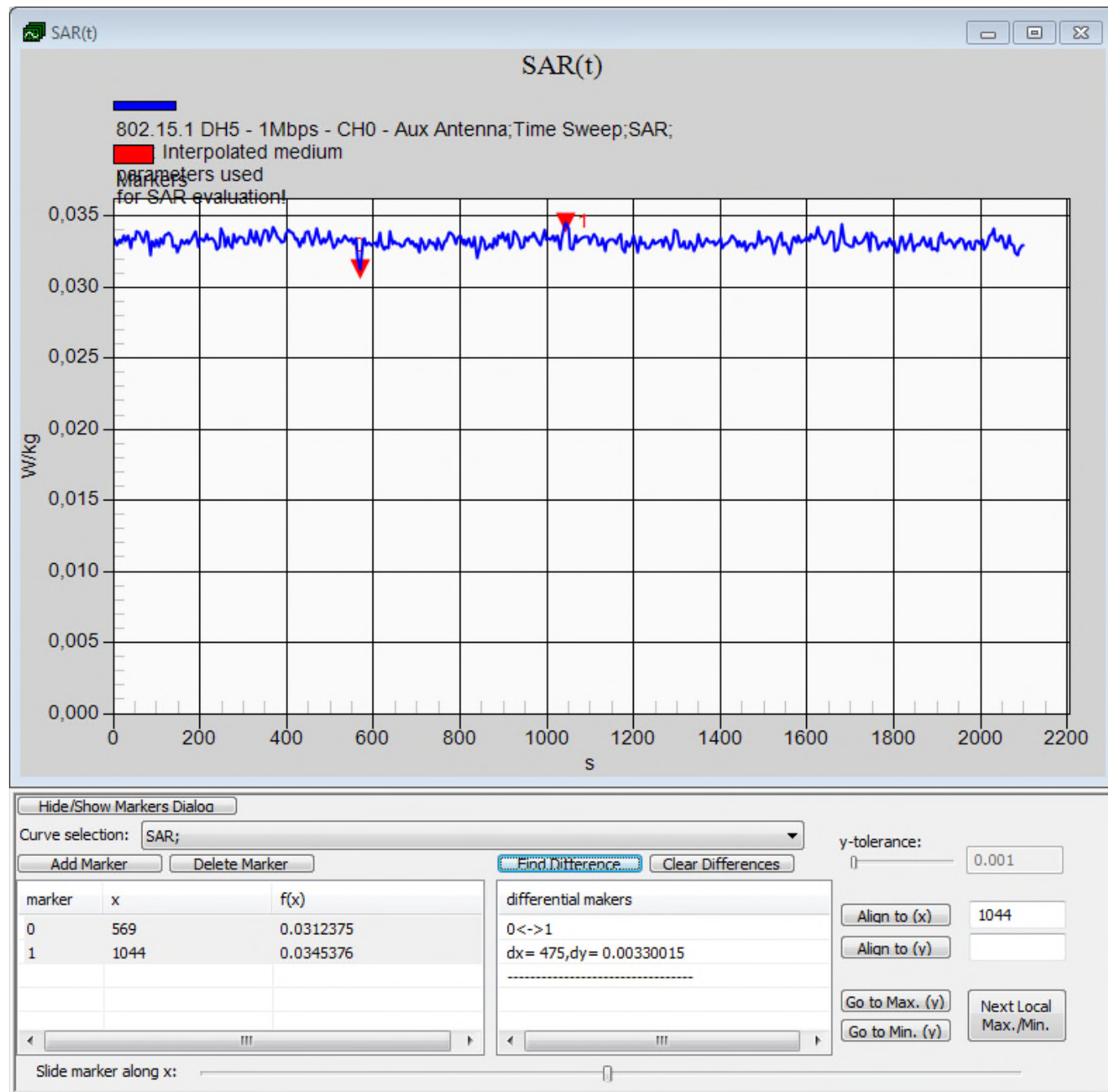
Maximum point SAR = 0.0360332

Minimum point SAR = 0.0353473

Maximum variation = $100 \times (0.0360332 - 0.0353473) / 0.0360332 = 1.90\%$

No additional scaling for WLAN 2.4GHz

SAR Drift for Bluetooth



Maximum point SAR = 0.0345376

Minimum point SAR = 0.0312375

Maximum variation = $100 \times (0.0345376 - 0.0312375) / 0.0345376 = 9.56\%$

Additional scaling factor (Bluetooth) = 1.0956

5.8. Conducted Output Power and Scaling Factors

Maximum Conducted Output Power – Including manufacturing Tolerances

Air Interface:	Wireless Link Configuration	Modulation	Main Antenna Max. Power (dBm)	Aux Antenna Max. Power (dBm)
WLAN 2.4 GHz	802.11b 1Mbps	DSSS	19.5	18.5
WLAN 2.4 GHz	802.11b 11Mbps	DSSS	19.5	18.5
WLAN 2.4 GHz	802.11g 6Mbps	OFDM	19.5	18.5
WLAN 2.4 GHz	802.11g 54Mbps	OFDM	17.5	16.5
WLAN 2.4 GHz	802.11n HT20 MCS0	OFDM	19.5	18.5
WLAN 2.4 GHz	802.11n HT20 MCS6	OFDM	17.5	16.5
WLAN 2.4 GHz	802.11n HT40 MCS0	OFDM	17.5	16.5
WLAN 2.4 GHz	802.11n HT40 MCS6	OFDM	15.5	14.5
Bluetooth	BDR	GFSK	N/A	10.3
Bluetooth	EDR	$\pi/4$ -DQPSK 8DPSK	N/A	7.3
Bluetooth	BLE	GFSK	N/A	7.3

Measured Conducted Output Power and Scaling Factors WLAN 2.4 GHz – Main Antenna

Channel	Frequency (MHz)	Modulation	Wireless Link Configuration	Meas. Power (dBm)	Max. Power (dBm)	Scaling Factor
1	2412	DSSS	802.11b 1Mbps	18.64	19.50	1.22
6	2437	DSSS	802.11b 1Mbps	18.72	19.50	1.20
10	2457	DSSS	802.11b 1Mbps	18.75	19.50	1.19
11	2462	DSSS	802.11b 1Mbps	17.78	18.50	-

Measured Conducted Output Power and Scaling Factors WLAN 2.4 GHz – Aux Antenna

Channel	Frequency (MHz)	Modulation	Wireless Link Configuration	Meas. Power (dBm)	Max. Power (dBm)	Scaling Factor
1	2412	DSSS	802.11b 1Mbps	17.14	18.50	1.37
6	2437	DSSS	802.11b 1Mbps	16.92	18.50	1.44
10	2457	DSSS	802.11b 1Mbps	16.90	18.50	1.45
11	2462	DSSS	802.11b 1Mbps	15.94	17.50	-

Meas. Power = Measured Average Power

Max. Power = Maximum Average Power

The Max Power is based on figures provided by the manufacturer and includes manufacturing tolerances

$$\text{Scaling Factor (WLAN 2.4GHz)} = 10^{\left[\frac{\text{Max.Power} - \text{Meas.Power}}{10}\right]}$$

Conducted Output Power and Scaling Factors Bluetooth – Aux Antenna

Channel	Frequency (MHz)	Modulation	Wireless Link Config.	Duty Factor (%)	Meas. Power (dBm)	Adj. Power (dBm)	Max. Power (dBm)	Scaling Factor*
2402	2402	GFSK	DM1 (BDR)	30.4	3.75	8.92	10.30	-
2441	2441	GFSK	DM1 (BDR)	30.4	3.04	8.21	10.30	-
2480	2480	GFSK	DM1 (BDR)	30.3	2.38	7.57	10.30	-
2402	2402	GFSK	DM3 (BDR)	65.5	7.07	8.91	10.30	-
2441	2441	GFSK	DM3 (BDR)	65.5	6.40	8.24	10.30	-
2480	2480	GFSK	DM3 (BDR)	65.4	5.73	7.57	10.30	-
2402	2402	GFSK	DM5 (BDR)	76.8	7.73	8.88	10.30	-
2441	2441	GFSK	DM5 (BDR)	76.8	7.08	8.23	10.30	-
2480	2480	GFSK	DM5 (BDR)	76.7	6.42	7.57	10.30	-
2402	2402	GFSK	DH1 (BDR)	30.5	3.69	8.85	10.30	-
2441	2441	GFSK	DH1 (BDR)	30.5	3.04	8.20	10.30	-
2480	2480	GFSK	DH1 (BDR)	30.4	2.39	7.56	10.30	-
2402	2402	GFSK	DH3 (BDR)	65.4	7.03	8.87	10.30	-
2441	2441	GFSK	DH3 (BDR)	65.3	6.38	8.23	10.30	-
2480	2480	GFSK	DH3 (BDR)	65.3	5.73	7.58	10.30	-
2402	2402	GFSK	DH5 (BDR)	76.9	7.75	8.89	10.30	1.52
2441	2441	GFSK	DH5 (BDR)	76.9	7.09	8.23	10.30	-
2480	2480	GFSK	DH5 (BDR)	76.9	6.43	7.57	10.30	-

* Scaling factor for Bluetooth includes contributions from the difference between measured and maximum power as well as the additional scaling to compensate for SAR drift. See equations below

Meas. Power = Measured Average Power. Adj. Power = Measured average power adjusted for duty factor

Max. Power = Maximum Average Power

The Max Power is based on figures provided by the manufacturer and includes manufacturing tolerances

$$\text{Scaling Factor (Bluetooth)} = 1.0956 \times 10^{\left[\frac{\text{Max.Power} - \text{Adj.Power}}{10} \right]}$$

5.9. Duty Factor Considerations

For WLAN 2.4GHz configurations, the device was set to transmit in test mode with 100% duty factor.

For Bluetooth configurations, the device was set to transmit in test mode and the resulting Duty Factor was measured together with the average power. An 'Adjusted Power' was then calculated by scaling up the measured power to the equivalent for 100% duty factor, in order to compare values with stated maximum power values.

Settings in the SAR measurement system were selected to correspond to the duty factors involved, therefore SAR compensation for the duty factor is automatically included in the results from the SAR test system.

6. SAR Measurement Information

6.1. Test Specifications

Testing was performed according to the requirements in the following specifications, which are part of the TÜV Rheinland Sweden scope of accreditation:

Spec. Number:	Title:	Version
IEEE 1528	IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques	2013

The following specifications were also used during the course of testing, for reference or guidance. Guidance documents and requirement standards that do not include test methods are not included as part of the accreditation scope.

Spec. Number:	Title:	Version
KDB 865664 D01	SAR Measurement Requirements for 100 MHz to 6 GHz	v01r04
KDB 447498 D01	RF Exposure Procedures and Equipment Authorization Policies for Portable and Mobile Devices	V06
KDB 248227 D01	SAR Guidance for IEEE 802.11 (Wi-Fi) Transmitters	V02r02

6.2. Deviations from the Test Specifications

Note that SAR testing for body and extremities exposure types was performed in accordance with the relevant KDB guidelines, which in turn refer to IEEE 1528 (which covers measurements of SAR in the head) as a basis.

6.3. SAR Limits

The following SAR limits have been applied in this test report to evaluate the compliance of the device against regulatory requirements

Reference:	Exposure Condition:	Limit: (W/kg)	Averaging Mass: (g)
FCC 47 CFR Part 2 (2.1093)	Body (General Population / Uncontrolled)	1.6	1
FCC 47 CFR Part 2 (2.1093)	Extremities (General Population / Uncontrolled)	4.0	10

6.4. Environmental Conditions

The air temperature and relative humidity in the lab are controlled and monitored automatically. These parameters are maintained between the following limits:

Air temperature: Minimum 20 °C Maximum 25 °C

Relative Humidity: Minimum 30 % Maximum 70 %

Tissue simulating fluid temperatures are measured at the start and end of testing and during dielectric measurements. Temperature data for the fluids is included with the SAR measurements in section 7

6.5. Test Configurations, Exclusions and Justifications

Controlling the Device During Testing

During conducted power measurements and SAR testing, the device was set in a test mode and controlled via commands sent from a laptop PC connected via USB. These commands allowed for the device to be forced into continuous transmission with dummy data and appropriate modulation characteristics, with transmit power set to the maximum. The specific transmit channel and wireless link configuration (data rate etc.) could be also be set.

Standalone SAR Test Exclusion Calculations

Standalone SAR test exclusions were calculated based on the equation in KDB 447498 D01 v06, as below:

$$\left[\frac{\text{Max Power of Channel, including tolerances (mW)}}{\text{Minimum Test Separation Distance (mm)}} \right] \times \sqrt{\text{Channel Frequency (GHz)}} \leq \text{Threshold}$$

Where the threshold is 3.0 for 1g SAR and 7.5 for 10g SAR

Where this equation is fulfilled, SAR measurements can be excluded.

For the sake of simplicity and to ensure conservative SAR results, the highest maximum power and highest channel frequency for each air interface and antenna combination were used

Standalone SAR Test Exclusion Calculations – 1g Body SAR (Separation Distance 5mm)

Air Interface:	Device Class	Antenna	Max Power (dBm)	Max Power (mW)	Frequency (MHz)	Result	Threshold	Excluded
WLAN 2.4 GHz	802.11b/g/n	Main	19.5	89.1	2462	30.0	3.0	NO
WLAN 2.4 GHz	802.11b/g/n	Aux	18.5	70.8	2462	22.2	3.0	NO
Bluetooth	BDR/EDR/ BLE	Aux	10.3	10.7	2480	3.4	3.0	NO

Standalone SAR Test Exclusion Calculations – 10g Extremities SAR (Separation Distance 5mm)

Air Interface:	Device Class	Antenna	Max Power (dBm)	Max Power (mW)	Frequency (MHz)	Result	Threshold	Excluded
WLAN 2.4 GHz	802.11b/g/n	Main	19.5	89.1	2462	30.0	7.5	NO
WLAN 2.4 GHz	802.11b/g/n	Aux	18.5	70.8	2462	22.2	7.5	NO
Bluetooth	BDR/EDR/ BLE	Aux	10.3	10.7	2480	3.4	7.5	YES

Physical Placement of the Device for SAR Testing

The device consists of a handheld unit with a wide end and a narrow end. The wide end includes the display screen and buttons for the user to control the device. The narrow end contains the microphone used for audio measurements. The antennas are mounted inside the wider part of the device.

The device can be placed on a stand (in which case the user will not be in close proximity), or held in the hand. Although no specific accessories for mounting the device on the body are supplied with the device, SAR measurements for use close to the body have been included in this report to ensure compliance.

For handheld use, and use close to the body, the manufacturer states that they expect that the following sides of the device may come in close proximity to the user:

- Front Side (side with screen)
- Back Side (side opposite screen)
- Left Edge (left side of device from perspective of someone reading the screen)
- Right Edge (right side of device from perspective of someone reading the screen)

A minimum distance of 5mm was chosen based on the response to a KDB inquiry. Photographs showing the placement of the device close to the SAR phantom are included in Appendix A

Dual Antenna Considerations

As the device is capable of transmitting simultaneously on two antennas in WLAN 2.4GHz mode, SAR measurements were performed individually for each antenna. The test mode allowed for the transmissions on each antenna to be controlled independently.

Calculations to determine exclusion of simultaneous SAR measurements for these configurations are shown in section 8.

WLAN 2.4GHz Wireless Configurations

SAR testing for WLAN 2.4GHz was performed in DSS mode with the configuration with the highest measured conducted power (802.11b DH5). As the highest channel (11 / 2462MHz) has a lower specified maximum power, testing was performed using channels 1, 6 and 10 (2412MHz, 2437MHz & 2457MHz respectively). The channel with the highest conducted power for each antenna was chosen for initial testing. Testing was performed on each of the four sides for each antenna.

The ratio of OFDM to DSSS maximum output power is 1:1. The highest reported SAR for DSSS, adjusted by this ratio is less than 1.2 W/kg, therefore testing for OFDM modes is excluded according to KDB 248227 D01 section 5.2.2. This exclusion applies to both body and Extremities SAR.

Although the highest reported standalone SAR in all cases was less than 0.8 W/kg, SAR measurements for all three channels (high, low and mid) was performed for the test position with the highest SAR to ensure a conservative SAR result.

Bluetooth Wireless Configurations

SAR testing for Bluetooth was performed using the configuration that gave the highest measured conducted power (DH5). The channel with the highest measured power was chosen for initial testing. Testing was performed on each of the four sides.

Bluetooth Low Energy configurations, and higher bit rate configurations for Bluetooth EDR were excluded from conducted power measurements (and SAR testing) as the maximum power in these modes is 3dB lower than for the standard Bluetooth modes.

As the highest reported SAR for Bluetooth mode was less than 0.8 W/kg, and lower than the WLAN 2.4GHz SAR, testing was excluded for other channels, as described in KDB 447498 D01 section 4.4.1.

7. SAR Measurement Results

7.1. SAR Measurement Results – WLAN 2.4GHz Body (Main Antenna)

Fluid temperature - Min: 20.6°C, Max: 22.0°C						SAR (1g)		
Scn. No.	Chan.	Freq. (MHz)	Mod.	Test Position	Wireless Link Configuration	Meas. SAR (W/kg)	Scl. Fact.	Rep. SAR (W/kg)
1	10	2457	DSSS	Body-Left Edge-5mm	802.11b-1Mbps	0.05	1.19	0.06
2	10	2457	DSSS	Body-Right Edge-5mm	802.11b-1Mbps	0.22	1.19	0.27
3	10	2457	DSSS	Body-Front-5mm	802.11b-1Mbps	0.22	1.19	0.26
4	10	2457	DSSS	Body-Back-5mm	802.11b-1Mbps	0.01	1.19	0.02
9	1	2412	DSSS	Body-Right Edge-5mm	802.11b-1Mbps	0.28	1.22	0.34
10	6	2437	DSSS	Body-Right Edge-5mm	802.11b-1Mbps	0.22	1.20	0.27

7.2. SAR Measurement Results – WLAN 2.4GHz Body (Aux Antenna)

Fluid temperature - Min: 20.6°C, Max: 22.0°C						SAR (1g)		
Scn. No.	Chan.	Freq. (MHz)	Mod.	Test Position	Wireless Link Configuration	Meas. SAR (W/kg)	Scl. Fact.	Rep. SAR (W/kg)
5	1	2412	DSSS	Body-Left Edge-5mm	802.11b-1Mbps	0.22	1.37	0.31
6	1	2412	DSSS	Body-Right Edge-5mm	802.11b-1Mbps	0.07	1.37	0.10
7	1	2412	DSSS	Body-Front-5mm	802.11b-1Mbps	0.08	1.37	0.11
8	1	2412	DSSS	Body-Back-5mm	802.11b-1Mbps	0.20	1.37	0.27
11	6	2437	DSSS	Body-Left Edge-5mm	802.11b-1Mbps	0.27	1.44	0.39
12	10	2457	DSSS	Body-Left Edge-5mm	802.11b-1Mbps	0.43	1.45	0.62

Meas. SAR = Measured SAR, Rep. SAR = Reported (Scaled) SAR, Scl. Fact. = Scaling Factor

Body positions are relative to phantom, i.e. "Body-Back" means the rear of the device is closest to the phantom

7.3. SAR Measurement Results – WLAN 2.4GHz Extremities (Main Antenna)

Fluid temperature - Min: 20.6°C, Max: 22.0°C						SAR (10g)		
Scn. No.	Chan.	Freq. (MHz)	Mod.	Test Position	Wireless Link Configuration	Meas. SAR (W/kg)	Scl. Fact.	Rep. SAR (W/kg)
1	10	2457	DSSS	Body-Left Edge-5mm	802.11b-1Mbps	0.03	1.19	0.03
2	10	2457	DSSS	Body-Right Edge-5mm	802.11b-1Mbps	0.10	1.19	0.12
3	10	2457	DSSS	Body-Front-5mm	802.11b-1Mbps	0.12	1.19	0.14
4	10	2457	DSSS	Body-Back-5mm	802.11b-1Mbps	0.06	1.19	0.07
9	1	2412	DSSS	Body-Right Edge-5mm	802.11b-1Mbps	0.14	1.22	0.17
10	6	2437	DSSS	Body-Right Edge-5mm	802.11b-1Mbps	0.11	1.20	0.13

7.4. SAR Measurement Results – WLAN 2.4GHz Extremities (Aux Antenna)

Fluid temperature - Min: 20.6°C, Max: 22.0°C						SAR (10g)		
Scn. No.	Chan.	Freq. (MHz)	Mod.	Test Position	Wireless Link Configuration	Meas. SAR (W/kg)	Scl. Fact.	Rep. SAR (W/kg)
5	1	2412	DSSS	Body-Left Edge-5mm	802.11b-1Mbps	0.10	1.37	0.14
6	1	2412	DSSS	Body-Right Edge-5mm	802.11b-1Mbps	0.04	1.37	0.06
7	1	2412	DSSS	Body-Front-5mm	802.11b-1Mbps	0.05	1.37	0.07
8	1	2412	DSSS	Body-Back-5mm	802.11b-1Mbps	0.07	1.37	0.10
11	6	2437	DSSS	Body-Left Edge-5mm	802.11b-1Mbps	0.12	1.44	0.18
12	10	2457	DSSS	Body-Left Edge-5mm	802.11b-1Mbps	0.20	1.45	0.28

7.5. SAR Measurement Results – Bluetooth Body (Aux Antenna)

Fluid temperature - Min: 20.7°C, Max: 22.1°C						SAR (1g)		
Scn. No.	Chan.	Freq. (MHz)	Mod.	Test Position	Wireless Link Configuration	Meas. SAR (W/kg)	Scl. Fact.	Rep. SAR (W/kg)
15	1	2402	GFSK	Body-Left Edge-5mm	DH5	0.03	1.52	0.04
16	1	2402	GFSK	Body-Right Edge-5mm	DH5	0.01	1.52	0.02
17	1	2402	GFSK	Body-Front-5mm	DH5	0.01	1.52	0.01
18	1	2402	GFSK	Body-Back-5mm	DH5	0.01	1.52	0.02

Meas. SAR = Measured SAR, Rep. SAR = Reported (Scaled) SAR, Scl. Fact. = Scaling Factor

Body positions are relative to phantom, i.e. "Body-Back" means the rear of the device is closest to the phantom

8. Simultaneous Transmission Calculations

SAR measurements for simultaneous transmission can be excluded if the sum of standalone SAR values for all relevant transmitter/antenna combinations in the simultaneous transmission configuration is less than the SAR limit.

In the table below, the highest reported SAR values for each relevant combination of antenna, frequency band and technology have been summed. Based on KDB 447498 D01 section 4.3.2, where the sum of the reported SAR values for relevant standalone SAR measurements is less than the SAR limit, simultaneous SAR measurements can be excluded.

As the device is not capable of transmitting simultaneously on different channels for each antenna, the summing has been performed separately for each channel.

Simultaneous Transmission Calculations for Body / 1g SAR

			Main Antenna	Aux Antenna	Simultaneous Transmission	
Scn. Nos.	Channel / Freq. (MHz)	Tech / Band	Highest 1g SAR (W/kg)	Highest 1g SAR (W/kg)	Sum of 1g SAR (W/kg)	Simultaneous Transmission Measurement Required?
5 & 9	1 / 2412	WLAN 2.4GHz	0.34	0.31	0.65	NO
10 & 11	6 / 2437	WLAN 2.4GHz	0.27	0.39	0.66	NO
2 & 12	10 / 2457	WLAN 2.4Ghz	0.27	0.62	0.89	NO

Simultaneous Transmission Calculations for Extremities / 10g SAR

			Main Antenna	Aux Antenna	Simultaneous Transmission	
Scn. Nos.	Channel / Freq. (MHz)	Tech / Band	Highest 10g SAR (W/kg)	Highest 10g SAR (W/kg)	Sum of 10g SAR (W/kg)	Simultaneous Transmission Measurement Required?
5 & 9	1 / 2412	WLAN 2.4GHz	0.17	0.14	0.31	NO
10 & 11	6 / 2437	WLAN 2.4GHz	0.13	0.18	0.31	NO
3 & 12	10 / 2457	WLAN 2.4Ghz	0.14	0.28	0.42	NO

9. Measurement Uncertainty

Specific Absorption Rate - Measurement Uncertainty – 300 MHz to 3 GHz								
Uncertainty Component	Uncert. Value	Prob. Distrib.	Divisor	Ci (1g)	Ci (10g)	Std. Uncert. (1g)	Std. Uncert. (10g)	Vi or Veff
- Measurement System								
Probe Calibration (k=1)	±6.0%	N	1	1.00	1.00	±6.0%	±6.0%	∞
Axial Isotropy	±4.7%	R	√3	0.70	0.70	±1.9%	±1.9%	∞
Hemispherical Isotropy	±9.6%	R	√3	0.70	0.70	±3.9%	±3.9%	∞
Boundary Effects	±1.0%	R	√3	1.00	1.00	±0.6%	±0.6%	∞
Linearity	±4.7%	R	√3	1.00	1.00	±2.7%	±2.7%	∞
System Detection Limits	±1.0%	R	√3	1.00	1.00	±0.6%	±0.6%	∞
Modulation Response	±2.4%	R	√3	1.00	1.00	±1.4%	±1.4%	∞
Readout Electronics	±0.3%	N	1	1.00	1.00	±0.3%	±0.3%	∞
Response Time	±0.8%	R	√3	1.00	1.00	±0.5%	±0.5%	∞
Integration Time	±2.6%	R	√3	1.00	1.00	±1.5%	±1.5%	∞
RF Ambient Cond. - Noise	±3.0%	R	√3	1.00	1.00	±1.7%	±1.7%	∞
RF Ambient Cond. - Reflections	±3.0%	R	√3	1.00	1.00	±1.7%	±1.7%	∞
Probe Psn. Mechanical Tolerance	±0.4%	R	√3	1.00	1.00	±0.2%	±0.2%	∞
Probe Psn. w.r.t. Phantom Shell	±2.9%	R	√3	1.00	1.00	±1.7%	±1.7%	∞
Maximum SAR Evaluation	±2.0%	R	√3	1.00	1.00	±1.2%	±1.2%	∞
- Test Sample Related								
Test Sample Positioning	±4.0%	N	1	1.00	1.00	±4.0%	±4.0%	303
Device Holder Disturb.	±3.6%	N	1	1.00	1.00	±3.6%	±3.6%	5
Power Drift	±5.0%	R	√3	1.00	1.00	±2.9%	±2.9%	∞
SAR Scaling	±6.8%	N	1	1.00	1.00	±6.8%	±6.8%	∞
- Phantom and Liquid Parameters								
Phantom Shell Uncertainty	±6.1%	R	√3	1.00	1.00	±3.5%	±3.5%	∞
SAR Correction	±1.9%	N	1	1.00	0.84	±1.9%	±1.6%	∞
Liquid Conductivity Measurement	±2.5%	N	1	0.78	0.71	±2.0%	±1.8%	∞
Liquid Permittivity Measurement	±2.5%	N	1	0.26	0.26	±0.7%	±0.7%	∞
Temp. Uncertainty (Conductivity)	±4.7%	R	√3	0.78	0.71	±2.1%	±1.9%	∞
Temp. Uncertainty (Permittivity)	±1.3%	R	√3	0.23	0.26	±0.2%	±0.2%	∞
COMBINED STANDARD UNCERTAINTY						±13.6%	±13.5%	
EXPANDED STANDARD UNCERTAINTY (k=2)						±27.2%	±27.1%	
Veff						1001	974	

System Validation - Measurement Uncertainty – 300 MHz to 6 GHz								
Uncertainty Component	Uncert. Value	Prob. Distrib.	Divisor	Ci (1g)	Ci (10g)	Std. Uncert. (1g)	Std. Uncert. (10g)	Vi or Veff
- Measurement System								
Probe Calibration (k=1)	±6.6%	N	1	1.00	1.00	±6.6%	±6.6%	∞
Axial Isotropy	±4.7%	R	√3	1.00	1.00	±2.7%	±2.7%	∞
Hemispherical Isotropy	±9.6%	R	√3	0.00	0.00	±0.0%	±0.0%	∞
Boundary Effects	±1.0%	R	√3	1.00	1.00	±0.6%	±0.6%	∞
Linearity	±4.7%	R	√3	1.00	1.00	±2.7%	±2.7%	∞
System Detection Limits	±1.0%	R	√3	1.00	1.00	±0.6%	±0.6%	∞
Modulation Response	±0.0%	R	√3	0.00	0.00	±0.0%	±0.0%	∞
Readout Electronics	±0.3%	N	1	1.00	1.00	±0.3%	±0.3%	∞
Response Time	±0.0%	R	√3	1.00	1.00	±0.0%	±0.0%	∞
Integration Time	±0.0%	R	√3	1.00	1.00	±0.0%	±0.0%	∞
RF Ambient Cond. - Noise	±3.0%	R	√3	1.00	1.00	±1.7%	±1.7%	∞
RF Ambient Cond. - Reflections	±3.0%	R	√3	1.00	1.00	±1.7%	±1.7%	∞
Probe Psn. Mechanical Tolerance	±0.8%	R	√3	1.00	1.00	±0.5%	±0.5%	∞
Probe Psn. w.r.t. Phantom Shell	±6.7%	R	√3	1.00	1.00	±3.9%	±3.9%	∞
Maximum SAR Evaluation	±2.0%	R	√3	1.00	1.00	±1.2%	±1.2%	∞
- Dipole Related								
Dipole Axis to Liquid Distance	±2.0%	N	1	1.00	1.00	±2.0%	±2.0%	∞
Deviation of Experimental Source	±5.5%	N	1	1.00	1.00	±5.5%	±5.5%	∞
Input Power and SAR Drift	±3.4%	R	√3	1.00	1.00	±2.0%	±2.0%	∞
- Phantom and Liquid Parameters								
Phantom Shell Uncertainty	±4.0%	R	√3	1.00	1.00	±2.3%	±2.3%	∞
SAR Correction	±1.9%	N	√3	1.00	0.84	±1.1%	±0.9%	∞
Liquid Conductivity Measurement	±2.5%	N	1	0.78	0.71	±2.0%	±1.8%	∞
Liquid Permittivity Measurement	±2.5%	N	1	0.26	0.26	±0.7%	±0.7%	∞
Temp. Uncertainty (Conductivity)	±5.0%	R	√3	0.78	0.71	±2.3%	±2.0%	∞
Temp. Uncertainty (Permittivity)	±2.0%	R	√3	0.23	0.26	±0.3%	±0.3%	∞
COMBINED STANDARD UNCERTAINTY						±11.6%	±11.5%	
EXPANDED STANDARD UNCERTAINTY (k=2)						±23.2%	±23.1%	

Note: Measurement uncertainty has been included in this report in order to fulfil requirements in the lab's ISO 17025 quality management system.

10. Test Equipment Status

Test Equipment List					
Type:	Manufacturer	Model	Serial Number / ID	Calibration Date:	Calibration Due:
E-Field Probe	SPEAG	EX3DV4	3805 / 2703947	19.07.2018	19.07.2019
Data Acquisition Electronics	SPEAG	DAE 3	428 / 2703949	11.07.2018	11.07.2019
SAM Phantom	SPEAG	ELI	TP - 1186 / 2709673	N/A	N/A
SAR Fluid	SPEAG	MSL2450	2709687	N/A	N/A
System Validation Kit	SPEAG	D2450V2	745 / 2703959	12.07.2018	12.07.2019
Signal Generator	Rohde & Schwarz	SMR 20	101398 / 2703971	11.07.2018	11.07.2021
Power Amplifier	BONN	BLMA 0830-3	056144A-02 / 2703963	11.07.2018	11.07.2019
Power Meter	Rohde & Schwarz	NRP	100442 / 2703978	11.07.2018	11.07.2019
Average Power Sensor	Rohde & Schwarz	NRP-Z21	101680 / 2703976	11.07.2018	11.07.2019
Average Power Sensor	Rohde & Schwarz	NRP-Z21	103135 / 2703977	10.07.2018	10.07.2019
RadiPower Wireless 6 GHz Power meter	Dare	RPR3006W	RPR6W-1901-006 / 2969972	18.02.2019	18.02.2020
Directional Coupler	ET Industries	C-058-20	216068001 / 2703982	07.08.2018	07.08.2019
DAK Dielectric Probe	SPEAG	SM DAK 520 AA	9 / 2703974	11.07.2018	11.07.2019
Temp. & humidity Logger	Lufft	OPUS 20	2703981	05.07.2018	05.07.2019

Software Version Information		
Equipment:	Software Name	Software Version:
SAR Measurement Systems	DASY 52	52.10.0 (1446)
Dielectric Measurement System	DAK	2.4.1.75

11. Tissue Simulating Fluids

11.1. Tissue Simulating Fluid Details

Type:	Manufacturer:	Used to Simulate:	Serial Number / ID:	Nominal Frequency (MHz)	Main Ingredients*:
MSL2450	SPEAG	Body Tissue	2709687	2450	H ₂ O, DGBE

*Note: The recipes for these fluids are proprietary to the manufacturers and hence the exact proportions of ingredients are not available

DGBE = Diethylene-Glycol-Monobutyl-Ether

H₂O = De-ionized Water

NaCl = Salt (Sodium Chloride)

Triton X-100 = Commercially Available Detergent

11.2. Tissue Simulating Fluid Measurements

Fluid: MSL2450 (2709687) – Body				Measured		Target		Deviation (%)	
Date:	Tech. / Band:	Chan.	Freq. (Mhz)	Permit-tivity	Conduc-tivity	Permit-tivity	Conduc-tivity	Permit-tivity	Conduc-tivity
2019-03-18	Sys Check	2450	2450.0	51.25	2.02	52.70	1.95	-2.8%	3.5%
2019-03-18	WLAN_2.4	1	2412.0	51.41	1.97	52.75	1.91	-2.5%	2.7%
2019-03-18	WLAN_2.4	6	2437.0	51.31	2.00	52.72	1.94	-2.7%	3.3%
2019-03-18	WLAN_2.4	10	2457.0	51.22	2.03	52.69	1.96	-2.8%	3.5%
2019-03-19	Sys Check	2450	2450.0	51.65	2.03	52.70	1.95	-2.0%	3.9%
2019-03-19	WLAN_2.4	1	2412.0	51.81	1.97	52.75	1.91	-1.8%	3.1%
2019-03-19	WLAN_2.4	6	2437.0	51.70	2.01	52.72	1.94	-1.9%	3.6%
2019-03-19	WLAN_2.4	10	2457.0	51.62	2.03	52.69	1.96	-2.0%	3.8%
2019-03-27	Sys Check	2450	2450.0	51.98	2.02	52.70	1.95	-1.4%	3.7%
2019-03-27	Bluetooth	1	2402.0	52.19	1.95	52.76	1.90	-1.1%	2.7%

12. System Verification

12.1. System Check Results

		Equipment				Normalised SAR (W/kg)		Target SAR (W/kg)		Deviation (%)	
Date & Sys. ID:	Freq. (Mhz)	Sys. Val Kit:	E-Probe	DAE	Fluid	1g	10g	1g	10g	1g	10g
2019-03-18 DASY 2	2450	745 - 2703959	3805 - 2703947	428 - 2703949	2709687	51.30	23.90	49.40	23.40	3.85%	2.14%
2019-03-19 DASY 2	2450	745 - 2703959	3805 - 2703947	428 - 2703949	2709687	50.83	23.81	49.40	23.40	2.90%	1.75%
2019-03-27 DASY 2	2450	745 - 2703959	3805 - 2703947	428 - 2703949	2709687	50.22	23.55	49.40	23.40	1.65%	0.66%

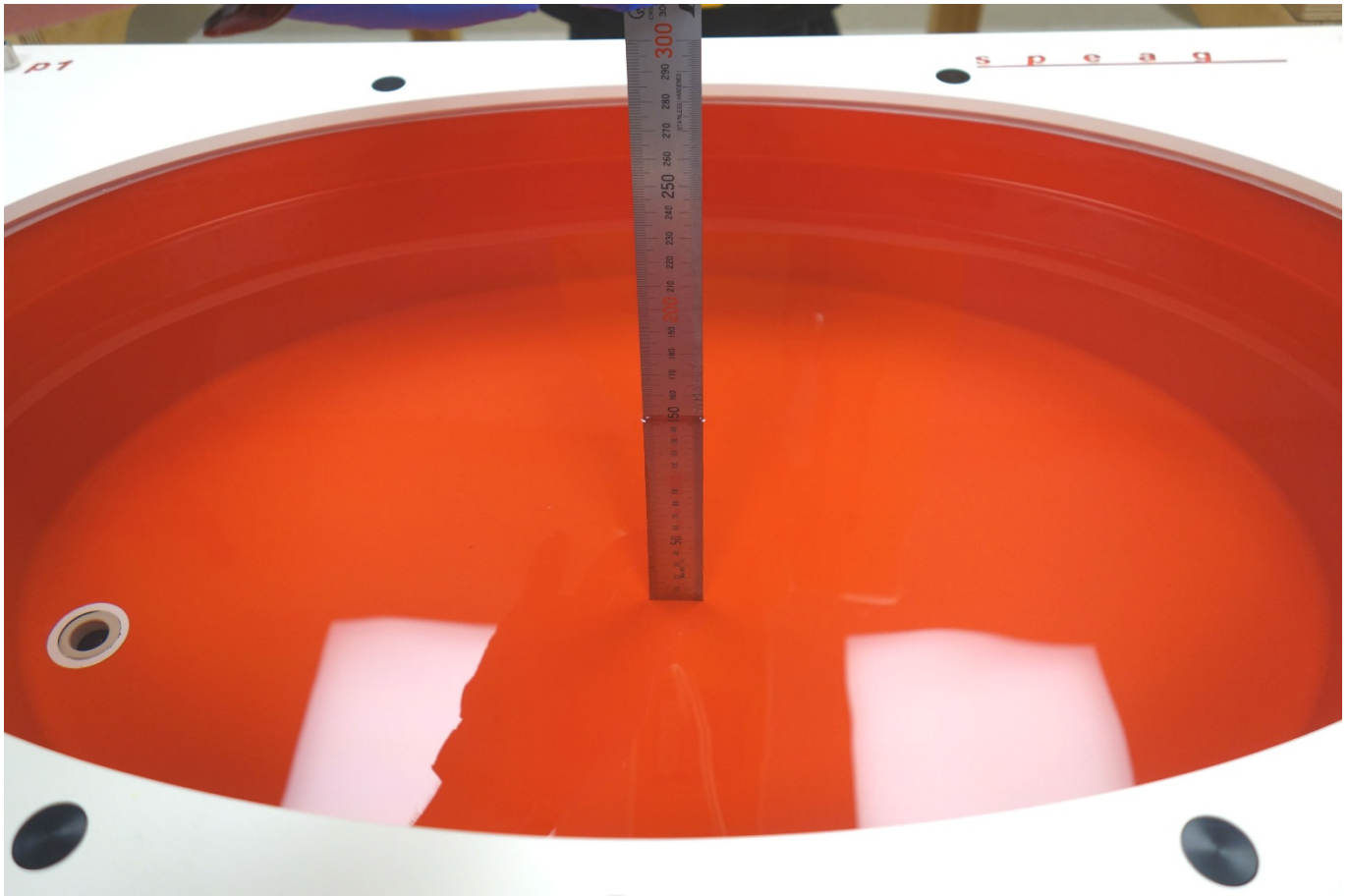
12.2. System Validation Details

		Equipment					
Date & Sys. ID:	Freq. (Mhz)	Sys. Val Kit:	E-Probe	DAE	Fluid	Signal Type(s)	Result
2018-10-09	2450	745 - 2703959	3805 - 2703947	428 - 2703949	2709687	CW, Pulse*	OK

*Additional signal types have been verified by the equipment manufacturer as part of the yearly calibration process.

12.3. Photograph of SAR Fluid Depth measurement

2018-03-18



12.4. System Check Scans

The following pages contain SAR scans for three System Checks, as follows:

2019-03-18	2450 MHz
2019-03-19	2450 MHz
2019-03-27	2450 MHz

Test Laboratory: TUV Rheinland Sweden AB - SAR Lab 2

SystemCheck_DASY2_2450MHz_2019-03-18

DUT: D2450V2 - SN745; Type: D2450V2; Serial: SN745

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; $\sigma = 2.019$ S/m; $\epsilon_r = 51.254$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY Configuration:

- Probe: EX3DV4 - SN3805; ConvF(7.16, 7.16, 7.16); Calibrated: 2018-07-19;
- Sensor-Surface: 2mm (Mechanical Surface Detection), $z = 1.0, 31.0$
- Electronics: DAE3 Sn428; Calibrated: 2018-07-11
- Phantom: ELI 1; Type: QDOVA002AA; Serial: TP:1186
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

System Performance Check 2GHz - 3GHz/d=10mm, Pin=100.00 mW, dist=2.0mm (EX-Probe)/Area Scan (61x91x1): Interpolated grid: $dx=1.000$ mm, $dy=1.000$ mm

Maximum value of SAR (interpolated) = 7.97 W/kg

System Performance Check 2GHz - 3GHz/d=10mm, Pin=100.00 mW, dist=2.0mm (EX-Probe)/Zoom Scan (7x7x7) (7x7x7)/Cube

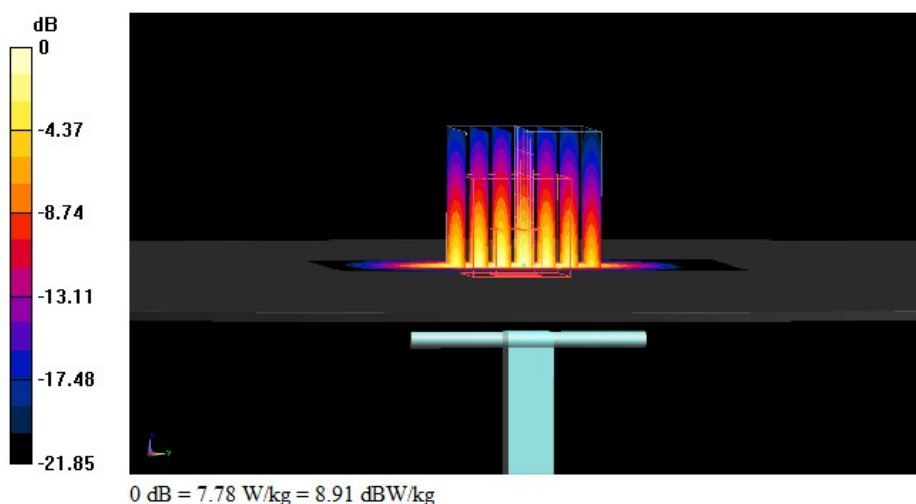
0: Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

Reference Value = 62.63 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 10.5 W/kg

SAR(1 g) = 5.13 W/kg; SAR(10 g) = 2.39 W/kg (SAR corrected for target medium)

Maximum value of SAR (measured) = 7.78 W/kg



Test Laboratory: TUV Rheinland Sweden AB - SAR Lab 2

SystemCheck_DASY2_2450MHz_2019-03-19

DUT: D2450V2 - SN745; Type: D2450V2; Serial: SN745

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; $\sigma = 2.026$ S/m; $\epsilon_r = 51.648$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY Configuration:

- Probe: EX3DV4 - SN3805; ConvF(7.16, 7.16, 7.16); Calibrated: 2018-07-19;
- Sensor-Surface: 2mm (Mechanical Surface Detection), $z = 1.0, 31.0$
- Electronics: DAE3 Sn428; Calibrated: 2018-07-11
- Phantom: ELI 1; Type: QDOVA002AA; Serial: TP:1186
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

System Performance Check 2GHz - 3GHz/d=10mm, Pin=99.54 mW, dist=2.0mm (EX-Probe)/Area Scan (61x91x1): Interpolated grid:
 $dx=1.000$ mm, $dy=1.000$ mm

Maximum value of SAR (interpolated) = 7.85 W/kg

System Performance Check 2GHz - 3GHz/d=10mm, Pin=99.54 mW, dist=2.0mm (EX-Probe)/Zoom Scan (7x7x7) (7x7x7)/Cube 0:

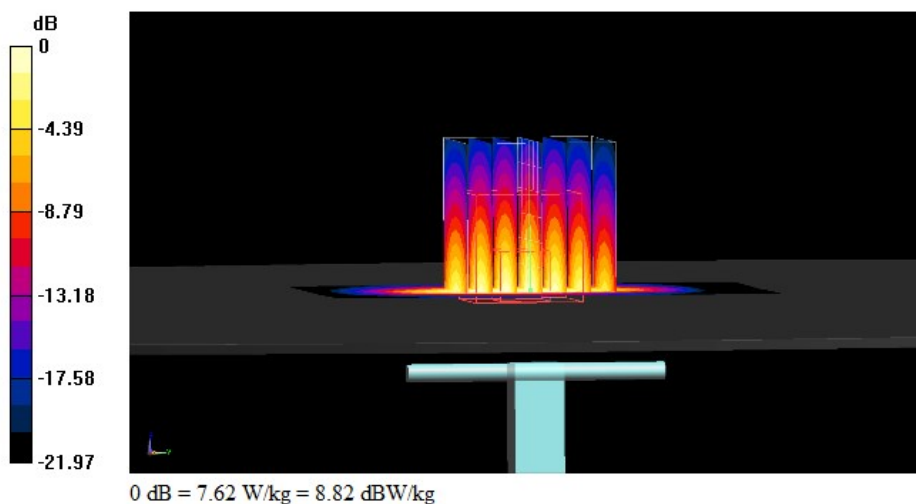
Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

Reference Value = 62.23 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 10.3 W/kg

SAR(1 g) = 5.06 W/kg; SAR(10 g) = 2.37 W/kg (SAR corrected for target medium)

Maximum value of SAR (measured) = 7.62 W/kg



Test Laboratory: TUV Rheinland Sweden AB - SAR Lab 2

SystemCheck_DASY2_2450MHz_2019-03-27

DUT: D2450V2 - SN745; Type: D2450V2; Serial: SN745

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; $\sigma = 2.022$ S/m; $\epsilon_r = 51.979$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY Configuration:

- Probe: EX3DV4 - SN3805; ConvF(7.16, 7.16, 7.16); Calibrated: 2018-07-19;
- Sensor-Surface: 2mm (Mechanical Surface Detection), $z = 1.0, 31.0$
- Electronics: DAE3 Sn428; Calibrated: 2018-07-11
- Phantom: ELI 1; Type: QDOVA002AA; Serial: TP:1186
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

System Performance Check 2GHz - 3GHz/d=10mm, Pin=99.77 mW, dist=2.0mm (EX-Probe)/Area Scan (61x91x1): Interpolated grid:
 $dx=1.000$ mm, $dy=1.000$ mm

Maximum value of SAR (interpolated) = 7.76 W/kg

System Performance Check 2GHz - 3GHz/d=10mm, Pin=99.77 mW, dist=2.0mm (EX-Probe)/Zoom Scan (7x7x7) (7x7x7)/Cube 0:

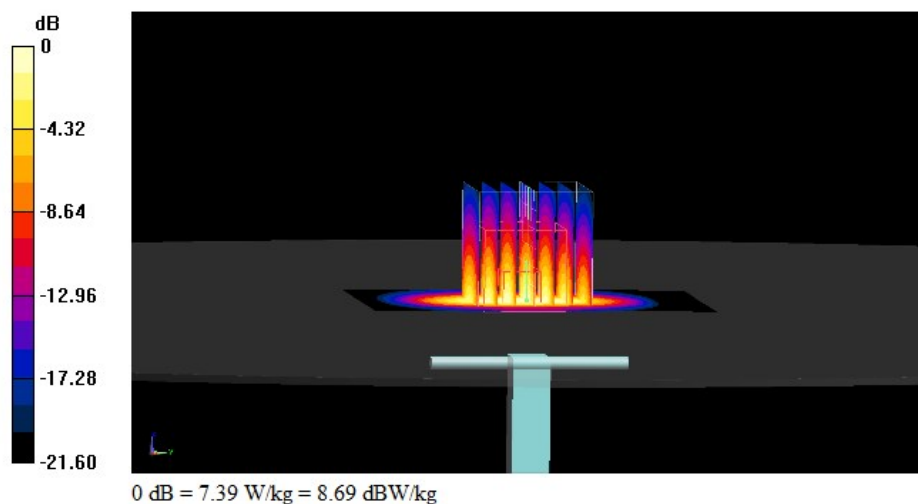
Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

Reference Value = 61.94 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 10.0 W/kg

SAR(1 g) = 5.01 W/kg; SAR(10 g) = 2.35 W/kg (SAR corrected for target medium)

Maximum value of SAR (measured) = 7.39 W/kg



13. SAR Scans

The following pages contain SAR scans for the highest reported SAR measurements for each configuration:

Scan 009	Main Antenna – WLAN 2.4GHz – Body & Extremities, Right edge
Scan 012	Aux Antenna – WLAN 2.4 GHz – Body & Extremities, Left edge
Scan 015	Aux Antenna – Bluetooth – Body, Left edge

Test Laboratory: TUV Rheinland Sweden AB - SAR Lab 2

Scan_009_23870160_A000224896-001_WLAN_2-4_Body_Extremities

DUT: 23870160; Type: Handheld Device; Serial: A000224896-001

Communication System: UID 10012 - CAB, IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps); Communication System Band: WLAN 2.4GHz (2412.0 - 2484.0 MHz); Frequency: 2412 MHz; Communication System PAR: 1.87 dB; PMF: 1.04833

Medium parameters used: $f = 2412.5$ MHz; $\sigma = 1.973$ S/m; $\epsilon_r = 51.809$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY Configuration:

- Probe: EX3DV4 - SN3805; ConvF(7.16, 7.16, 7.16); Calibrated: 2018-07-19;
- Sensor-Surface: 2mm (Mechanical Surface Detection), $z = 1.0, 31.0$
- Electronics: DAE3 Sn428; Calibrated: 2018-07-11
- Phantom: ELI 1; Type: QDOVA002AA; Serial: TP:1186
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Right Side-Phantom 5mm 2/802.11b - 1Mbps - CH1 - Main Antenna/Area Scan (61x181x1): Interpolated grid: $dx=1.500$ mm, $dy=1.500$ mm
Maximum value of SAR (interpolated) = 0.396 W/kg

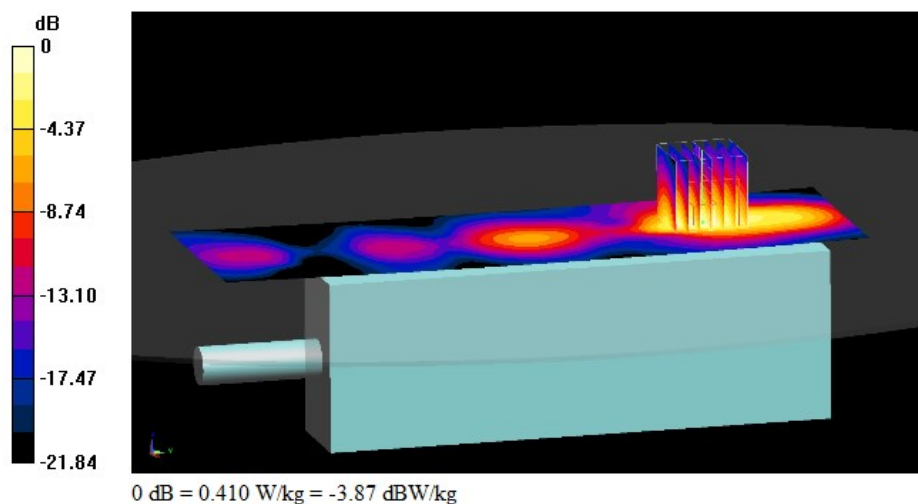
Right Side-Phantom 5mm 2/802.11b - 1Mbps - CH1 - Main Antenna/Zoom Scan (7x7x7)/Cube 0: Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

Reference Value = 12.66 V/m; Power Drift = 0.18 dB

Peak SAR (extrapolated) = 0.548 W/kg

SAR(1 g) = 0.276 W/kg; SAR(10 g) = 0.136 W/kg (SAR corrected for target medium)

Maximum value of SAR (measured) = 0.410 W/kg



Test Laboratory: TUV Rheinland Sweden AB - SAR Lab 2

Scan_012_23870160_A000224896-001_WLAN_2-4_Body_Extremities

DUT: 23870160; Type: Handheld Device; Serial: A000224896-001

Communication System: UID 10012 - CAB, IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps); Communication System Band: WLAN 2.4GHz (2412.0 - 2484.0 MHz); Frequency: 2457 MHz; Communication System PAR: 1.87 dB; PMF: 1.04833

Medium parameters used (interpolated): $f = 2457$ MHz; $\sigma = 2.035$ S/m; $\epsilon_r = 51.617$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY Configuration:

- Probe: EX3DV4 - SN3805; ConvF(7.16, 7.16, 7.16); Calibrated: 2018-07-19;
- Sensor-Surface: 2mm (Mechanical Surface Detection), $z = 1.0, 31.0$
- Electronics: DAE3 Sn428; Calibrated: 2018-07-11
- Phantom: ELI 1; Type: QDOVA002AA; Serial: TP:1186
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Left Side-Phantom 5mm 2/802.11b - 1Mbps - CH10 - Aux Antenna/Area Scan (61x181x1): Interpolated grid: $dx=1.500$ mm, $dy=1.500$ mm

[Info: Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (interpolated) = 0.663 W/kg

Left Side-Phantom 5mm 2/802.11b - 1Mbps - CH10 - Aux Antenna/Zoom Scan (7x7x7)/Cube 0: Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

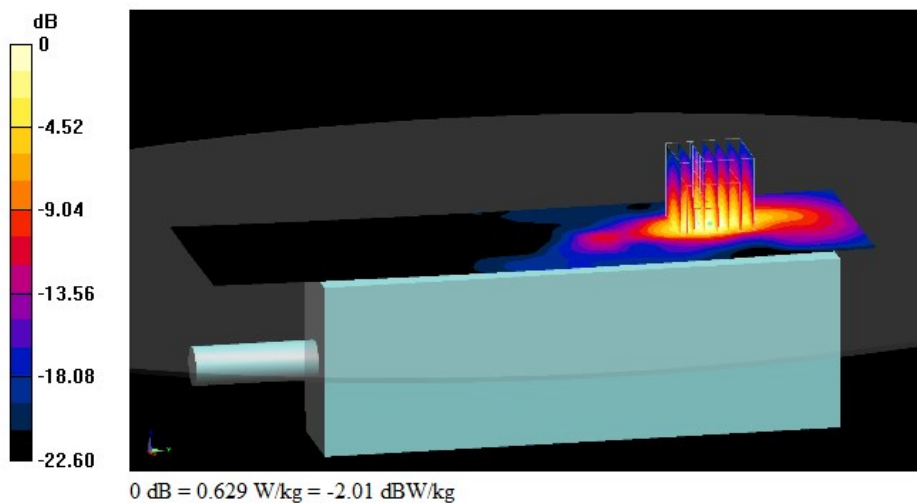
Reference Value = 14.72 V/m; Power Drift = -0.05 dB

Peak SAR (extrapolated) = 0.869 W/kg

SAR(1 g) = 0.427 W/kg; SAR(10 g) = 0.196 W/kg (SAR corrected for target medium)

[Info: Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (measured) = 0.629 W/kg



Test Laboratory: TUV Rheinland Sweden AB - SAR Lab 2

Scan_015_23870160_A000224896-001_Bluetooth_Body_Extremities

DUT: 23870160; Type: Handheld Device; Serial: A000224896-001

Communication System: UID 10032 - CAA, IEEE 802.15.1 Bluetooth (GFSK, DH5); Communication System Band: ISM 2.4 GHz Band (2400.0 - 2483.5 MHz); Frequency: 2402 MHz; Communication System PAR: 1.16 dB; PMF: 1.14288

Medium parameters used (interpolated): $f = 2402$ MHz; $\sigma = 1.954$ S/m; $\epsilon_r = 52.187$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY Configuration:

- Probe: EX3DV4 - SN3805; ConvF(7.16, 7.16, 7.16); Calibrated: 2018-07-19;
- Sensor-Surface: 2mm (Mechanical Surface Detection), $z = 1.0, 31.0$
- Electronics: DAE3 Sn428; Calibrated: 2018-07-11
- Phantom: ELI 1; Type: QDOVA002AA; Serial: TP:1186
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Left Side-Phantom 5mm/802.15.1 DH5 - 1Mbps - CH0 - Aux Antenna/Area Scan (61x181x1): Interpolated grid: $dx=1.500$ mm, $dy=1.500$ mm

[Info: Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (interpolated) = 0.0368 W/kg

Left Side-Phantom 5mm/802.15.1 DH5 - 1Mbps - CH0 - Aux Antenna/Zoom Scan (7x7x7)/Cube 0: Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

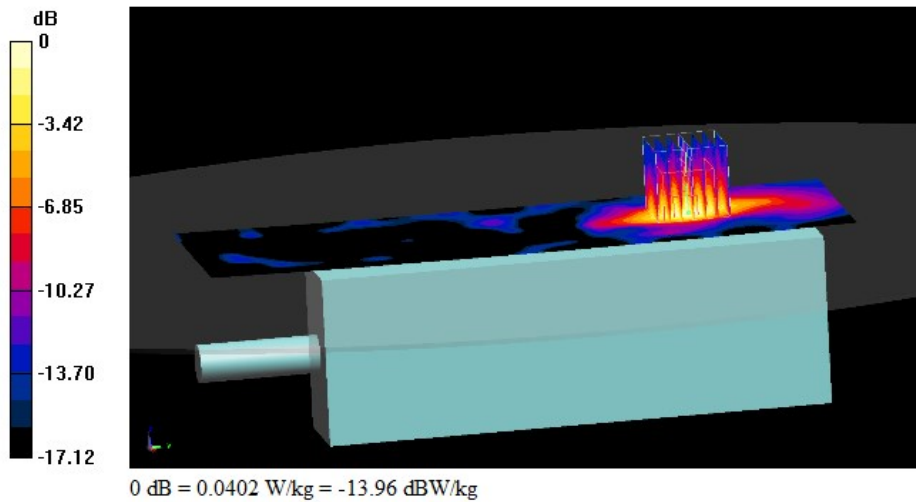
Reference Value = 4.157 V/m; Power Drift = 0.16 dB

Peak SAR (extrapolated) = 0.0560 W/kg

SAR(1 g) = 0.027 W/kg; SAR(10 g) = 0.013 W/kg (SAR corrected for target medium)

[Info: Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (measured) = 0.0402 W/kg



14. General Description of the Test System

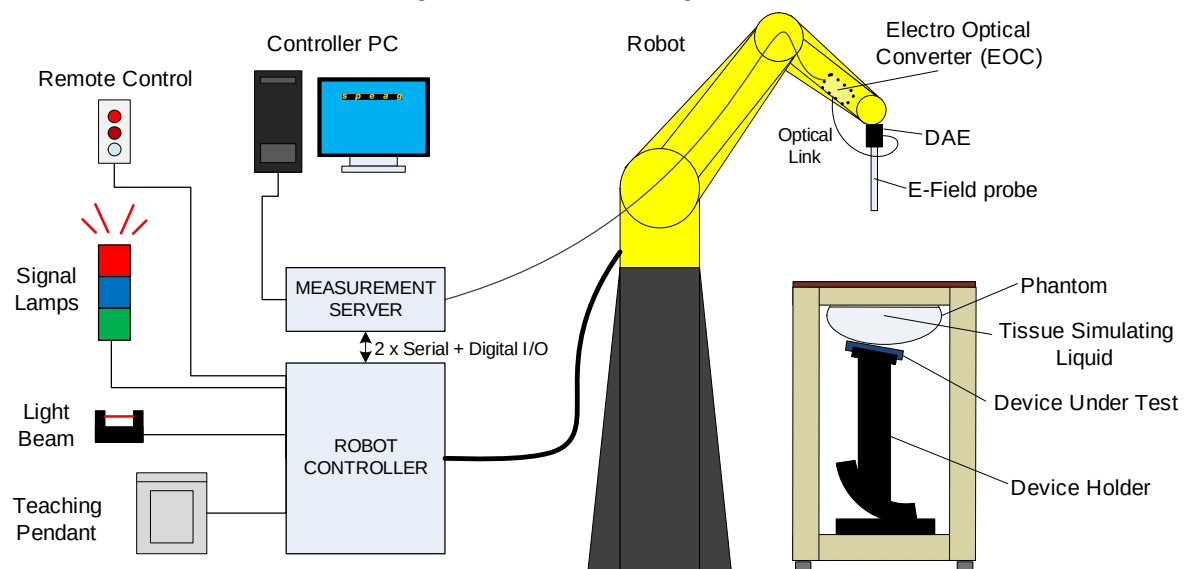
14.1. The DASY52 System

DASY52 Overview

Each of the lab's DASY52 (Dosimetric Assessment SYstem, 5th generation) consists of the following items:

- A standard high precision 6-axis robot (Stäubli RX90B L) with controller.
- Remote control and teaching pendant for the robot
- An isotropic E-Field probe optimized and calibrated for the targeted measurement.
- A "Data Acquisition Electronics" (DAE) which performs signal processing and other tasks.
- An "Electro-Optical Converter" (EOC) which performs conversion from optical to electrical signals.
- A measurement server to perform time-critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- A Light Beam for probe alignment.
- A computer running "Windows 7 Professional" operating system and the DASY52 software.
- One or more phantoms (Twin SAM or ELI types) which contain the Tissue Simulating Fluid and hold it in the required form.
- Tissue Simulating Liquid(s)
- A Device Holder
- Other circuitry to ensure robot safety including warning lamps and cut-off switches.

Figure 1 – DASY 52 Block Diagram



Stäubli RX90B L Robot Details

The Stäubli robot is a standard industrial robot arm with 6 axes. In this application, it is used to position the E-Field probe in 3 dimensions with high accuracy and repeatability.

Specifications	RX90B L
Number of Axes	6
Nominal Load	3.5 kg
Maximum Load	6 kg
Reach	1100 mm
Repeatability	± 0.025 mm
Weight	113 kg

E-Field Probe Details

For SAR testing, the lab uses two types of Dosimetric E-Field probes from SPEAG. These are the ES3DV3 type and the EX3DV4 type. These probes are specially designed and calibrated for use in liquids with high permittivities.

Specifications	ES3DV3 Probe
Frequency	10 MHz to 4 GHz; Linearity: ± 0.2 dB (30 MHz to 4 GHz)
Directivity	± 0.2 dB in TSL (rotation around probe axis) ± 0.3 dB in TSL (rotation normal to probe axis)
Dynamic Range	5 µW/g to > 100 mW/g; Linearity: ± 0.2 dB
Dimensions	Overall length: 337 mm (Tip: 20 mm) Tip diameter: 3.9 mm (Body: 12 mm) Distance from probe tip to dipole centers: 2.0 mm

Specifications	EX3DV4 Probe
Frequency	10 MHz to > 6 GHz Linearity: ± 0.2 dB (30 MHz to 6 GHz)
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 mW/g Linearity: ± 0.2 dB (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

Data Acquisition Electronics Details

The data acquisition electronics (DAE4 or DAE3) consist of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder with a control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information, as well as an optical uplink for commands and the clock.

The mechanical probe mounting device includes two different sensor systems for frontal and sideways probe contacts. They are used for mechanical surface detection and probe collision detection.

Specifications	DAE
Measurement Range	-100 to +300 mV (16 bit resolution and two range settings: 4mV, 400mV)
Input Offset Voltage	< 5 μ V (with auto zero)
Input Resistance	200 MOhm
Input Bias Current	< 50 fA
Battery Power	> 10 hours of operation (with two 9.6 V NiMH accus)
Dimensions (L x W x H)	60 x 60 x 68 mm
Calibration	ISO/IEC 17025 calibration service available.

Interpolation, Extrapolation and Detection of Maxima

The probe is calibrated at the center of the dipole sensors which is located 1 to 2.7mm away from the probe tip. During measurements, the probe stops shortly above the phantom surface, depending on the probe and the surface detecting system. Both distances are included as parameters in the probe configuration file. The software always knows exactly how far away the measured point is from the surface. As the probe cannot directly measure at the surface, the values between the deepest measured point and the surface must be extrapolated.

The choice of the coordinate system defining the location of the measurement points has no influence on the uncertainty of the interpolation, Maxima Search and extrapolation routines. The interpolation, extrapolation and maximum search routines are all based on the modified Quadratic Shepard's method

Thereby, the interpolation scheme combines a least-square fitted function method and a weighted average method which are the two basic types of computational interpolation and approximation. The DASY routines construct a once-continuously differentiable function that interpolates the measurement values as follows:

- For each measurement point a trivariate (3-D) / bivariate (2-D) quadratic is computed. It interpolates the measurement values at the data point and forms a least-square fit to neighboring measurement values.
- The spatial location of the quadratic with respect to the measurement values is attenuated by an inverse distance weighting. This is performed since the calculated quadratic will fit measurement values at nearby points more accurate than at points located further away.
- After the quadratics are calculated for at all measurement points, the interpolating function is calculated as a weighted average of the quadratics.

System Check and Validation Sources

As an RF source in system checks and system validations, the lab uses dipoles supplied by SPEAG which are matched for use near flat phantoms filled with tissue simulating liquids. These are symmetrical dipoles with a $\lambda/4$ balun.

A range of these dipoles are available with dimensions to suit the frequencies required by testing. The input signal is provided by commercially available signal generators and amplifiers.

SAR Phantom Details

Currently available in the lab are two types of phantom, both supplied by SPEAG. To allow for testing of devices that are intended for use at the ear, several "Twin SAM" phantoms are in place. For testing of larger devices in other positions, an "ELI" model phantom is also available.

Specifications	Twin SAM Phantom
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 fibre reinforced (VE-GF) Relative Permittivity <5, Loss Tangent <0.05
Liquid Compatibility	Compatible with all SPEAG tissue simulating
Shell Thickness	2 ± 0.2 mm (6 ± 0.2 mm at ear point)
Dimensions (incl. Wooden Support)	Length: 1000 mm Width: 500 mm Height: adjustable feet
Filling Volume	approx. 25 litres
Wooden Support	SPEAG standard phantom table

Specifications ELI Phantom	
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 fibre reinforced (VE-GF) Relative Permittivity <5, Loss Tangent <0.05
Liquid Compatibility	Compatible with all SPEAG tissue simulating
Shell Thickness	2.0 ± 0.2 mm (bottom plate)
Dimensions	Major axis: 600 mm Minor axis: 400 mm
Filling Volume	approx. 30 litres
Wooden Support	SPEAG standard phantom table

Tissue Simulating Liquid Details

The lab stocks quantities of multiple Tissue Simulating Liquids to cover a wide range of test frequencies, from approximately 700MHz to 6GHz and for different test requirements: e.g. simulating head tissue or muscle tissue. The ingredients vary depending on the frequency and can include substances such as water, Sugar, Salt, Diethylene Glycol Butyl Ether (DGBE), emulsifiers such as 'Tween', and oil.

The liquids are supplied ready-mixed and conform to the suggested recipes in the various test specifications.

Device Holder Details

The mounting device for hand-held transmitters supplied by SPEAG enables rotation of the mounted transmitter device to specified spherical coordinates. At the heads, the rotation axis is at the ear opening. Transmitter devices can be easily and accurately positioned according to IEC 62209-1, IEEE 1528, FCC, or other specifications. The device holder can be locked for positioning at different phantom sections (left head, right head, flat).

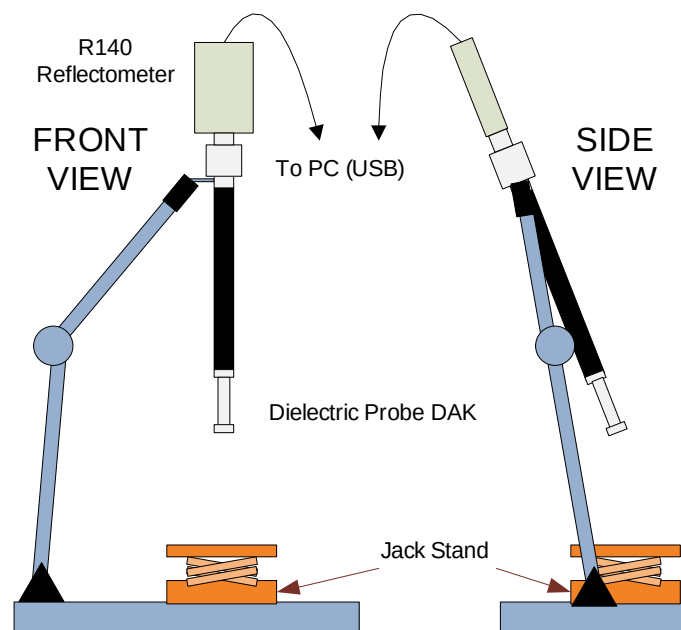
In addition, an extension for laptop devices is available which facilitates testing of larger devices according to IEC 62209-2 (e.g., laptops, cameras, etc.). It is lightweight and fits easily on the upper part of the standard mounting device in place of the phone positioner. The extension is fully compatible with the Twin SAM, ELI and other flat phantoms.

14.2. Dielectric Measurement Setup

For measuring the dielectric properties of the various Tissue Simulating Fluids, a SPEAG Dielectric Assessment Kit (DAKS) is used. The DAK probe is mounted using the supplied stand and is permanently attached to the R140 Vector Reflectometer with a rigid connection. The reflectometer is connected in turn to a controller PC via USB.

A jack stand is placed under the probe to allow for raising and lowering the sample. Alternatively, the probe and PC can be moved together and measurements can be made directly in the SAR Phantom. Calculations and control of the instruments are performed by the software supplied with the kit.

Figure 2 – Dielectric Measurement equipment Setup



15. Amendment History

Version	Date	Author	Reviewer	Description of changes made
001	2019-04-15	Niall Forrester		First release
002	2019-06-17	Niall Forrester		Added BLE with conducted power table and justifications, more detail in result summary and appendix with antenna diagram
003	2019-06-24	Niall Forrester		Updated summary table and fixed typo (1g->10g) in simultaneous transmission tables