KDB 865664 D01 SAR Measurement 100MHz to 6GHz
FCC 47 CFR part 2 (2.1093)

SAR EVALUATION REPORT

For

Audio Player Device with IEEE 802.11b radio

Model: Toniebox
FCC ID: 2AU47-00001

REPORT NUMBER UL-SAR-RP13352918-916A V2.0
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Prepared for

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REVISION HISTORY

Version	Issue Date	Revisions	Revised By
1.0	05 August 2020	Initial Issue	--
2.0	12 August 2020	Updated in accordance with TCB feedback	Marc Montserrat

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1. Attestation of Test Results

Applicant Name	Boxine GmbH					
Model	Toniebox					
Test Device is	A representative test sample					
Device category	Portable					
Date Tested	10 June to 11 June 2020					
ICNIRP Guidelines Limits for SAR Exposure Characteristics	General Population/Localised SAR (Body) – 1g-SAR limit 1.6 W/kg General Population/Localised SAR (Extremity) – 10g-SAR limit 4.0 W/kg					
The highest reported SAR values	RF Exposure Conditions		Equipment Class			
			Licensed	DTS	U-NII	DSS
	Standalone	Body	N/A	0.18 W/kg	N/A	N/A
		Extremity	N/A	0.07 W/kg	N/A	N/A
Applicable Standards	FCC 47 CFR part 2 (2.1093) IEEE Std 1528:2013 KDB publications					
Test Results	Pass					

UL Verification Services Ltd. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Verification Services Ltd. based on interpretations and/or observations of test results. Measurement Uncertainties are in accordance with the above standard and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample(s), under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Verification Services Ltd. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Ltd. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by UKAS. This report is written to support regulatory compliance of the applicable standards stated above.

Issued By:	Prepared By:
	
Naseer Mirza Lead Project Engineer UL	Marc Montserrat Senior Engineer UL

2. Test Specification, Methods and Procedures

2.1. Test Specification

Reference:	KDB Publication Number: 865664 D01 SAR Measurement 100 MHz to 6 GHz
Title:	SAR Measurement Requirements for 100 MHz to 6 GHz
Introduction:	The SAR Measurement procedures for 100MHz to 6GHz are described in this document. Field probes, tissue dielectric properties, SAR scans, measurement accuracy and variability of the measured results are discussed. The field probe and SAR scan requirements are derived from criteria considered in standard IEEE 1528-2013. The wireless product and technology specific procedures in applicable KDB publications are required to be used unless further guidance has been approved by the FCC.
Purpose of Test:	To determine if the Equipment Under Test complies with the Specific Absorption Rate for general population/uncontrolled exposure limit of 1.6 W/kg as specified in FCC 47 CFR part 2 (2.1093).

2.2. Methods and Procedures Reference Documentation

The methods and procedures used were as detailed in:

IEEE 1528:2013

IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communication Devices: Measurement Techniques.

FCC KDB Publication:
KDB 248227 D01 802 11 Wi-Fi SAR v02r02
KDB 447498 D01 General RF Exposure Guidance v06
KDB 447498 D03 Supplement C Cross-Reference v01
KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04
KDB 865664 D02 RF Exposure Reporting v01r02

2.3. Definition of Measurement Equipment

The measurement equipment used complied with the requirements of the standards referenced in the methods & procedures section above. Section 4.3 contains a list of the test equipment used.

3. Facilities and Accreditation

The test sites and measurement facilities used to collect data are located at

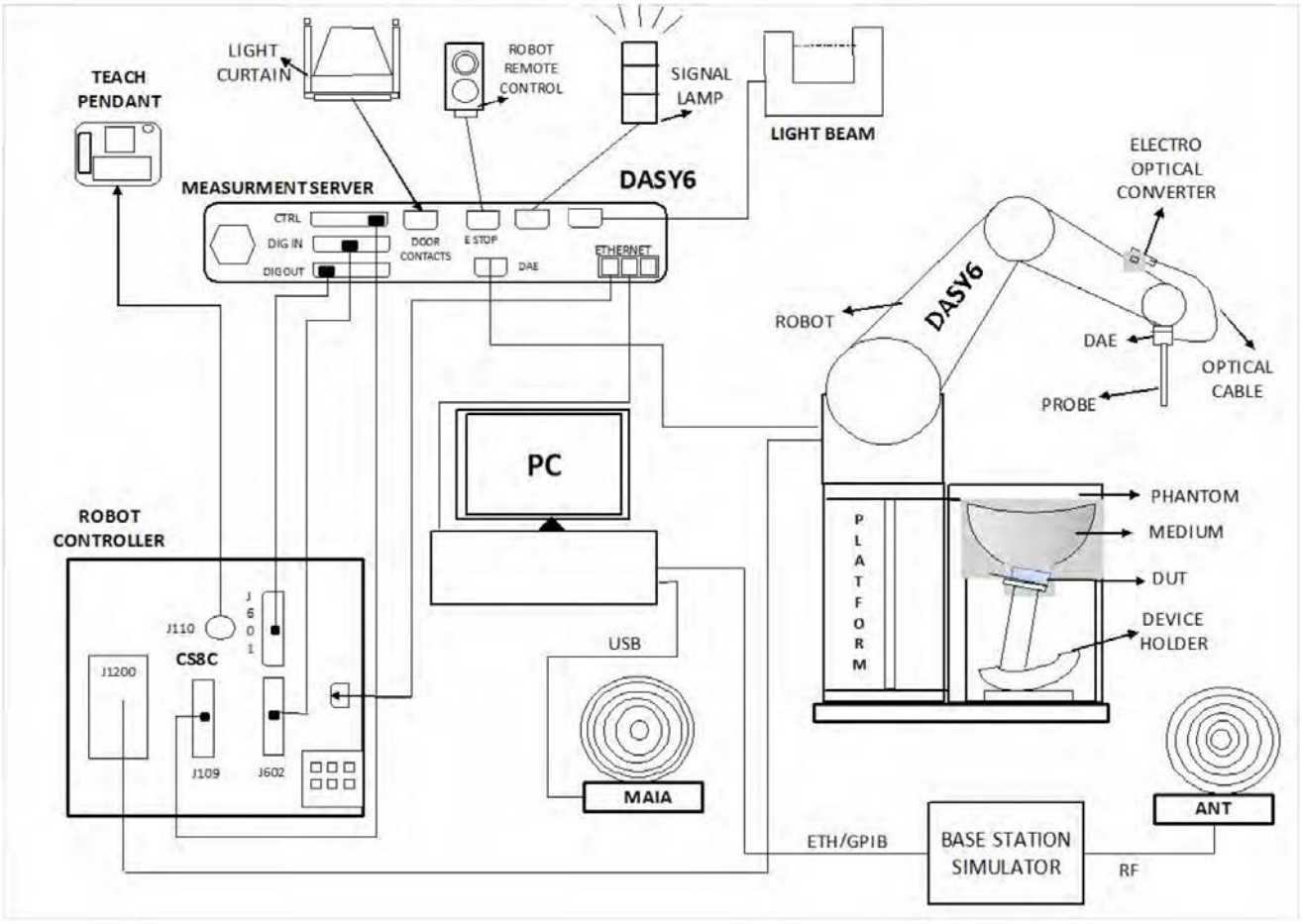
Unit 1-3 Horizon, Kingsland Business Park, Wade Road, Basingstoke, Hampshire, RG24 8AH UK	Facility Type
SAR Lab 64	Controlled Environment Chamber

UL International (UK) Ltd, is accredited by UKAS (United Kingdom Accreditation Service), Laboratory UKAS Code 5772.

4. SAR Measurement System & Test Equipment

4.1. SAR Measurement System

The DASY system used for performing compliance tests consists of the following items:



- A standard high precision 6-axis robot with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic Field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running Win 8.1 or Win 10 and the DASY software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as warning lamps, etc.
- The phantom, the device holder and other accessories according to the targeted measurement.

4.2. SAR Measurement Procedure

4.2.1. Normal SAR Measurement Procedure

The following procedure shall be performed for each of the test conditions

a) Measure the local SAR at a test point within 8 mm of the phantom inner surface that is closest to the DUT.

b) Measure the two-dimensional SAR distribution within the phantom (area scan procedure). The boundary of the measurement area shall not be closer than 20 mm from the phantom side walls. The distance between the measurement points should enable the detection of the location of local maximum with an accuracy of better than half the linear dimension of the tissue cube after interpolation. A maximum grid spacing of 20 mm for frequencies below 3 GHz and (60/f [GHz]) mm for frequencies of 3 GHz and greater is recommended. The maximum distance between the geometrical centre of the probe detectors and the inner surface of the phantom shall be 5 mm for frequencies below 3 GHz and $\delta \ln(2)/2$ mm for frequencies of 3 GHz and greater, where δ is the plane wave skin depth and ln(x) is the natural logarithm. The maximum variation of the sensor-phantom surface distance shall be ± 1 mm for frequencies below 3 GHz and ± 0,5 mm for frequencies of 3 GHz and greater. At all measurement points the angle of the probe with respect to the line normal to the surface should be less than 5°. If this cannot be achieved for a measurement distance to the phantom inner surface shorter than the probe diameter, additional uncertainty evaluation is needed.

c) From the scanned SAR distribution, identify the position of the maximum SAR value, in addition identify the positions of any local maxima with SAR values within 2 dB of the maximum value that will not be within the zoom scan of other peaks; additional peaks shall be measured only when the primary peak is within 2 dB of the SAR compliance limit (e.g., 1 W/kg for 1,6 W /kg 1 g limit, or 1,26 W/kg for 2 W /kg, 10 g limit).

d) Measure the three-dimensional SAR distribution at the local maxima locations identified in step c) (zoom For frequencies at or below 3 GHz, the following procedure shall be applied: The horizontal grid step shall be 8 mm or less. The grid step in the vertical direction shall be 5 mm or less if uniform spacing is used. If variable spacing is used in the vertical direction, the maximum spacing between the two closest measured points to the phantom shell (M1 and M2) shall be 4 mm or less and the spacing between farther points shall increase by a factor of 1,5 or less. The minimum size of the zoom scan volume shall be 30 mm by 30 mm by 30 mm

For frequencies above 3 GHz, the minimum size of the zoom scan volume may be reduced to 22 mm by 22 mm by 22 mm. The horizontal grid step shall be (24/*f* [GHz]) mm or less. If uniform spacing in the vertical direction is used, the grid step in the vertical direction shall be (10/(*f* [GHz] − 1)) mm or less. If variable spacing is used in the vertical direction, the maximum spacing between the two measured points closest to the phantom shell shall be (12/*f* [GHz]) mm or less and the spacing between further points shall increase by a factor of 1,5 or less. For other parameters, see Zoom Scan Parameters table.

When the highest 1 g or 10 g cube is touching the boundary of a zoom-scan volume, the entire zoom scan shall be repeated with the new centre located at the maximum psSAR location indicated by the preceding zoom scan measurement. If the zoom scan measured as defined above complies with both of the following criteria, or if the peak spatial-average SAR is below 0,1 W/kg, no additional measurements are needed:

1) the smallest horizontal distance from the local SAR peaks to all points 3 dB below the SAR peak shall be larger than the horizontal grid steps in both *x* and y directions (Δx, Δy). This shall be checked for the measured zoom scan plane conformal to the phantom at the distance z_{M1}. The minimum distance shall be recorded in the SAR test report;

2) the ratio of the SAR at the second measured point (M2) to the SAR at the closest measured point (M1) at the *x-y* location of the measured maximum SAR value shall be at least 30 %. This ratio (in %) shall be recorded in the SAR test report.

If one or both of the above criteria are not met, the zoom scan measurement shall be repeated using a finer resolution while keeping the other zoom scan parameters compatible with Zoom Scan Parameters table. New horizontal and vertical grid steps shall be determined from the measured SAR distribution so that the above criteria are met. Compliance with the above two criteria shall be demonstrated for the new measured zoom scan. The size of the higher resolution zoom scan and other parameters of Zoom Scan Parameters table shall apply. The closest point to the phantom shell shall be 2 mm or less for graded grids and the grading factor shall be 1,5 or less.
Uncertainties due to field distortion between the media boundary and the dielectric enclosure of the probe should also be minimized, which is achieved if the distance between the phantom surface and physical

tip of the probe is larger than the probe tip diameter. Other methods may utilize correction procedures to compensate for boundary effects that enable high precision measurements closer than half the probe diameter. For all measurement points, the angle of the probe normal to the flat phantom surface shall be less than 5º.

Zoom Scan Parameters

Parameter	DUT transmit frequency being tested	
	$f \leq 3$ GHz	3 GHz < $f \leq 6$ GHz
Maximum distance between the closest measured points and the phantom surface (z_{M1} in Figure 14 and Table 2, in mm)	5	$\delta \ln(2)/2$ [a]
Maximum angle between the probe axis and the flat phantom surface normal (α in Figure 14)	5°	5°
Maximum spacing between measured points in the x- and y-directions (Δx and Δy, in mm)	8	$24/f$ [b,c]
For uniform grids: Maximum spacing between measured points in the direction normal to the phantom shell (Δz_1 in Figure 14, in mm)	5	$10/(f - 1)$
For graded grids: Maximum spacing between the two closest measured points in the direction normal to the phantom shell (Δz_1 in Figure 14, in mm)	4	$12/f$
For graded grids: Maximum incremental increase in the spacing between measured points in the direction normal to the phantom shell ($R_z = \Delta z_2/\Delta z_1$ in Figure 14)	1,5	1,5
Minimum edge length of the zoom scan volume in the x- and y-directions (L_z in 7.2.5.3, in mm)	30	22
Minimum edge length of the zoom scan volume in the direction normal to the phantom shell (L_h in 7.2.5.3, in mm)	30	22
Tolerance in the probe angle	1°	1°

[a] δ is the penetration depth for a plane-wave incident normally on a planar half-space.

[b] This is the maximum spacing allowed, which may not work for all circumstances.

[c] f is the frequency in GHz.

e) Use post processing (e.g. interpolation and extrapolation) procedures to determine the local SAR values at the spatial resolution needed for mass averaging.

f) The local SAR should be measured at the same location as in Step a). SAR drift is assessed and reported in the uncertainty budget.

In the event that the evaluation of measurement drift exceeds the 5 % tolerance, it is required that SAR be reassessed following guidelines contained within this standard.

If the drift is larger than 5 %, then the measurement drift shall be considered a bias, not an uncertainty. A correction shall be applied to the measured SAR value. It is not necessary to record the drift in the uncertainty budget (i.e. ui = 0 %). The uncertainty budget reported in a measurement report should correspond to the highest SAR value reported (after correction, if applicable). Alternatively, the uncertainty budget reported should cover all measurements, i.e., it should report a conservative value.

4.3. Test Equipment

The measuring equipment used to perform the tests documented in this report has been calibrated in accordance with the manufacturers' recommendations, and is traceable to recognized national standards.

UL Asset No.	Instrument Name	Manufacturer	Type	Serial No.	Date Last Calibrated	Cal. Interval (Months)
PRE0194808	E-Field Probe	SPEAG	EX3DV4	7549	05 Aug 2019	12
A2546	Data Acquisition Equipment	SPEAG	DAE4	1435	13 Feb 2020	12
PRE0191242	Phantom	SPEAG	ELI V5	1253	Cal as part of system	-
PRE0131865	2450 MHz Dipole	SPEAG	D2450V2	725	08 Oct 2019	12
PRE0191906	POWERSOURCE1	SPEAG	SE UMS 160 BA	4012	29 Apr 2020	12
M1851	RS Hygrometer	RS Components	408-6109	D10Q65	01 Apr 2020	12
PRE0179707	Body Handset Positioner	SPEAG	MD4HACV5-HAC	None	Calibration not required	-
PRE0178120	Measurement Server	SPEAG	SE UMS 028 BD	1593	Calibration not required	-
PRE0179698	Phantom Support Structure	SPEAG	Phantom Table	-	Calibration not required	-
PRE0178116	Robot Arm	Staubli	TX60 L	F17/5ETWB1/A/01	Calibration not required	-
PRE0178124	Robot Power Supply	SPEAG	CS8C	F17/5ETWB1/C/01	Calibration not required	-
PRE0175232	Power Sensor	Rohde & Schwarz	NRP-Z51	104649-JG	16 Apr 2020	12
M1015	Vector Network Analyser	Keysight	8753ES	US39172406	02 Dec 2019	12
M1755	DAK 3.5 Fluid Probe	SPEAG	SM DAK 040 CA	1089	Calibrated before use	-
A2621	Digital Camera	Nikon	S3600	41010357	Calibration not required	-

4.4. SAR System Specifications

Robot System	
Positioner:	Stäubli Unimation Corp. Robot Model: TX60L
Repeatability:	±0.030 mm
No. of Axis:	6
Serial Number(s):	F17/5ETWB1/A/01
Reach:	920 mm
Payload:	2.0 kg
Control Unit:	CS8C
Programming Language:	V+
Data Acquisition Electronic (DAE) System	
Serial Number:	DAE4 SN: 1435
PC Controller	
PC:	HP EliteDesk800
Operating System:	Windows 10
Data Card:	DASY Measurement Servers
Data Controller	
Features:	Signal Amplifier, multiplexer, A/D converted and control logic.
Software:	cDASY6 Software
Connecting Lines:	Optical downlink for data and status info. Optical uplink for commands and clock.
PC Interface Card	
Function:	24 bit (64 MHz) DSP for real time processing Link to DAE4 16 bit A/D converter for surface detection system serial link to robot direct emergency stop output for robot.
Phantom	
Phantom:	ELI Phantom
Shell Material:	Fibreglass
Thickness:	2.0 ±0.1 mm
E-Field Probe	
Model:	EX3DV4
Serial No:	7549
Construction:	Triangular core
Frequency:	10MHz to >6GHz
Linearity:	±0.2 dB (30 MHz to 6 GHz)
Probe Length (mm):	337
Probe Diameter (mm):	10
Tip Length (mm):	9
Tip Diameter (mm):	2.5
Sensor X Offset (mm):	1
Sensor Y Offset (mm):	1
Sensor Z Offset (mm):	1

5. Measurement Uncertainty

No measurement or test can ever be perfect and the imperfections give rise to error of measurement in the results. Consequently, the result of a measurement is only an approximation to the value of the measurand (the specific quantity subject to measurement) and is only complete when accompanied by a statement of the uncertainty of the approximation.

The expression of uncertainty of a measurement result allows realistic comparison of results with reference values and limits given in specifications and standards.

The uncertainty of the result may need to be taken into account when interpreting the measurement results.

The reported expanded uncertainties below are based on a standard uncertainty multiplied by an appropriate coverage factor, such that a confidence level of approximately 95% is maintained. For the purposes of this document “approximately” is interpreted as meaning “effectively” or “for most practical purposes”.

Test Name	Confidence Level	Calculated Uncertainty
Uncertainty- Freq. < 3 GHz Body Configuration 1g	95%	±26.19 %
Uncertainty- Freq. < 3 GHz Body Configuration 10g	95%	±24.32 %

The methods used to calculate the above uncertainties are in line with those recommended within the various measurement specifications. Where measurement specifications do not include guidelines for the evaluation of measurement uncertainty, the published guidance of the appropriate accreditation body is followed.

5.1. Uncertainty – Freq. < 3 GHz Body Configuration 1g

Type	Source of uncertainty	+ Value	- Value	Probability Distribution	Divisor	$c_{i\ (10g)}$	Standard Uncertainty		υ_i or υ_{eff}
							+ u (%)	- u (%)	
B	Probe calibration	10.100	10.100	normal (k=2)	2.0000	1.0000	5.050	5.050	∞
B	Axial Isotropy	0.500	0.500	Rectangular	1.7321	0.7071	0.204	0.204	∞
B	Hemispherical Isotropy	2.600	2.600	Rectangular	1.7321	0.7071	1.061	1.061	∞
B	Boundary Effect	1.000	1.000	Rectangular	1.7321	1.0000	0.577	0.577	∞
B	Linearity	0.600	0.600	normal (k=2)	2.0000	1.0000	0.300	0.300	∞
B	Detection Limits	0.250	0.250	Rectangular	1.7321	1.0000	0.144	0.144	∞
B	Readout Electronics	0.300	0.300	normal (k=1)	1.0000	1.0000	0.300	0.300	∞
B	Modulation Response Time	9.600	9.600	normal (k=2)	2.0000	1.0000	4.800	4.800	∞
B	Response Time	1.010	1.010	Rectangular	1.7321	1.0000	0.583	0.583	∞
B	Integration Time	4.320	4.320	Rectangular	1.7321	1.0000	2.494	2.494	∞
B	RF Ambient conditions	0.260	0.260	Rectangular	1.7321	1.0000	0.150	0.150	∞
B	Probe Positioner Mechanical Tolerance	0.020	0.020	Rectangular	1.7321	1.0000	0.012	0.012	∞
B	Probe Positioning with regard to Phantom Shell	0.400	0.400	Rectangular	1.7321	1.0000	0.231	0.231	∞
B	Extrapolation and integration/ Maximum SAR evaluation	2.000	2.000	Rectangular	1.7321	1.0000	1.155	1.155	∞
A	Test Sample Positioning	5.730	5.730	normal (k=1)	1.0000	1.0000	5.730	5.730	34.5
A	Device Holder uncertainty	7.480	7.480	normal (k=1)	1.0000	1.0000	7.480	7.480	5
B	Drift of output power	5.000	5.000	Rectangular	1.7321	1.0000	2.887	2.887	∞
B	Phantom Shell Uncertainty	5.700	5.700	Rectangular	1.7321	1.0000	3.291	3.291	∞
B	Uncertainty in SAR correction for deviations in permittivity and conductivity	1.900	1.900	Rectangular	1.7321	1.0000	1.097	1.097	∞
B	Liquid Conductivity (measured value)	5.288	5.288	normal (k=2)	2.0000	0.0000	0.000	0.000	∞
B	Liquid Permittivity (measured value)	2.500	2.500	normal (k=2)	2.0000	0.0000	0.000	0.000	∞
B	Liquid Conductivity (temperature uncertainty)	1.300	1.300	Rectangular	1.7321	1.0000	0.751	0.751	∞
B	Liquid Permittivity (temperature uncertainty)	0.320	0.320	Rectangular	1.7321	1.0000	0.185	0.185	∞
	Combined standard uncertainty			t-distribution			12.96	12.96	42
	Expanded uncertainty			k = 2.021			26.19	26.19	42

5.2. Uncertainty – Freq. < 3 GHz Body Configuration 10g

Type	Source of uncertainty	+ Value	- Value	Probability Distribution	Divisor	$c_{i\ (10g)}$	Standard Uncertainty		υ_i or υ_{eff}
							+ u (%)	- u (%)	
B	Probe calibration	10.100	10.100	normal (k=2)	2.0000	1.0000	5.050	5.050	∞
B	Axial Isotropy	0.500	0.500	Rectangular	1.7321	0.7071	0.204	0.204	∞
B	Hemispherical Isotropy	2.600	2.600	Rectangular	1.7321	0.7071	1.061	1.061	∞
B	Boundary Effect	1.000	1.000	Rectangular	1.7321	1.0000	0.577	0.577	∞
B	Linearity	0.600	0.600	normal (k=2)	2.0000	1.0000	0.300	0.300	∞
B	Detection Limits	0.250	0.250	Rectangular	1.7321	1.0000	0.144	0.144	∞
B	Readout Electronics	0.300	0.300	normal (k=1)	1.0000	1.0000	0.300	0.300	∞
B	Modulation Response Time	9.600	9.600	normal (k=2)	2.0000	1.0000	4.800	4.800	∞
B	Response Time	1.010	1.010	Rectangular	1.7321	1.0000	0.583	0.583	∞
B	Integration Time	4.320	4.320	Rectangular	1.7321	1.0000	2.494	2.494	∞
B	RF Ambient conditions	0.260	0.260	Rectangular	1.7321	1.0000	0.150	0.150	∞
B	Probe Positioner Mechanical Tolerance	0.020	0.020	Rectangular	1.7321	1.0000	0.012	0.012	∞
B	Probe Positioning with regard to Phantom Shell	0.400	0.400	Rectangular	1.7321	1.0000	0.231	0.231	∞
B	Extrapolation and integration/ Maximum SAR evaluation	2.000	2.000	Rectangular	1.7321	1.0000	1.155	1.155	∞
A	Test Sample Positioning	5.650	5.650	normal (k=1)	1.0000	1.0000	5.650	5.650	34.5
A	Device Holder uncertainty	6.090	6.090	normal (k=1)	1.0000	1.0000	6.090	6.090	5
B	Drift of output power	5.000	5.000	Rectangular	1.7321	1.0000	2.887	2.887	∞
B	Phantom Shell Uncertainty	5.700	5.700	Rectangular	1.7321	1.0000	3.291	3.291	∞
B	Uncertainty in SAR correction for deviations in permittivity and conductivity	1.600	1.600	Rectangular	1.7321	1.0000	0.924	0.924	∞
B	Liquid Conductivity (measured value)	5.288	5.288	normal (k=2)	2.0000	0.0000	0.000	0.000	∞
B	Liquid Permittivity (measured value)	2.500	2.500	normal (k=2)	2.0000	0.0000	0.000	0.000	∞
B	Liquid Conductivity (temperature uncertainty)	1.300	1.300	Rectangular	1.7321	1.0000	0.751	0.751	∞
B	Liquid Permittivity (temperature uncertainty)	0.320	0.320	Rectangular	1.7321	1.0000	0.185	0.185	∞
	Combined standard uncertainty			t-distribution			12.16	12.16	71
	Expanded uncertainty			k = 2			24.32	24.32	71

6. Device Under Test (DUT) Information

6.1. DUT Description

DUT Description:	The device under test is an audio book. It works in conjunction with Tonie figures containing a product ID that is read by the Toniebox via passive RFID receiver. Via the WLAN module in the Toniebox, the audiobook content is downloaded from the Boxine cloud to the internal storage and played on the loudspeaker. The device chipset supports IEEE 802.11b radio, however, in the application software 802.11b mode is used exclusively.		
Serial Number:	SAR 2 – 2011P1300491572	SAR Evaluation	
	3083893 #2	Conducted Power Measurements	
Hardware Version Number:	1.2		
Software Version Number:	2.0		
Country of Manufacture:	China		
Device dimension	Overall (Height x Width x Depth): 120.0 mm x 120.0 mm x 120.0 mm		
Date of Receipt:	26 May 2020		
Antenna Type:	Internal integral		
Antenna Length:	Unknown		
Number of Antenna Positions:	Antenna 1 – WLAN – Transmit / Receive		1 fixed
Operating Configurations	Body Extremity		
Battery Type	☒ Standard – Lithium-ion battery ☐ Extended (large capacity)		

6.2. Wireless Technologies

Wi-Fi						
Band	Description					
	Channel No. 20 MHz BW	Freq. (MHz)	Channel No. 40 MHz BW	Freq. (MHz)	Channel No. 80 MHz BW	Freq. (MHz)
Wi-Fi 2.4 GHz (802.11b)	1	2412.0	N/A			
	2	2417.0				
	3	2422.0				
	4	2427.0				
	5	2432.0				
	6	2437.0				
	7	2442.0				
	8	2447.0				
	9	2452.0				
	10	2457.0				
	11	2462.0				
	12	2467.0				
	13	2472.0				

6.3. Nominal and Maximum Output power

RF Air interface	Channel	Centre Freq (MHz)	Target + Max. Tolerances (dBm)		
			1-DSSS	2-DSSS	11-CCK
Wi-Fi 2.4 GHz (802.11b)	1	2412.0	15.80	15.80	15.90
	2	2417.0	15.78	15.78	15.95
	3	2422.0	16.25	16.25	16.50
	4	2427.0	16.20	16.20	16.45
	5	2432.0	16.15	16.15	16.45
	6	2437.0	16.65	16.65	16.95
	7	2442.0	17.10	17.10	17.30
	8	2447.0	16.50	16.50	16.80
	9	2452.0	16.05	16.05	16.30
	10	2457.0	16.10	16.10	16.40
	11	2462.0	16.20	16.20	16.45
	12	2467.0	Not Supported	Not Supported	Not Supported
	13	2472.0	Not Supported	Not Supported	Not Supported

Note: The powers above have been declared as module max. rated output powers including upper tolerance.

7. RF Exposure Conditions (Test Configurations)

7.1. Configuration Consideration

Technology Antenna	Configuration	Antenna-to-User Separation	Position	Antenna-to-Edge Separation (mm)	Evaluation Considered
Wi-Fi	Body & Extremity	0mm	Top	< 35	Yes
			Bottom	< 35	Yes
			Edge 1 (Front Face)	> 35	No
			Edge 2 (Right Face)	< 35	Yes
			Edge 2-3	< 35	Yes
			Edge 3 (Back Face)	< 35	Yes
			Edge 4 (Left Face)	> 35	No

Note:

1. The Antenna to edge separation distances are indicated in the 'Antenna Schematics' located in Section 12.1 of this report

7.2. SAR Test Exclusion Consideration

Frequency Band	Configuration	
	Body	Extremity
Wi-Fi 2.4 GHz	No	No

Note:

1. As per KDB publication 447498 D01, the frequency bands with rated power including upper tolerance, which qualify for Standalone Test Exclusion, are as per the above table.
2. The details for the Maximum Rated Power and tolerance(s) can be found in section 6.

8. Conducted Output Power Measurements

8.1. RF Output Average Power Measurement: Wi-Fi 2.4 GHz

8.1.1. Wi-Fi 802.11b (2.4 GHz)

		Avg Power (dBm)	
Channel Number	Frequency (MHz)	Data Rate: 11 Mbps	Operating Mode
		Ant 1	
1	2412.0	15.20	802.11b HT20 (CCK)
2	2417.0	15.80	
3	2422.0	16.00	
6	2437.0	16.40	
7	2442.0	17.15	
11	2462.0	16.10	

Note:

1. Conducted power measurements on DSSS mode were not performed as max. rated power including tolerance is equal or lower than other modes.

9. Dielectric Property Measurements & System Check

9.1.Tissue Dielectric Parameters

The temperature of the tissue-equivalent medium used during measurement must also be within 18°C to 25°C and within ± 2°C of the temperature when the tissue parameters are characterized.
The dielectric parameters must be measured before the tissue-equivalent medium is used in a series of SAR measurements. The parameters should be re-measured after each 3 – 4 days of use; or earlier if the dielectric parameters can become out of tolerance; for example, when the parameters are marginal at the beginning of the measurement series.
Tissue dielectric parameters were measured at the low, middle and high frequency of each operating frequency range of the test device.

IEEE 1528:2013

Target Frequency (MHz)	Head		Body (FCC only)	
	ε_r	σ (S/m)	ε_r	σ (S/m)
150	52.30	0.76	61.90	0.80
300	45.30	0.87	58.20	0.92
450	43.50	0.87	56.70	0.94
750	41.90	0.89	-	-
835	41.50	0.90	55.20	0.97
900	41.50	0.97	55.00	1.05
915	41.50	0.98	55.00	1.06
1450	40.50	1.20	54.00	1.30
1500	40.40	1.23	-	-
1610	40.30	1.29	53.80	1.40
1640	40.20	1.31	-	-
1750	40.10	1.37	-	-
1800	40.00	1.40	53.30	1.52
1900	40.00	1.40	53.30	1.52
2000	40.00	1.40	53.30	1.52
2100	39.80	1.49	-	-
2300	39.50	1.67	-	-
2450	39.20	1.80	52.70	1.95
2600	39.00	1.96	-	-
3000	38.50	2.40	52.00	2.73
3500	37.90	2.91	-	-
4000	37.40	3.43	-	-
4500	36.80	3.94	-	-
5000	36.20	4.45	49.30	5.07
5100	36.10	4.55	49.10	5.18
5200	36.00	4.66	49.00	5.30
5250	35.90	4.71	48.90	5.36
5300	35.90	4.76	48.90	5.42
5400	35.80	4.86	48.70	5.53
5500	35.60	4.96	48.60	5.65
5600	35.50	5.07	48.50	5.77
5700	35.40	5.17	48.30	5.88
5750	35.40	5.22	48.30	5.94
5800	35.30	5.27	48.20	6.00
6000	35.10	5.48	-	-

NOTE: For convenience, permittivity and conductivity values at some frequencies that are not part of the original data from Drossos et al. [B60] or the extension to 5800 MHz are provided (i.e., the values shown in italics). These values were linearly interpolated between the values in this table that are immediately above and below these values, except the values at 6000 MHz that were linearly extrapolated from the values at 3000 MHz and 5800 MHz.

9.2. System Check

SAR system verification is required to confirm measurement accuracy, according to the tissue dielectric media, probe calibration points and other system operating parameters required for measuring the SAR of a test device. The system verification must be performed for each frequency band and within the valid range of each probe calibration point required for testing the device. The same SAR probe(s) and tissue-equivalent media combinations used with each specific SAR system for system verification must be used for device testing. When multiple probe calibration points are required to cover substantially large transmission bands, independent system verifications are required for each probe calibration point. A system verification must be performed before each series of SAR measurements using the same probe calibration point and tissue-equivalent medium. Additional system verification should be considered according to the conditions of the tissue-equivalent medium and measured tissue dielectric parameters, typically every three to four days when the liquid parameters are re-measured or sooner when marginal liquid parameters are used at the beginning of a series of measurements.

9.3. Numerical Target SAR Values

The numerical SAR target values are obtained from the reference standards. The measured values are normalised to 1 Watt.

System Dipole	Serial No.	Cal. Date	Freq. (MHz)	Numerical SAR Target Values (W/kg)		
				1g/10g	Head	Body
D2450V2	725	08 Oct 2019	2450	1g	52.40	51.20
				10g	24.00	23.70

9.4. Dielectric Property Measurements & System Check Results

The 1-g SAR and 10-g SAR measured with a reference dipole, using the required tissue-equivalent medium at the test frequency, must be within ±10% of the numerical SAR target. The internal limit is set to ±10%.

Site 64

2450 Head
Date: 09 Jun 2020
Reference Dipole Antenna: D2450V2 - SN725

Simulant	Frequency (MHz)	Room Temp(℃)	Liquid Temp(℃)	Parameters	Target Value	Measured Value	Deviation (%)	Limit (%)
Head	2450	22.7	21.6	ε_r	39.20	37.95	-3.18	10
				σ (S/m)	1.80	1.82	1.13	10
				1g (W/kg)	52.40	52.67	0.52	10
				10g (W/kg)	24.00	24.74	3.09	10

Note: As per FCC RF Exposure procedures - April 2019 presentation - Tissue Simulating Liquids (TSL), page 19, effective February 19, 2019, FCC has permitted the use of the head-tissue simulating liquid specified in IEC 62209-1 for all SAR tests – head, body and extremity.

10. Measurements, Examinations and Derived Results

10.1. General Comments

In order to determine the highest value of the peak spatial-average SAR, all required device positions, configurations and operating modes were tested per each frequency band. SAR measurement was performed on the highest output channel, and overall worst case configurations was tested on remaining channels,

In case the reported SAR levels were higher than half of the SAR limit, remaining channels on that particular test position were also evaluated.

The maximum reported SAR plots for each band or configuration can be found on this report, other plots are on file and can be made available upon request.

Note: Refer to section 7 for the configuration considered for SAR test.

10.2. Specific Absorption Rate - Test Results

10.2.1. WLAN 2.4GHz Body 1g

Max Reported SAR = 0.18 (W/kg)

					For LTE Only		Power (dBm)		1g: SAR Results (W/kg)			
Mode	Dist. (mm)	DUT Position	Channel Number	Freq (MHz)	#RB	Start RB	Tune Up Limit	Meas.	Meas. SAR Level	Reported SAR	Notes	Plot No.
802.11b (CCK)	0	Top	7	2442.0	-	-	17.30	17.15	0.17	0.18	-	001
802.11b (CCK)	0	Bottom	7	2442.0	-	-	17.30	17.15	0.05	0.05	-	-
802.11b (CCK)	0	Edge 2 (Right Face)	7	2442.0	-	-	17.30	17.15	0.04	0.04	-	-
802.11b (CCK)	0	Edge 3 (Back Face)	7	2442.0	-	-	17.30	17.15	0.02	0.02	-	-
802.11b (CCK)	0	Edge 2-3	7	2442.0	-	-	17.30	17.15	0.03	0.03	-	-
802.11b (CCK)	0	Top	3	2422.0	-	-	16.50	16.00	0.12	0.13	-	-
802.11b (CCK)	0	Top	11	2462.0	-	-	16.45	16.10	0.12	0.13	-	-

Note(s):

10.2.2. WLAN 2.4GHz Extremity 10g

Max Reported SAR = 0.07 (W/kg)

					For LTE Only		Power (dBm)		10g: SAR Results (W/kg)			
Mode	Dist. (mm)	DUT Position	Channel Number	Freq (MHz)	#RB	Start RB	Tune Up Limit	Meas.	Meas. SAR Level	Reported SAR	Notes	Plot No.
802.11b (CCK)	0	Top	7	2442.0	-	-	17.30	17.15	0.07	0.07	-	001
802.11b (CCK)	0	Bottom	7	2442.0	-	-	17.30	17.15	0.03	0.03	-	-
802.11b (CCK)	0	Edge 2 (Right Face)	7	2442.0	-	-	17.30	17.15	0.02	0.02	-	-
802.11b (CCK)	0	Edge 3 (Back Face)	7	2442.0	-	-	17.30	17.15	0.01	0.01	-	-
802.11b (CCK)	0	Edge 2-3	7	2442.0	-	-	17.30	17.15	0.02	0.02	-	-
802.11b (CCK)	0	Top	3	2422.0	-	-	16.50	16.00	0.05	0.05	-	-
802.11b (CCK)	0	Top	11	2462.0	-	-	16.45	16.10	0.05	0.05	-	-

Note(s):

10.3. SAR Measurement Variability

In accordance with published RF Exposure KDB procedure 865664 D01 SAR measurement 100 MHz to 6 GHz. These additional measurements are repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device should be returned to ambient conditions (normal room temperature) with the battery fully charged before it is re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results.

Body 1g-SAR:

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.

Extremity 10g-SAR:

1) Repeated measurement is not required when the original highest measured SAR is < 2.0 W/Kg; steps 2) through 4) do not apply.
2) When the original highest measured 10g-SAR is ≥ 2.00 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 ≥ 3.625 W/kg (~ 10% from the 10g-SAR limit).
4) Perform a third repeated measurement only if the original, first or second repeated measurement is ≥ 3.75 W/Kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.

Note: Measured 1g and 10g-SAR levels were below the thresholds hence measurement variability was not considered.

11. Highest Standalone Transmission

11.1. Highest Standalone Reported SAR

Individual Transmitter Evaluation per Band:

Exposure Configuration	Technology Band	Reported 1g - SAR (W/Kg)	Highest Reported 1g - SAR (W/Kg)
Body (Separation Distance 0mm)	Wi-Fi 2.4	0.18	0.18

Exposure Configuration	Technology Band	Reported 10g - SAR (W/Kg)	Highest Reported 10g - SAR (W/Kg)
Extremity (Separation Distance 0mm)	Wi-Fi 2.4	0.07	0.07

11.2. Simultaneous Transmission analysis

Simultaneous transmission SAR test analysis is determined for each operating configuration and exposure condition according to the *reported* standalone SAR of each applicable simultaneous transmitting antenna.

The worst case simultaneous transmission analysis is considered for the following cases:

Note: No simultaneous transmission analysis is required, as DUT do not support this feature.