SAR Evaluation Report

EUT Information

Manufacturer	Thrane & Thrane A/S
Model Name	TT-3965A
Brand Name	SAILOR 3965 UHF FireFighter
FCC ID	ROJTT-3965A
IC number	6200B-3965
EUT Type	TNF licensed non-broadcast transmitter / UHF Radio
Intended Use	body worn with belt clip and PTT configuration in front of face

Prepared by

Testing Laboratory	IMST GmbH, Test Center Carl-Friedrich-Gauß-Str. 2 – 4 47475 Kamp-Lintfort Germany
Laboratory Accreditation	The Test Center facility ‘Dosimetric Test Lab’ within IMST GmbH is accredited by the German National ‘Deutsche Akkreditierungsstelle GmbH (DAkkS)’ for testing according to the scope as listed in the accreditation certificate: D-PL-12139-01-00. The German Bundesnetzagentur (BNetzA) recognizes IMST GmbH as CAB-EMC on the basis of the Council Decision of 22. June 1998 concerning the conclusion of the MRA between the European Community and the United States of America (1999/178/EC) in accordance with § 4 of the Recognition Ordinance of 11. January 2016. The recognition is valid until 20. July 2021 under the registration number: BNetzA-CAB-16/21-14.

Prepared for

Applicant	Thrane & Thrane A/S Lundtoftegaardsvej 93D 2800 Kgs. Lyngby s Denmark

Test Specification

Applied Rules/Standards	IEEE 1528-2013, FCC CFR 47 § 2.1093, RSS-102 Issue 5	
Exposure Category	☐ general public / uncontrolled exposure	☒ occupational / controlled exposure
Test Result	☒ PASS	☐ FAIL

Report Information

Data Stored	60320_6180631
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Remarks	A revised version of the report supersedes all previous versions. This report relates only to the item(s) evaluated. This report shall not be reproduced, except in its entirety, without the prior written approval of IMST GmbH. The results and statements contained in this report reflect the evaluation for the certain model described above. The manufacturer is responsible for ensuring that all production devices meet the intent of the requirements described in this report.

Table of Contents

1 Subject of Investigation and Test Results

The TT-3965A is a new TNF licensed non-broadcast transmitter / UHF Radio (portable device) from Thrane & Thrane A/S which is intended to be used as worn on the body with connected PTT remote speaker microphone or in front of face for voice communication.

The objective of the measurements performed by IMST was the dosimetric assessment of one device in the intended use positions.

1.1 Technical Data of EUT

Product Specifications		
Model Name	TT-3965A	
SN	1967470221	
Firmware Version	N/A	
Frequency Range	457.525 – 467.575 MHz (TX/RX)	
Band	25 kHz wide band	
Antenna Type	stubby UHF antenna	
Maximum Antenna Gain	3.0 dBi	
Maximum Avg. Output Power *	High Power	33.0 dBm / 2.0 W (radiated)
	Low Power	26.0 dBm / 0.4 W (radiated)
Power Supply	Primary: B3906 Li-Ion battery 7.4 VDC 1650 mAh (rechargeable) Optional: B3503 Li-Ion battery 7.4 VDC 3000 mAh (non rechargeable)	
Used Accessory	belt clip, PTT remote speaker microphone (C500), leather case	
EUT Stage	☒ production unit	☐ identical prototype
Notes: *for additional details please refer chapter 6.3		

Table 1: Technical data of EUT declared by the manufacturer.

1.2 Sketches of EUT

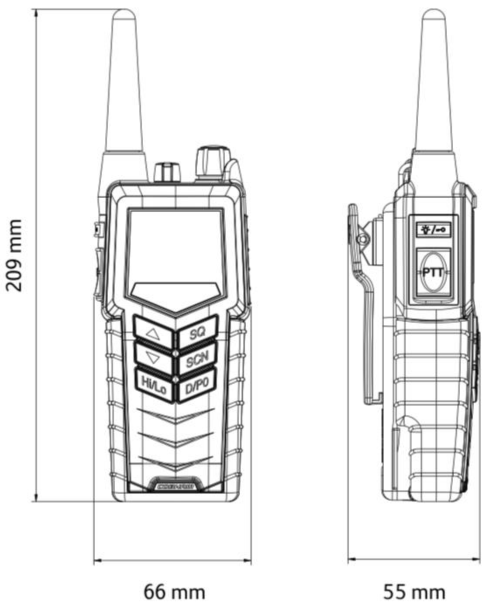

Fig. 1: Sketches and antenna location of the EUT.

1.3 Test Specification / Normative References

The tests documented in this report were performed according to the standards and rules described below.

Test Specifications		
Test Standard / Rule	**Description**	**Issue Date**
☒ 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 Techniques.	June 14, 2013
☐ FCC CFR 47 § 2.1091	Code of Federal Regulations; Title 47. Radiofrequency radiation exposure evaluation: **Mobile Devices.**	October 01, 2010
☒ FCC CFR 47 § 2.1093	Code of Federal Regulations; Title 47. Radiofrequency radiation exposure evaluation: **Portable Devices.**	October 01, 2010
☒ RSS-102, Issue 5	Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)	March, 2015
Measurement Methodology KDB		
☒ KDB 865664 D01 v01r04	SAR measurement 100 MHz to 6 GHz	August 07, 2015
☒ KDB 865664 D02 v01r02	Exposure Reporting	October 23, 2015
Product KDB		
☒ KDB 447498 D01 v06	General RF Exposure Guidance	October 23, 2015
☒ KDB 648474 D04 v01r03	Handset SAR	October 23, 2015
☒ KDB 643646 D01 v01r03	SAR Test for Occupational PTT Radios	October 23, 2015

Table 2: Normative references.

1.4 Attestation of Test Results

Highest Reported SAR_{1g} [W/kg]								
Band	**Frequency [MHz]**	**CH**	**Exposure Side of EUT**	**Gap [mm]**	**Pic. No.**	**Highest Reported SAR1g [W/kg] DF 50%**	**SAR1g Limit [W/kg]**	
UHF	462.550	mid	back with attached belt clip	0	*5*	2.089	8.0	PASS

Notes: To establish a continuous transmitting signal with 100% duty cycle at specific frequency and with maximum output power, engineering test software has been used.
All measured SAR results and configurations are shown in chapter 6.6 on page 15.

Table 3: Test results.

Prepared by: ....

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Reviewed by: ....

Dessislava Patrishkova
Quality Assurance

2 Exposure Criteria and Limits

2.1 SAR Limits

Human Exposure Limits				
Condition	Uncontrolled Environment (General Population)		Controlled Environment (Occupational)	
	SAR Limit [W/kg]	Mass Avg.	SAR Limit [W/kg]	Mass Avg.
SAR averaged over the whole body mass	0.08	whole body	0.4	whole body
Peak spatially-averaged SAR for the head, neck & trunk	1.6	1g of tissue*	8.0	1g of tissue*
Peak spatially-averaged SAR in the limbs	4.0	10g of tissue*	20.0	10g of tissue*
Note: *Defined as a tissue volume in the shape of a cube				

Table 4: SAR limits specified in IEEE Standard C95.1-2005 and Health Canada's Safety Code 6.

In this report the comparison between the exposure limits and the measured data is made using the spatial peak SAR; the power level of the device under test guarantees that the whole body averaged SAR is not exceeded.

2.2 Exposure Categories

General Public / Uncontrolled Exposure
General population comprises individuals of all ages and of varying health status, and may include particularly susceptible groups or individuals. In many cases, members of the public are unaware of their exposure to electromagnetic fields. Moreover, individual members of the public cannot reasonably be expected to take precautions to minimize or avoid exposure.
Occupational / Controlled Exposure
The occupationally exposed population consists of adults who are generally exposed under known conditions and are trained to be aware of potential risk and to take appropriate precautions.

Table 5: RF exposure categories.

2.3 Distinction between Maximum Permissible Exposure and SAR Limits

The biological relevant parameter describing the effects of electromagnetic fields in the frequency range of interest is the specific absorption rate SAR (dimension: power/mass). It is a measure of the power absorbed per unit mass. The SAR may be spatially averaged over the total mass of an exposed body or its parts. The SAR is calculated from the r.m.s. electric field strength E inside the human body, the conductivity σ and the mass density ρ of the biological tissue:

$$SAR = \sigma \frac{E^2}{\rho} = c \frac{\partial T}{\partial t}\bigg|_{t \to 0+} \quad . \qquad (1)$$

The specific absorption rate describes the initial rate of temperature rise $\partial T / \partial t$ as a function of the specific heat capacity c of the tissue. A limitation of the specific absorption rate prevents an excessive heating of the human body by electromagnetic energy.

As it is sometimes difficult to determine the SAR directly by measurement (e.g. whole body averaged SAR), the standard specifies more readily measurable maximum permissible exposures in terms of external electric E and magnetic field strength H and power density S, derived from the SAR limits. The limits for E, H and S have been fixed so that even under worst case conditions, the limits for the specific absorption rate SAR are not exceeded.

3 The Measurement System

DASY is an abbreviation of „Dosimetric Assessment System“ and describes a system that is able to determine the SAR distribution inside a phantom of a human being according to different standards. The DASY4 system consists of the following items as shown in Fig: 2. Additionally, Fig: 3 shows the equipment, similar to the installations in other laboratories.

- Fully compliant with all current measurement standards as stated in Fig. 4
- High precision robot with controller
- Measurement server (for surveillance of the robot operation and signal filtering)
- Data acquisition electronics DAE (for signal amplification and filtering)
- Field probes calibrated for use in liquids
- Electro-optical converter EOC (conversion from the optical into a digital signal)
- Light beam (improving of the absolute probe positioning accuracy)
- Two SAM phantoms filled with tissue simulating liquid
- DASY4 software
- SEMCAD

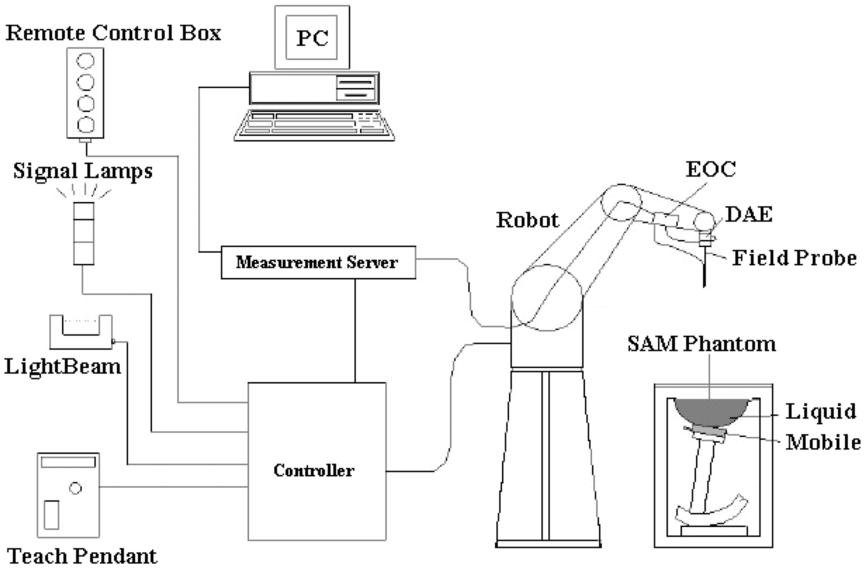

Fig. 2: The DASY4 measurement system.

Fig. 3: The measurement set-up with a DASY system and phantoms containing tissue simulating liquid.

The EUT operating at the maximum power level is placed by a non-metallic device holder (delivered from Schmid & Partner) in the above described positions at a shell phantom of a human being. The distribution of the electric field strength *E* is measured in the tissue simulating liquid within the shell phantom. For this miniaturised field probes with high sensitivity and low field disturbance are used. Afterwards the corresponding SAR values are calculated with the known electrical conductivity σ and the mass density ρ of the tissue in the SEMCAD FDTD software. The software is able to determine the averaged SAR values (averaging region 1 g or 10 g) for compliance testing.

The measurements are done by two scans: first a coarse scan determines the region of the maximum SAR, afterwards the averaged SAR is measured in a second scan within the shape of a cube.

3.1 Phantoms

TWIN SAM PHANTOM V4.0	
	Specific Anthropomorphic Mannequin defined in IEEE 1528 and IEC 62209-1 and delivered by Schmid & Partner Engineering AG. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. The details and the Certificate of conformity can be found in Fig. 5.
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

ELI4 Phantom	
	Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. The details and the Certificate of conformity can be found in Fig. 6.
Shell Thickness	2.0 ± 0.2 mm (bottom plate)
Dimensions	Major axis: 600 mm Minor axis: 400 mm
Filling Volume	approx. 30 liters

3.2 E-Field-Probes

For the measurements the Dosimetric E-Field Probes ET3DV6R or EX3DV4 with following specifications are used. They are manufactured and calibrated in accordance with FCC and IEEE 1528-2013 recommendations annually by Schmid & Partner Engineering AG.

ET3DV6R	
Construction	Symmetrical design with triangular core Built-in optical fiber for surface detection system (ET3DV6 only) Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Dimensions	Overall length: 337 mm (Tip: 16 mm) Tip diameter: 6.8 mm (Body: 12 mm) Distance from probe tip to dipole centers: 2.7 mm
Frequency	10 MHz to 2.3 GHz Linearity: ± 0.2 dB (30 MHz to 2.3 GHz)
Directivity	Axial isotropy: ± 0.2 dB in TSL (rotation around probe axis) Spherical isotropy: ± 0.4 dB in TSL (rotation normal to probe axis)
Dynamic Range	5 µW/g to > 100 mW/g; Linearity: ± 0.2 dB
Calibration Range	450 MHz / 750 MHz / 835 MHz / 1750 MHz / 1900 MHz for head and body simulating liquid

EX3DV4	
Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
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
Frequency	10 MHz to > 6 GHz Linearity: ± 0.2 dB (30 MHz to 6 GHz)
Directivity	Axial isotropy: ± 0.3 dB in TSL (rotation around probe axis) Spherical isotropy: ± 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)
Calibration Range	2450 MHz / 2600 MHz / 5250 MHz / 5600 MHz / 5800 MHz for head and body simulating liquid

4 Measurement Procedure

4.1 General Requirement

The test shall be performed in a laboratory with an environment which avoids influence on SAR measurements by ambient EM sources and any reflection from the environment itself. The ambient temperature shall be in the range of 20°C to 26°C and 30-70% humidity. All tests have been conducted according the latest version of all relevant KDBs.

4.2 Measurement Procedure

The following steps are used for each test position:

- Establish a call with the maximum output power with a base station simulator. The connection between the mobile phone and the base station simulator is established via air interface.
- Measurement of the local E-field value at a fixed location (P1). This value serves as a reference value for calculating a possible power drift.
- Measurement of the SAR distribution with resolution settings for area scan and zoom scan according KDB 865664 D01 as shown in Table *6*.
- The used extrapolation and interpolation routines are all based on the modified Quadratic Shepard´s method [DASY4].
- Repetition of the E-field measurement at the fixed location (P1) and repetition of the whole procedure if the two results differ by more than ± 0.21dB.

			≤ 3 GHz	≥ 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface			5 ± 1 mm	½·δ·ln(2) ± 0.5 mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location			30° ± 1°	20° ± 1°
Maximum area scan spatial resolution: Δx_{Area}, Δy_{Area}			≤ 2 GHz: ≤ 15 mm 2 - 3 GHz: ≤ 12 mm	3 - 4 GHz: ≤ 12 mm 4 - 6 GHz: ≤ 10 mm
			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.	
Maximum zoom scan spatial resolution: ΔX_{Zoom}, ΔY_{Zoom}			≤ 2 GHz: ≤ 8 mm 2 - 3 GHz: ≤ 5 mm*	3 - 4 GHz: ≤ 5 mm* 4 - 6 GHz: ≤ 4 mm*
Maximum zoom scan spatial resolution, normal to phantom surface	Uniform grid: $\Delta Z_{Zoom}(n)$		≤ 5 mm	3 - 4 GHz: ≤ 4 mm 4 - 5 GHz: ≤ 3 mm 5 - 6 GHz: ≤ 2 mm
	graded grid	$\Delta Z_{Zoom}(1)$: between 1st two points closest to phantom surface	≤ 4 mm	3 - 4 GHz: ≤ 3 mm 4 - 5 GHz: ≤ 2.5 mm 5 - 6 GHz: ≤ 2 mm
		$\Delta Z_{Zoom}(n>1)$: between subsequent points	≤ 1.5· $\Delta Z_{Zoom}(n-1)$	
Minimum zoom scan volume	x, y, z		≥ 30 mm	3 - 4 GHz: ≥ 28 mm 4 - 5 GHz: ≥ 25 mm 5 - 6 GHz: ≥ 22 mm
Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium: see draft standard IEEE P1528-2011 for details. * When zoom scan is required and the reported SAR from the area scan based 1-g SAR estimation procedures of KDB 447498 is ≤ 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				

Table 6: Parameters for SAR scan procedures.

4.3 Measurement Variability

According to KDB 865664 repeated measurements are required only when the measured SAR is ≥ 0.80 W/kg. If the measured SAR value of the initial repeated measurement is < 1.45 W/kg with ≤ 20% variation, only one repeated measurement is required to reaffirm that the results are not expected to have substantial variations, which may introduce significant compliance concerns. A second repeated measurement is required only if the measured result for the initial repeated measurement is within 10% of the SAR limit and vary by more than 20%, which are often related to device and measurement setup difficulties. The following procedures are applied to determine if repeated measurements are required.

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

For controlled use devices (occupational exposure) where the 8 W/kg for 1 gram of tissue applies, the SAR thresholds are multiplied by a factor of 5.

4.4 Body-Worn Accessory Exposure Conditions

According to chapter 2.3 of KDB 648474 D04 body-worn accessory exposure is typically related to voice mode operations when handsets are carried in body-worn accessories. The body-worn accessory procedures in KDB Publication 447498 D01 should be used to test for body-worn accessory SAR compliance, without a headset connected to it. When the reported SAR for a body-worn accessory, measured without a headset connected to the handset, is > 1.2 W/kg (for general public exposure) or 6.0 W/kg (for occupational exposure), the highest reported SAR configuration for that wireless mode and frequency band should be repeated for the body-worn accessory with a headset attached to the handset.

5 System Verification and Test Conditions

5.1 Date of Testing

Date of Testing				
Band	**Test Configuration**	**Frequency [MHz]**	**Date of System Check**	**Date of SAR Measurement**
UHF	Head	450	April 24, 2018	April 24, 2018
	Body	450	May 04, 2018	May 04, 2018

Table 7: Date of testing.

5.2 Environment Conditions

Environment Conditions		
Ambient Temperature[°C]	**Liquid Temperature [°C]**	**Humidity [%]**
22.0 ± 2	22.0 ± 2	40.0 ± 10
Notes: To comply with the required noise level (less than 12 mW/kg) periodically measurements without a DUT were conducted.		

Table 8: Environment Conditions.

5.3 Tissue Simulating Liquid Recipes

Tissue Simulating Liquid								
Frequency Range		**Water**	**Tween 20**	**Tween 80**	**Salt**	**Preventol**	**DGME**	**Triton X/100**
[MHz]		**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
Head Tissue								
☐	300	50.4	47.3	-	2.2	0.1	-	-
☒	450	50.8	47.5	-	1.6	0.1	-	-
☐	700 - 1000	52.8	46.0	-	1.1	0.1	-	-
☐	1600 - 1800	55.4	44.1	-	0.4	0.1	-	-
☐	1850 - 1980	55.2	44.5	-	0.2	0.1	-	-
☐	2000 - 2700	55.7	45.2	-	-	0.1	-	-
☐	5000 - 6000	65.5	-	-	-	-	17.25	17.25
Body Tissue								
☐	300	70.3	28.6	-	1.0	0.1	-	-
☒	450	71.0	28.0	-	0.9	0.1	-	-
☐	700 - 1000	71.2	28.0	-	0.7	0.1	-	-
☐	1600 - 1800	71.4	28.0	-	0.5	0.1	-	-
☐	1850 - 1980	71.5	28.0	-	0.4	0.1	-	-
☐	2000 - 2700	71.6	28.0	-	0.3	0.1	-	-
☐	5000 - 6000	79.9	-	20.0	-	0.1	-	-
Notes: Used liquid for measurement is checked above.								

Table 9: Recipes of the tissue simulating liquid.

5.4 Tissue Simulating Liquid Parameters

For the measurement of the following parameters the Speag DAK-3.5 dielectric probe kit is used, representing the open-ended coaxial probe measurement procedure.

Tissue Simulating Liquids									
Ambient Temperature(C) : 22.0 ± 2			Liquid Temperature(C) : 22.1			Humidity (%) : 40.0 ± 10			Date
Band	Frequency	Channel	Permittivity			Conductivity			
			Measured	Target	Delta	Measured	Target	Delta	
	[MHz]		ε'	ε'	+/- 5 [%]	σ [S/m]	σ [S/m]	+/- 5 [%]	
UHF	*450.0*	*System Check*	*43.7*	*43.5*	*0.4*	*0.857*	*0.870*	*-1.5*	2018-Apr-24
	457.5	low	43.6	43.4	0.3	0.86	0.87	-0.8	
	462.5	mid	43.5	43.4	0.2	0.87	0.87	-0.4	
	467.6	high	43.5	43.4	0.2	0.87	0.87	-0.1	
Notes: The dielectric properties of the tissue simulating liquid must be measured within 24 h before the SAR testing.									

Table 10: Parameters of the head tissue simulating liquid.

Tissue Simulating Liquids									
Ambient Temperature(C) : 22.0 ± 2			Liquid Temperature(C) : 23.1			Humidity (%) : 40.0 ± 10			Date
Band	Frequency	Channel	Permittivity			Conductivity			
			Measured	Target	Delta	Measured	Target	Delta	
	[MHz]		ε'	ε'	+/- 5 [%]	σ [S/m]	σ [S/m]	+/- 5 [%]	
UHF	*450.0*	*System Check*	*57.4*	*56.7*	*1.3*	*0.954*	*0.940*	*1.5*	2018-May-04
	457.5	low	57.3	56.7	1.1	0.96	0.94	2.1	
	462.5	mid	57.2	56.6	1.0	0.96	0.94	2.4	
	467.6	high	57.1	56.6	0.9	0.97	0.94	2.6	
Notes: The dielectric properties of the tissue simulating liquid must be measured within 24 h before the SAR testing.									

Table 11: Parameters of the body tissue simulating liquid.

5.5 Simplified Performance Checking

The simplified performance check was realized using the dipole validation kit. The input power of the dipole antenna was 250 mW (CW) and it was placed under the flat part of the SAM phantom. The target and measured results are listed in the table 12 and shown in Appendix C - System Verification Plots. The target values were adopted from the calibration certificates found also in the appendix.

System Check Results										
Frequency [MHz]	Dipole #SN	Measured				Target		Delta		Date
		with 250 mW		scaled to 1 W		normalized to 1 W		+/- 10 [%]		
		1g	10g	1g	10g	1g	10g	1g	10g	
		SAR Values with Head TSL [W/kg]								
450	D450V2 #1014	1.17	0.77	4.68	3.09	4.84	3.22	-3.31	-3.86	2018-Apr-24
		SAR Values with Body TSL [W/kg]								
		1.22	0.81	4.88	3.24	4.76	3.18	2.52	2.14	2018-May-04

Table 12: Dipole target and measured results.

6 SAR Measurement Conditions and Results

6.1 Test Conditions

Test Conditions					
Band	**TX Range [MHz]**	**RX Range [MHz]**	**Used Channels**	**Crest Factor**	**Phantom**
UHF	457.525 – 467.575	457.525 – 467.575	low / mid / high	1	ELI 4
Notes: To establish a continuous transmitting signal with 100% duty cycle at specific frequency and with maximum output power, engineering test software has been used					

Table 13: Used channels and crest factors during the test.

6.2 Tune-Up Information

Tune-Up Average Output Power				
Band	**Power Level**	**Frequency [MHz]**	**CH**	**Tune-Up Limit [dBm]**
UHF	High	457.525 - 457.525 – 467.575	low / mid / high	32.0
	Low	457.525 - 457.525 – 467.575	low / mid / high	27.0
Notes:				

Table 14: Maximum conducted output power values declared by the manufacturer.

6.3 Measured Output Power

Measured Average Output Power					
Band	**Power Level**	**Frequency [MHz]**	**CH**	**Measured Output Power [dBm]**	
				B3906 Battery	**B3503 Battery**
UHF	High	457.525	Low	31.25	31.40
		462.550	Mid	31.45	31.60
		467.575	High	31.55	31.70
Notes:					

Table 15: Measured conducted output power values.

6.4 Standalone SAR Test Exclusion according to KDB 447498

SAR test exclusion is determined for the EUT according to KDB 447498 D01 with 1g SAR exclusion thresholds for 100 MHz to 6GHz at test separation distances ≤ 50 mm determined by:

*[(max power of channel. incl. tune-up tolerance. mW) / (min test separation distance. mm)] * [√f(GHz)]*

≤ 3.0 for 1g SAR and ≤ 7.5 for 10g extremity SAR, where

• f(GHz) is the RF channel transmit frequency in GHz
• Power and distance are rounded to the nearest mW and mm before calculation
• The result is rounded to one decimal place for comparison

When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

Standalone SAR Test Exclusion Consideration (FCC)										
Mode	Freq.	Distance	Output Power 100% DC		Maximum Duty Cycle	Output Power 50% DC		Threshold Comparison Value	SAR Testing Exclusion Threshold Value	SAR Testing Required
	[MHz]	[mm]	[dBm]	[mW]	[%]	[dBm]	[mW]		HEAD/BODY	HEAD/BODY
UHF	468	5	32.0	1584.89	50.00	28.99	792.45	108.4	≤ 3.0	YES

Table 16: SAR test exclusion for the applicable transmitter according to KDB 447498.

When the standalone SAR test exclusion applies to an antenna that transmits simultaneously with other antennas the standalone SAR must be estimated according to KDB 447498 in order to determine simultaneous transmission SAR test exclusion:

- *(max. power of channel including tune-up tolerance. mW)/(min. test separation distance. mm)]·[√f(GHz)/x] W/kg for test separation distances ≤ 50 mm;*

  where x = 7.5 for 1-g SAR and x = 18.75 for 10-g SAR

When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

- *0.4 W/kg for 1g SAR and 1.0 W/kg for 10g SAR. when the test separation distance is > 50 mm*

6.5 SAR Test Exclusion Consideration according to RSS-102

Standalone SAR Test Exclusion Consideration (ISED)										
Mode	Freq.	Distance	Output Power 100% DC		Maximum Duty Cycle	Output Power 50% DC		SAR Testing Exclusion Threshold Value (controlled exposure)	SAR Testing Exclusion	SAR Testing Required
	[MHz]	[mm]	[dBm]	[mW]	[%]	[dBm]	[mW]	HEAD/BODY	HEAD/BODY	HEAD/BODY
UHF	468	5	32.0	1584.89	50.00	29.0	792.45	252.0	NO	YES

Table 17: SAR test exclusion for the applicable transmitter according to RSS-102, section 2.5.1.

6.6 SAR Results

The tables below contain the measured SAR values averaged over a mass of 1g. SAR assessment was conducted in the worst case configuration with output power values according to Table 14. According to KDB 447498 D01, the reported SAR is the measured SAR value adjusted for maximum tune-up tolerance.

Furthermore, SAR measurements are performed with an engineering test mode with a continuous wave transmission signal. Since the DUT operates with a mechanical PTT button, the conservative 50 % duty factor is applied according to chapter 6.1 of KDB 447498 D01.

Reported SAR is calculated by the following formulas:

- Scaling factor tune up limit = tune-up limit power (mW) / RF power (mW)
- Scaling factor max. duty cycle = max. possible duty cycle / used duty cycle for SAR measurement
- Reported SAR = measured SAR * scaling factor tune up limit * scaling factor max. duty cycle

The plots with the highest measured SAR values are shown in Appendix B - SAR Distribution Plots.

SAR Measurement Results														
Band	Freq. [MHz]	CH	Test Side	Gap [mm]	Type of Bat.	Pic. No.	Measured SAR1g [W/kg]		Power Drift [dB]	Output Power [dBm]		Scaling Factor Tune-Up Limit	Reported SAR1g [W/kg]	Plot No.
							100% DF	50% DF		Meas.	Limit		50% DF	
UHF	HEAD Exposure / In Front of Face (PTT Configuration)													
	462.550	Mid	Front + belt clip	25	3906	4	1.880	0.940	-0.197	31.45	32.00	1.135	1.067	-
	462.550	Mid		25	3503	4	2.370	1.185	-0.212	31.60	32.00	1.096	1.299	1
	457.525	Low		25	3503	4	2.200	1.100	-0.117	31.60	32.00	1.096	1.206	-
	467.575	High		25	3503	4	1.340	0.670	-0.188	31.60	32.00	1.096	0.735	-
	BODY Exposure / Back Side of DUT													
	462.550	Mid	Back + belt clip	0	3906	5	2.780	1.390	-0.192	31.45	32.00	1.135	1.578	-
	462.550	Mid		0	3503	5	3.810	1.905	0.009	31.60	32.00	1.096	2.089	2
	457.525	Low		0	3503	5	3.350	1.675	0.113	31.60	32.00	1.096	1.837	-
	467.575	High		0	3503	5	2.860	1.430	-0.161	31.60	32.00	1.096	1.568	-
	462.550	Mid	Back + belt clip + C500	0	3503	6	1.190	0.595	-0.103	31.60	32.00	1.096	0.652	-
	462.550	Mid	Back + case	0	3503	7	3.560	1.780	-0.16	31.60	32.00	1.096	1.952	-

Notes: To establish a continuous transmitting signal with 100% duty cycle at specific frequency and with maximum output power, engineering test software has been used.
A duty factor of 50 % is applied according to chapter 6.1 of KDB 447498 D01.
Measurement with attached audio accessory (C500) is performed only in w/c-configuration with attached belt clip.

Table 18: SAR measurement results.

To control the output power stability during the SAR test the used DASY4 system calculates the power drift by measuring the e-field at the same location at the beginning and at the end of the measurement for each test position. These drift values can be found in the above tables labeled as: (Power Drift [dB]). This ensures that the power drift during one measurement is within 5%.

7 Administrative Measurement Data

7.1 Calibration of Test Equipment

Test Equipment Overview						
	Test Equipment	Manufacturer	Model	Serial Number	Last Calibration	Next Calibration
DASY System Components						
☒	Software Versions DASY4	SPEAG	V4.7	N/A	N/A	N/A
☒	Software Versions SEMCAD	SPEAG	V1.8	N/A	N/A	N/A
☒	Dosimetric E-Field Probe	SPEAG	ET3DV6R	1579	02/2018	02/2019
☐	Dosimetric E-Field Probe	SPEAG	ET3DV6R	1669	02/2017	02/2019
☐	Dosimetric E-Field Probe	SPEAG	EX3DV4	3536	09/2016	09/2018
☐	Dosimetric E-Field Probe	SPEAG	EX3DV4	3860	09/2017	09/2018
☒	Data Acquisition Electronics	SPEAG	DAE 3	335	02/2018	02/2019
☐	Data Acquisition Electronics	SPEAG	DAE 4	631	09/2017	09/2018
☐	Phantom	SPEAG	SAM	1059	N/A	N/A
☐	Phantom	SPEAG	SAM	1176	N/A	N/A
☐	Phantom	SPEAG	SAM	1340	N/A	N/A
☐	Phantom	SPEAG	SAM	1341	N/A	N/A
☒	Phantom	SPEAG	ELI4	1004	N/A	N/A
Dipoles						
☒	System Validation Dipole	SPEAG	D450V2	1014	03/2018	03/2021
☐	System Validation Dipole	SPEAG	D835V2	470	03/2018	03/2021
☐	System Validation Dipole	SPEAG	D900V2	006	11/2015	11/2018
☐	System Validation Dipole	SPEAG	D1640V2	311	09/2015	09/2018
☐	System Validation Dipole	SPEAG	D1750V2	1005	03/2018	03/2021
☐	System Validation Dipole	SPEAG	D1900V2	535	03/2018	03/2021
☐	System Validation Dipole	SPEAG	D2450V2	709	11/2015	11/2018
☐	System Validation Dipole	SPEAG	D2600V2	1019	11/2015	11/2018
☐	System Validation Dipole	SPEAG	D5GHzV2	1028	05/2017	05/2020
Material Measurement						
☒	Network Analyzer	Agilent	E5071C	MY46103220	08/2017	08/2019
☒	Dielectric Probe Kit	SPEAG	DAK-3.5	1234	02/2018	02/2020
☒	Thermometer	LKMelectronic	DTM3000	3511	02/2018	02/2020
Power Meters and Sensors						
☒	Power Meter	Anritsu	ML2487A	6K00002319	06/2016	06/2018
☒	Power Sensor	Anritsu	MA2472A	990365	06/2016	06/2018
☒	Power Meter	Anritsu	ML2488A	6K00002078	06/2016	06/2018
☒	Power Sensor	Anritsu	MA2472A	002122	06/2016	06/2018
☒	Spectrum Analyzer	Rohde & Schwarz	FSP7	100433	04/2018	04/2020
RF Sources						
☒	Network Analyzer	Agilent	E5071C	MY46103220	08/2017	08/2019
☒	RF Generator	Rohde & Schwarz	SM300	100142	N/A	N/A
Amplifiers						
☒	Amplifier 10 MHz – 4200 MHz	Mini Circuits	ZHL-42-42W	D080504-1	N/A	N/A
☐	Amplifier 2 GHz – 6 GHz	Ciao Wireless	CA26-451	37452	N/A	N/A
Radio Tester						
☐	Radio Communication Tester	Anritsu	MT8815B	6200576536	04/2016	04/2018
☐	Radio Communication Tester	Anritsu	MT8820C	6200918336	04/2016	04/2018
Notes: Used test equipment for measurement is checked above.						

Table 19: Calibration of test equipment.

7.2 Uncertainty Assessment

Uncertainty Budget for SAR Measurements according to IEEE 1528-2013 (300 MHz - 6 GHz)								
Error Sources	**Uncertainty Value [± %]**	**Probability Distribution**	**Divisor**	**ci**	**ci**	**Standard Uncertainty [± %]**		**vi² or veff**
Measurement System				1g	10g	1g	10g	
Probe calibration	6.7	Normal	1	1	1	6.7	6.7	∞
Axial isotropy	0.3	Rectangular	√3	√0.5	√0.5	0.1	0.1	∞
Hemispherical isotropy	1.3	Rectangular	√3	√0.5	√0.5	0.5	0.5	∞
Boundary effects	1.0	Rectangular	√3	1	1	0.6	0.6	∞
Linearity	0.3	Rectangular	√3	1	1	0.2	0.2	∞
System detection limit	1.0	Rectangular	√3	1	1	0.6	0.6	∞
Modulation response	4.0	Rectangular	√3	1	1	2.3	2.3	∞
Readout electronics	0.3	Normal	1	1	1	0.3	0.3	∞
Response time	0.8	Rectangular	√3	1	1	0.5	0.5	∞
Integration time	1.4	Rectangular	√3	1	1	0.8	0.8	∞
RF ambient conditions - noise	3.0	Rectangular	√3	1	1	1.7	1.7	∞
RF ambient conditions - refl.	3.0	Rectangular	√3	1	1	1.7	1.7	∞
Probe positioner mech. tol.	0.4	Rectangular	√3	1	1	0.2	0.2	∞
Probe positioning	2.9	Rectangular	√3	1	1	1.7	1.7	∞
Algorithms for max SAR eval.	4.0	Rectangular	√3	1	1	2.3	2.3	∞
Test Sample Related								
Test sample positioning	2.9	Normal	1	1	1	2.9	2.9	145
Device holder uncertainty	3.6	Normal	1	1	1	3.6	3.6	5
SAR drift measurement (< 0.2 dB)	4.7	Rectangular	√3	1	1	2.7	2.7	∞
SAR scaling	2.0	Rectangular	√3	1	1	1.2	1.2	∞
Phantom and Set-up								
Phantom uncertainty	4.0	Rectangular	√3	1	1	2.3	2.3	∞
SAR correction for perm./cond.	1.9	Normal	1	1	0.84	1.9	1.6	∞
Liquid conductivity (meas.)	5.0	Normal	1	0.78	0.71	3.9	3.6	∞
Liquid permittivity (meas.)	5.0	Normal	1	0.23	0.26	1.2	1.3	∞
Liquid conductivity temp. unc.	2.9	Rectangular	√3	0.78	0.71	1.3	1.2	∞
Liquid permittivity temp. unc.	1.8	Rectangular	√3	0.23	0.26	0.2	0.3	∞
Combined Standard Uncertainty						11.1	11.0	
Coverage Factor for 95%						kp=2		
Expanded Standard Uncertainty						**22.2**	**21.9**	
Notes: *Worst case probe calibration uncertainty has been applied for all available probes and frequencies.*								

Table 20: Uncertainty budget for SAR measurements.

Uncertainty Budget for SAR System Validation according to IEEE 1528-2013 (300 MHz - 6 GHz)								
Error Sources	**Uncertainty Value [± %]**	**Probability Distribution**	**Divisor**	**ci**	**ci**	**Standard Uncertainty [± %]**		**vi² or veff**
Measurement System				1g	10g	1g	10g	
Probe calibration	6.7	Normal	1	1	1	6.7	6.7	∞
Axial isotropy	0.3	Rectangular	√3	1	1	0.1	0.1	∞
Hemispherical isotropy	1.3	Rectangular	√3	0	0	0.0	0.0	∞
Boundary effects	1.0	Rectangular	√3	1	1	0.6	0.6	∞
Linearity	0.3	Rectangular	√3	1	1	0.2	0.2	∞
System detection limit	1.0	Rectangular	√3	1	1	0.6	0.6	∞
Modulation response	0.0	Rectangular	√3	0	0	0.0	0.0	∞
Readout electronics	0.3	Normal	1	1	1	0.3	0.3	∞
Response time	0.0	Rectangular	√3	0	0	0.0	0.0	∞
Integration time	0.0	Rectangular	√3	0	0	0.0	0.0	∞
RF ambient conditions - noise	1.0	Rectangular	√3	1	1	0.6	0.6	∞
RF ambient conditions - refl.	1.0	Rectangular	√3	1	1	0.6	0.6	∞
Probe positioner mech. tol.	0.4	Rectangular	√3	1	1	0.2	0.2	∞
Probe positioning	2.9	Rectangular	√3	1	1	1.7	1.7	∞
Algorithms for max SAR eval.	4.0	Rectangular	√3	1	1	2.3	2.3	∞
Validation Dipole								
Dev. of exp. dipole from num.	5.0	Normal	1	1	1	5.0	5.0	∞
Input power and SAR drift (< 0.2 dB)	4.7	Rectangular	√3	1	1	2.7	2.7	∞
Dipole axis to liquid distance (< 2deg)	2.0	Rectangular	√3	1	1	1.2	1.2	∞
Phantom and Set-up								
Phantom uncertainty	4.0	Rectangular	√3	1	1	2.3	2.3	∞
SAR correction for perm./cond.	1.9	Normal	1	1	0.84	1.9	1.6	∞
Liquid conductivity (meas.)	5.0	Normal	1	0.78	0.71	3.9	3.6	∞
Liquid permittivity (meas.)	5.0	Normal	1	0.23	0.26	1.2	1.3	∞
Liquid conductivity temp. unc.	2.9	Rectangular	√3	0.78	0.71	1.3	1.2	∞
Liquid permittivity temp. unc.	1.8	Rectangular	√3	0.23	0.26	0.2	0.3	∞
Combined Standard Uncertainty						10.7	10.6	
Coverage Factor for 95%						kp=2		
Expanded Standard Uncertainty						**21.5**	**21.2**	
Notes: *Worst case probe calibration uncertainty has been applied for all available probes and frequencies.*								

Table 21: Uncertainty budget for SAR system validation.

8 Report History

Revision History				
Revision	**Description of Revision**	**Date**	**Revised Page**	**Revised By**
/	Initial Release	Mai 09, 2018	-	-
1	Version of KDB 865664 D02 v01r01 corrected to v01r0**2**	June 01, 2018	4	AR
	SAR values corrected to SAR thresholds, chapter 4.4 added		10	
	Justification added for not testing back + case + C500 config.		15 (table 18)	

END OF THE SAR REPORT

Please refer to separated appendix file for the following data:

- Appendix A - Pictures
- Appendix B - SAR Distribution Plots
- Appendix C - System Verification Plots
- Appendix D – Certificates of Conformity
- Appendix E – Calibration Certificates for DAEs
- Appendix F – Calibration Certificates for E-Field Probes
- Appendix G – Calibration Certificates for Dipoles