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

SAR EVALUATION REPORT

For

Digital Microscope and Scanner Device with IEEE 802.11a/b/g/n/ac Radio

Model: OCUS
Contains FCC ID: 2AQ5IOCUS1

Report Number UL-SAR-RP12447929-116A V2.0
ISSUE DATE: 20 March 2019

Prepared for

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REVISION HISTORY

Version	Issue Date	Revisions	Revised By
1.0	10 January 2019	Initial Issue	--
2.0	20 March 2019	The following amendments were made in the report: 1. Typo corrected on front page 2. Typo corrected in section 6.1	Naseer Mirza

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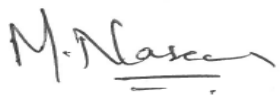
1. Attestation of Test Results

Applicant Name	Grundium Oy					
Model	OCUS					
Test Device is	A representative test sample					
Device category	Portable					
Date Tested	14 December 2018 to 20 December 2018					
ICNIRP Guidelines Limits for SAR Exposure Characteristics	General Population/Localised SAR (Head and trunk) – 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	0.25 W/Kg	0.24 W/Kg	N/A
	Standalone	Extremity	N/A	0.12 W/Kg	0.09 W/Kg	N/A
	Simultaneous Transmission	Body	N/A	N/A	N/A	N/A
	Simultaneous Transmission	Extremity	N/A	N/A	N/A	N/A
Applicable Standards	FCC 47 CFR part 2 (2.1093) KDB publication					
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 VS Ltd.	Chanthu Thevarajah Senior Engineer UL VS Ltd.

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 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

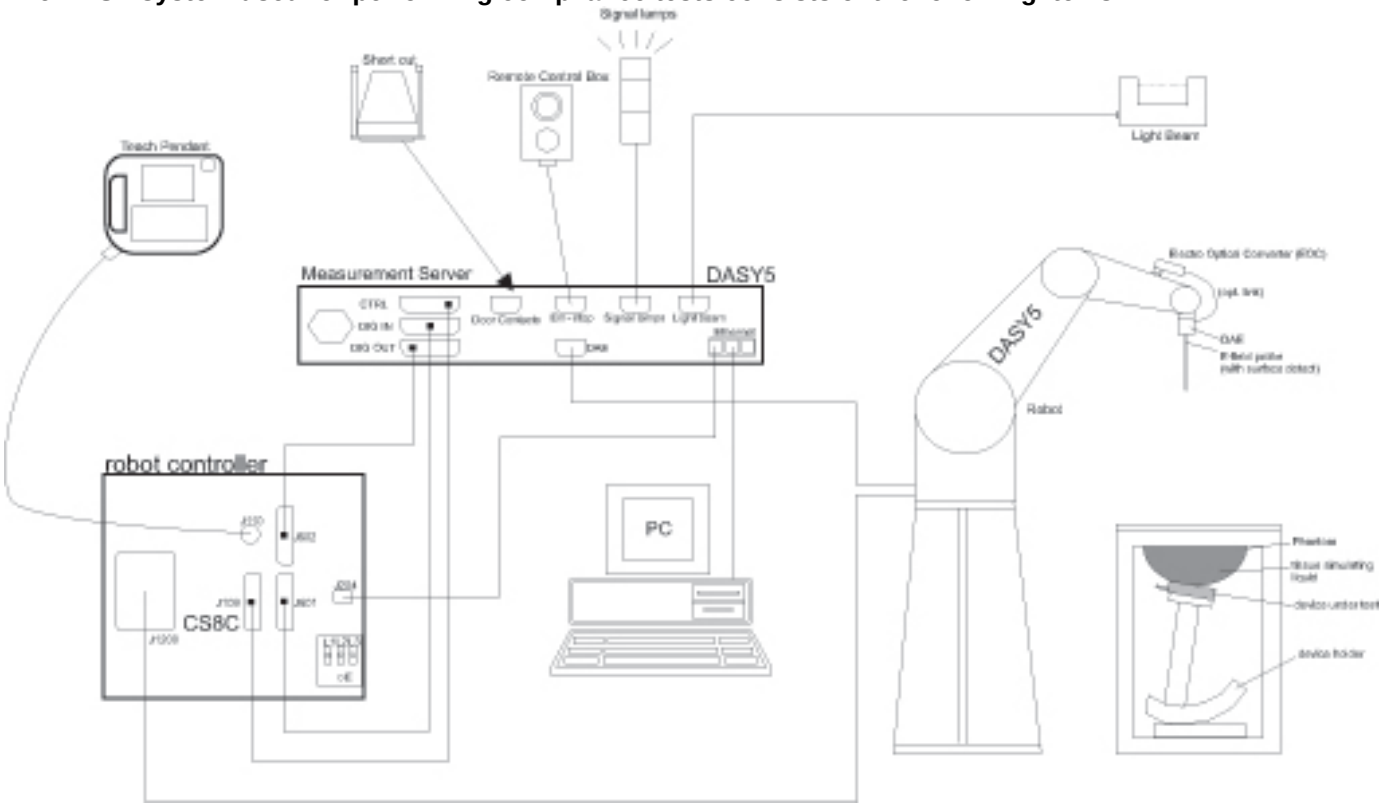
Unit 1 Horizon, Kingsland Business Park, Wade Road, Basingstoke, Hampshire, RG24 8AH UK	Facility Type
SAR Lab 60	Controlled Environment Chamber

UL Verification Services Ltd, is accredited by UKAS (United Kingdom Accreditation Service), Laboratory UKAS Code 0644.

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

a) Measure the two-dimensional SAR distribution within the phantom (area scan procedure).
b) 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 δ 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 6 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 scan procedure). The horizontal grid step shall be (24 / f [GHz]) mm or less but not more than 8 mm. The minimum zoom scan size is 30 mm by 30 mm by 30 mm for frequencies below 3 GHz. For higher frequencies, the minimum zoom scan size can be reduced to 22 mm by 22 mm by 22 mm. The grid step in the vertical direction shall be (8-f [GHz]) mm or less but not more than 5 mm, 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 shall be (12/f [GHz]) mm or less but not more than 4 mm, and the spacing between farther points shall increase by an incremental factor not exceeding 1,5. When variable spacing is used, extrapolation routines shall be tested with the same spacing as used in measurements. 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 δ 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. Separate grids shall be centred on each of the local SAR maxima found in step c). 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 probe tip diameter. Other methods may utilize correction procedures for these boundary effects that enable high precision measurements closer than half the probe diameter. For all measurement points, the angle of the probe with respect to the flat phantom surface shall be less than 5º.
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.

Area Scan Parameters:

	≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	5 mm ± 1 mm	½·δ·ln(2) mm ± 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.	

Zoom Scan Parameters:

			≤ 3 GHz	> 3 GHz
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

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 No.	Instrument	Manufacturer	Type No.	Serial No.	Date Last Calibrated	Cal. Interval (Months)
A2546	Data Acquisition Electronics	SPEAG	DAE4	1435	06 Feb 2018	12
A1377	5GHz Dipole Kit	SPEAG	D5GHzV2	1016	12 Feb 2018	12
A1322	2450 MHz Dipole Kit	SPEAG	D2450V2	725	17 Sep 2018	12
A2545	Probe	SPEAG	EX3DV4	3995	24 Apr 2018	12
G0611	Robot Power Supply	SPEAG	DASY52	F14/5UA6A1/C/01	Calibrated as part of system	
M1876	Robot Arm	Staubli	TX60 L	F14/5UA6A1/A/01	Calibrated as part of system	-
M1755	DAK Fluid Probe	SPEAG	SM DAK 040 CA	1089	Calibrated before use	-
M1015	Network Analyser	Agilent	Agilent 8753ES	US39172406	14 Oct 2018	12
A2621	Digital Camera	Nikon	S3600	41010357	N/A	-
A2252	Phantom	SPEAG	ELI Phantom	1177	Calibrated as part of system	-
PRE0141348	Phantom Support Structure	SPEAG	DASY6 Phantom Table	-	Calibrated as part of system	-
M1853	RS Hygrometer	RS Components	408-6109	D10Q69	11 Apr 2018	12
PRE0176848	RF Coax Cable	Huber+Suhner	Superflex 126	503319	Calibrated before use	-
PRE0141988	Directional Coupler	RF-Lambda	RFDC5M06G15	12042502539	Calibrated before use	-
A2689	Amplifier	Mini-Circuits	ZVE-8G	910401427	Calibrated before use	-
M1838	Signal Generator	R & S	SME06	1038.6002.06	22 Mar 2018	12
M1840	Dual Channel Power Meter	R & S	NRVD	844860/040	22 Mar 2018	12
M1044	Power Sensor	R & S	NRV-Z1	893350/0019	06 Nov 2017	12
PRE0141348	Phantom Support Structure	SPEAG	Phantom Table	-	Calibrated as part of system	-
A2550	Phantom	SPEAG	ELi Phantom	1251	Calibrated as part of system	-

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):	F14/5UA6A1/C/01
Reach:	800 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:	DASY5 Measurement Servers
Data Converter	
Features:	Signal Amplifier, multiplexer, A/D converted and control logic.
Software:	DASY5 PRO 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:	3995
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 %	±19.22 %
Uncertainty- Freq. > 3 GHz Body Configuration 1g	95 %	±16.37 %

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	$c_{i\ (1g)}$	Standard Uncertainty		υ_i or υ_{eff}
							+ u (%)	- u (%)	
B	Probe calibration	5.050	5.050	normal (k=1)	1.0000	1.0000	5.050	5.050	∞
B	Axial Isotropy	0.250	0.250	normal (k=1)	1.0000	1.0000	0.250	0.250	∞
B	Hemispherical Isotropy	1.300	1.300	normal (k=1)	1.0000	1.0000	1.300	1.300	∞
B	Spatial Resolution	0.500	0.500	Rectangular	1.7321	1.0000	0.289	0.289	∞
B	Boundary Effect	0.769	0.769	Rectangular	1.7321	1.0000	0.444	0.444	∞
B	Linearity	0.300	0.300	Rectangular	1.7321	1.0000	0.173	0.173	∞
B	Detection Limits	0.200	0.200	Rectangular	1.7321	1.0000	0.115	0.115	∞
B	Readout Electronics	0.160	0.160	normal (k=1)	1.0000	1.0000	0.160	0.160	∞
B	Response Time	0.000	0.000	Rectangular	1.7321	1.0000	0.000	0.000	∞
B	Integration Time	8.520	8.520	Rectangular	1.7321	1.0000	4.919	4.919	∞
B	RF Ambient conditions	3.000	3.000	Rectangular	1.7321	1.0000	1.732	1.732	∞
B	Probe Positioner Mechanical Restrictions	4.000	4.000	Rectangular	1.7321	1.0000	2.309	2.309	∞
B	Probe Positioning with regard to Phantom Shell	2.850	2.850	Rectangular	1.7321	1.0000	1.645	1.645	∞
B	Extrapolation and integration/ Maximum SAR evaluation	5.080	5.080	Rectangular	1.7321	1.0000	2.933	2.933	∞
A	Test Sample Positioning	0.147	0.147	normal (k=1)	1.0000	1.0000	0.147	0.147	10
A	Device Holder uncertainty	0.154	0.154	normal (k=1)	1.0000	1.0000	0.154	0.154	10
B	Phantom Uncertainty	4.000	4.000	Rectangular	1.7321	1.0000	2.309	2.309	∞
B	Drift of output power	5.000	5.000	Rectangular	1.7321	1.0000	2.887	2.887	∞
B	Liquid Conductivity (target value)	5.000	5.000	Rectangular	1.7321	0.6400	1.848	1.848	∞
A	Liquid Conductivity (measured value)	2.470	2.470	normal (k=1)	1.0000	0.6400	1.581	1.581	5
B	Liquid Permittivity (target value)	5.000	5.000	Rectangular	1.7321	0.6000	1.732	1.732	∞
A	Liquid Permittivity (measured value)	2.430	2.430	normal (k=1)	1.0000	0.6000	1.458	1.458	5
	Combined standard uncertainty			t-distribution			9.81	9.81	>500
	Expanded uncertainty			k = 1.96			19.22	19.22	>500

5.2. Uncertainty – Freq. > 3 GHz Body Configuration 1g

Type	Source of uncertainty	+ Value	- Value	Probability Distribution	Divisor	$c_{i\ (1g)}$	Standard Uncertainty		υ_i or υ_{eff}
							+ u (%)	- u (%)	
B	Probe calibration	5.050	5.050	normal (k=1)	1.0000	1.0000	5.050	5.050	∞
B	Axial Isotropy	0.250	0.250	normal (k=1)	1.0000	1.0000	0.250	0.250	∞
B	Hemispherical Isotropy	1.300	1.300	normal (k=1)	1.0000	1.0000	1.300	1.300	∞
B	Spatial Resolution	0.500	0.500	Rectangular	1.7321	1.0000	0.289	0.289	∞
B	Boundary Effect	0.769	0.769	Rectangular	1.7321	1.0000	0.444	0.444	∞
B	Linearity	0.300	0.300	Rectangular	1.7321	1.0000	0.173	0.173	∞
B	Detection Limits	0.200	0.200	Rectangular	1.7321	1.0000	0.115	0.115	∞
B	Readout Electronics	0.160	0.160	normal (k=1)	1.0000	1.0000	0.160	0.160	∞
B	Response Time	0.000	0.000	Rectangular	1.7321	1.0000	0.000	0.000	∞
B	Integration Time	0.000	0.000	Rectangular	1.7321	1.0000	0.000	0.000	∞
B	RF Ambient conditions	3.000	3.000	Rectangular	1.7321	1.0000	1.732	1.732	∞
B	Probe Positioner Mechanical Restrictions	4.000	4.000	Rectangular	1.7321	1.0000	2.309	2.309	∞
B	Probe Positioning with regard to Phantom Shell	2.850	2.850	Rectangular	1.7321	1.0000	1.645	1.645	∞
B	Extrapolation and integration/ Maximum SAR evaluation	5.080	5.080	Rectangular	1.7321	1.0000	2.933	2.933	∞
A	Test Sample Positioning	1.360	1.360	normal (k=1)	1.0000	1.0000	1.360	1.360	10
A	Device Holder uncertainty	0.154	0.154	normal (k=1)	1.0000	1.0000	0.154	0.154	10
B	Phantom Uncertainty	4.000	4.000	Rectangular	1.7321	1.0000	2.309	2.309	∞
B	Drift of output power	5.000	5.000	Rectangular	1.7321	1.0000	2.887	2.887	∞
B	Liquid Conductivity (target value)	5.000	5.000	Rectangular	1.7321	0.6400	1.848	1.848	∞
A	Liquid Conductivity (measured value)	0.770	0.770	normal (k=1)	1.0000	0.6400	0.493	0.493	5
B	Liquid Permittivity (target value)	5.000	5.000	Rectangular	1.7321	0.6000	1.732	1.732	∞
A	Liquid Permittivity (measured value)	0.990	0.990	normal (k=1)	1.0000	0.6000	0.594	0.594	5
	Combined standard uncertainty			t-distribution			8.35	8.35	>500
	Expanded uncertainty			k = 1.96			16.37	16.37	>500

6. Device Under Test (DUT) Information

6.1. DUT Description

DUT Description:	The DUT is a digital microscope scanner that contains WLAN module with FCC ID: 2AQ5IOCUS1. It module supports WiFi 2.4 GHz (802.11b/g/n) and WiFi 5.0 GHz (a/n/ac) radio.		
Serial Number:	MGU-00001-000035	WiFi 2.4/5.3GHz	SAR Evaluation
	MGU-00001-000035	WiFi 2.4/5.3GHz	Conducted Power Measurements
Hardware Version Number:	A.02.02.02		
Software Version Number:	1.0.146		
Country of Manufacture:	Finland		
Device dimension	Overall (Height x Width x Depth): 180.0 mm x 180.0 mm x 190.0 mm		
Date of Receipt:	07 December 2018		
Antenna Type:	Internal integral		
Antenna Length:	Unknown		
Number of Antenna Positions:	Antenna 1 – WIFI – Transmit		1 fixed
	Antenna 2 – WIFI – Receive Only		1 fixed
Battery Type(s):	LiMn (Lithium Manganese) coin cell (ML2016)		

Note: There is no battery in the DUT to operate it, the LiMn (Lithium Manganese) coin cell (ML2016) is to keep the DUT real-time clock in time. The DUT is operated using main AC power supply.

6.2. Wireless Technologies

Wireless technologies	Frequency bands	Operating mode	Duty Cycle
Wi-Fi	2.4 GHz	802.11b 802.11g 802.11n (HT20)	100%
	5.0 GHz	802.11a 802.11n (HT20) 802.11n (HT40) 802.11ac (VHT20) 802.11ac (VHT40) 802.11ac (VHT80)	100%

Wi-Fi						
Band	Description					
	20 MHz BW Ch.#	Frq. (MHz)	40 MHz BW Ch.#	Frq. (MHz)	80 MHz BW Ch.#	Frq. (MHz)
Wi-Fi 2.4 GHz (802.11b/g/n)	1	2412.0	N/A			
	2	2417.0				
	6	2437.0				
	10	2457.0				
	11	2462.0				
	12	2467.0				
	13	2472.0				
Wi-Fi 5.0 GHz 5.2 (U-NII-1) (802.11a/n/ac)	36	5180.0	38	5190.0	-	
	40	5200.0	-		42	5210.0
	44	5220.0	46	5230.0		
	48	5240.0	-			
Wi-Fi 5.0 GHz 5.3 (U-NII-2A) (802.11a/n/ac)	52	5260.0	54	5270.0	-	
	56	5280.0	-		58	5290.0
	60	5300.0	62	5310.0		
	64	5320.0	-			
Wi-Fi 5.0 GHz 5.6 (U-NII-2C) (802.11a/n/ac)	100	5500.0	Not Supported			
	104	5520.0				
	108	5540.0				
	112	5560.0				
	116	5580.0				
	120	5600.0				
	124	5620.0				
	128	5640.0				
	132	5660.0				
	136	5680.0				
	140	5700.0				
	144	5720.0				
Wi-Fi 5.0 GHz 5.8 (U-NII-3) (802.11a/n/ac)	149	5745.0				
	153	5765.0				
	157	5785.0				
	161	5805.0				
	165	5825.0				

6.3. Nominal and Maximum Output power

Channel	Freq(MHz)	Jetson TX2(P3310)			
		Type	Target Power (dBm)		
			11b	11g	11n (HT20)
1	2412	A	14.00	14.00	12.00
2	2417	A	14.50	14.00	12.00
3	2422	A	14.50	14.00	12.00
4	2427	A	14.50	14.00	12.00
5	2432	A	14.50	14.00	12.00
6	2437	A	14.50	14.00	12.00
7	2442	A	14.50	14.00	12.00
8	2447	A	14.50	14.00	12.00
9	2452	A	14.50	14.00	12.00
10	2457	A	14.50	14.00	12.00
11	2462	A	14.50	13.00	12.00
12	2467	A	14.00	9.00	9.00
13	2472	A	10.50	5.50	5.50
14	2484	D	-	-	-

Channel	Freq(MHz)	Jetson TX2(P3310)				
		Type	Target Power (dBm)			
			11a	11n/ac(20)	11n/ac(40)	11ac(80)
36	5180	A	14.00	8.00		
38	5190	A			10.00	
40	5200	A	13.50	8.00		
42	5210	A				9.50
44	5220	A	13.50	8.00		
46	5230	A			10.00	
48	5240	A	13.50	8.00		
52	5260	DFS	14.50	10.00		
54	5270	P			12.00	
56	5280	P	14.50	10.00		
58	5290	P				11.00
60	5300	P	15.00	10.00		
62	5310	P			12.00	

Note:

1. Jetson TX2(P3310) have a tolerance of ± 1.5 dB

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
WLAN	Body / Extremity	0mm	Edge 1	< 25	Yes
			Edge 2	> 25	No

Note:

1. Prior to the testing the 'test positions' and 'separation distances' were agreed with FCC via KDB inquiry.

7.2. SAR Test Exclusion Consideration

Frequency Band	Configuration(s)	
	Body	Extremity
WLAN 2.4 GHz	No	No
WLAN 5.2 GHz	Yes[1]	Yes[1]
WLAN 5.3 GHz	No	No

Note:

1. As per KDB 248227, U-NII-2A was chosen for SAR evaluation as maximum rated power for U-NII-2A > U-NII-1. Based on the measurements obtained, SAR measurements on U-NII-1 band are not required as highest reported SAR from U-NII-2A band is ≤ 1.2 W/Kg.

8. Conducted Output Power Measurements

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

Note: Additional Conducted power measurements are performed on adjacent Channels having same or higher Max. rated power than the standard Channels (i.e., 1, 6, and 11).

8.1.1. Wi-Fi 802.11b (2.4 GHz) - SISO

		Avg Power (dBm)	
Channel Number	Frequency (MHz)	6Mbps	Operating Mode
		Body/Extremity	
1	2412	14.49	802.11b
2	2417	15.74	
6	2437	15.70	
11	2462	15.69	
12	2467	13.66	
13	2472	11.73	

Note: Conducted power measurements for 802.11g/n modes not required, as the Max. Rated Power for this mode was ≤ than 802.11b.

8.2. RF Output Average Power Measurement: Wi-Fi 5.0 GHz

8.2.1. Wi-Fi 802.11a/n/ac (5.0 GHz) – SISO Sub Band 2 (5.3 GHz U-NII-2A)

		Avg Power (dBm)	
Channel Number	Frequency (MHz)	13.5 Mbps	Operating Mode
		Body	
52	5260	15.72	802.11a
60	5300	16.40	
64	5320	16.43	

Note:

1. As per KDB 248227, U-NII-2A was chosen for SAR evaluation as maximum rated power for U-NII-1 < U-NII-2A. Based on the max target + tolerances declared, SAR measurements on U-NII-1 band are not required as highest reported SAR from U-NII-2A band is ≤ 1.2 W/Kg.
2. Conducted power measurements for 802.11n/ac HT20/ 802.11n/ac (HT40)/ 802.11ac VHT80 (SISO) modes not required, as the Max. Rated Power for these mode was ≤ than higher bandwidth modes 802.11a.

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. Reference Target SAR Values

The reference SAR values are obtained from the calibration certificate of system validation dipoles. The measured values are normalised to 1 Watt.

System Dipole	Serial No.	Cal. Date	Freq. (MHz)	Target SAR Values (mW/g)	
				1g/10g	Body
D2440V2	725	17 Sep 2018	2450	1g	50.80
				10g	23.80
D5GHzV2	1016	12 Feb 2018	5250	1g	73.9
				10g	20.7
			5600	1g	76.7
				10g	21.5
			5750	1g	73.5
				10g	20.5

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 manufacturer calibrated dipole SAR target. The internal limit is set to ±10%.

Site 60

System check 2450 Body

Date: 18/12/2018
Validation dipole and Serial Number: D2450V2 / SN: 725

Simulant	Frequency (MHz)	Room Temp (℃)	Liquid Temp (℃)	Parameters	Target Value	Measured Value	Deviation (%)	Limit (%)
Body	2450	22.0	22.5	**εr**	52.70	54.37	3.17	10.00
				Σ	1.95	1.92	-1.35	10.00
				1g (W/kg)	50.80	47.48	-6.52	10.00
				10g (W/kg)	23.80	21.74	-8.62	10.00

System check 5250 Body
Date: 18/12/2018
Validation dipole and Serial Number: D5GHzV2 / SN: 1016

Simulant	Frequency (MHz)	Room Temp (℃)	Liquid Temp (℃)	Parameters	Target Value	Measured Value	Deviation (%)	Limit (%)
Body	5250	22.0	22.5	**εr**	48.90	49.31	0.84	10.00
				Σ	5.36	5.35	-0.09	10.00
				1g (W/kg)	73.90	73.82	-0.10	10.00
				10g (W/kg)	20.70	20.75	0.24	10.00

10. Measurements, Examinations and Derived Results

10.1. General Comments

SAR test was performed in accordance with the criteria in KDB 248227.

In the 2.4 GHz band, separate SAR procedures were applied to DSSS and OFDM configurations to simplify DSSS test requirements. SAR test was evaluated on the mode with the highest rated power, which is in this case was 802.11b mode. OFDM mode was not evaluated because when the highest reported SAR for DSSS was adjusted by the ratio of OFDM to DSSS specified maximum output power, the adjusted SAR obtained was < 1.2W/kg.

In the 5.0 GHz band, the initial test configuration transmission mode was determined by the 802.11 configuration with the highest maximum output power specified for production units, including upper tune-up tolerance, in each standalone and aggregated frequency band. Since multiple channel bandwidth configuration modes have the same specified maximum output power, SAR test was performed on the largest channel bandwidth with the lowest order modulation.

For the cases where the power was not flat throughout the mode to test, additional runs were also performed on the next highest bandwidth provided the power response was identical. This was performed in order to assess the SAR response throughout the frequency band and establish that all worst cases have been evaluated.

Note: SAR Values represented by “-“ indicate no SAR peaks were detected during area scans.

10.2. Specific Absorption Rate - Test Results – Body Worn

10.2.1.WLAN 2.4 GHz - Body 1g

Max Reported 1g-SAR = 0.25 (W/kg)

					Power (dBm)		1g: SAR Results (W/kg)				
Mode	Dist. (mm)	EUT Position	Channel Number	Freq (MHz)	Tune Up Limit	Meas.	Meas. SAR Level	Reported SAR	Transmitting Antenna	Notes	Plot No.
802.11b	0	Edge 1	2	2417.0	16.00	15.74	0.23	0.25	Core 0	1	1
802.11b	0	Edge 1	6	2437.0	16.00	15.70	0.22	0.24	Core 0	-	-
802.11b	0	Edge 1	11	2462.0	16.00	15.85	0.21	0.22	Core 0	-	-

Note(s):

1. Test were performed on adjacent Channels having same or higher Max. rated power than the standard Channels (i.e., 1, 6, and 11).

10.2.2.WLAN 5.2GHz - Body 1g

As per KDB 248227, U-NII-1 was not chosen for SAR evaluation as maximum rated power for U-NII-1 < U-NII-2A. Based on the measurements obtained, SAR measurements on U-NII-1 band are not required as highest reported SAR from U-NII-2A band is ≤ 1.2 W/Kg.

10.2.3.WLAN 5.3GHz - Body 1g

Max Reported 1g-SAR = 0.24 (W/kg)

					Power (dBm)		1g: SAR Results (W/kg)				
Mode	Dist. (mm)	EUT Position	Channel Number	Freq (MHz)	Tune Up Limit	Meas.	Meas. SAR Level	Reported SAR	Transmitting Antenna	Notes	Plot No.
802.11a	0	Edge 1	60	5300.0	16.50	15.74	0.22	0.24	Core 0	-	2
802.11a	0	Edge 1	52	5260.0	16.00	15.70	0.19	0.20	Core 0	-	-
802.11a	0	Edge 1	64	5320.0	16.50	15.85	0.22	0.23	Core 0	-	-

Note(s):

10.3. Specific Absorption Rate - Test Results – Extremity

10.3.1.WLAN 2.4GHz - Extremity 10g
Max Reported 10g-SAR = 0.12 (W/kg)

					Power (dBm)		10g: SAR Results (W/kg)				
Mode	Dist. (mm)	EUT Position	Channel Number	Freq (MHz)	Tune Up Limit	Meas.	Meas. SAR Level	Reported SAR	Transmitting Antenna	Notes	Plot No.
802.11b	0	Edge 1	2	2417.0	16.00	15.74	0.12	0.12	Core 0	1	1
802.11b	0	Edge 1	6	2437.0	16.00	15.70	0.11	0.12	Core 0	-	-
802.11b	0	Edge 1	11	2462.0	16.00	15.85	0.11	0.11	Core 0	-	-

Note(s):

1. Test were performed on adjacent Channels having same or higher Max. rated power than the standard Channels (i.e., 1, 6, and 11).

10.3.2.WLAN 5.2GHz - Extremity 10g

As per KDB 248227, U-NII-1 was not chosen for SAR evaluation as maximum rated power for U-NII-1 < U-NII-2A. Based on the measurements obtained, SAR measurements on U-NII-1 band are not required as highest reported SAR from U-NII-2A band is ≤ 1.2 W/Kg.

10.3.3.WLAN 5.3GHz - Extremity 10g
Max Reported 10g-SAR = 0.09 (W/kg)

					Power (dBm)		10g: SAR Results (W/kg)				
Mode	Dist. (mm)	EUT Position	Channel Number	Freq (MHz)	Tune Up Limit	Meas.	Meas. SAR Level	Reported SAR	Transmitting Antenna	Notes	Plot No.
802.11a	0	Edge 1	60	5300.0	16.50	15.74	0.09	0.09	Core 0	-	2
802.11a	0	Edge 1	52	5260.0	16.00	15.70	0.07	0.08	Core 0	-	-
802.11a	0	Edge 1	64	5320.0	16.50	15.85	0.09	0.09	Core 0	-	-

Note(s):

10.4. 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.

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.

Note: SAR variability measurement not required as all measured 1g-SAR values are below 0.8 W/Kg.

11. Simultaneous Transmission Analysis

11.1. Highest Standalone Reported SAR

Individual Transmitter Evaluation per Band:

Exposure Configuration	Technology Band	Reported 1g - SAR (W/Kg)	Equipment Class	Highest Reported 1g - SAR (W/Kg)
BODY (Separation Distance 0mm)	WLAN 2.4 GHz	0.25	DTS	0.25
	WLAN 5.3 GHz	0.24	U-NII	0.24

Exposure Configuration	Technology Band	Reported 10g - SAR (W/Kg)	Equipment Class	Highest Reported 10g - SAR (W/Kg)
Extremity (Separation Distance 0mm)	WLAN 2.4 GHz	0.12	DTS	0.12
	WLAN 5.3 GHz	0.09	U-NII	0.09

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.

Note: As transmitting antenna does can simultaneously transmit, no simultaneous transmission analysis is required.