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

SAR EVALUATION REPORT

For

Luggage Tracker with Cellular and Bluetooth Radio

Model: VERSA1
FCC ID: 2ASXO-VERSA1
Contains FCC ID: 2ASXO-TMUE910GL

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1. Attestation of Test Results

Applicant Name	Versa Group BV					
Model	VERSA1					
Test Device is	A representative test sample					
Device category	Portable					
Date Tested	17 December 2019 to 21 February 2020					
ICNIRP Guidelines Limits for SAR Exposure Characteristics	General Population/Localised SAR (Head and trunk): 1g-SAR limit 1.6 W/kg					
The highest reported SAR values	RF Exposure Conditions		Equipment Class			
			Licensed	DTS WLAN 2.4 GHz	U-NII WLAN 5 GHz	DTS BTLE
	Standalone	Body	1.19 W/Kg	N/A	N/A	0.01 W/Kg
	Simultaneous Transmission	Body	1.20 W/Kg	N/A	N/A	1.20 W/Kg
Applicable Standards	FCC 47 CFR part 2 (2.1093) KDB publication					
Test Results	Pass					

UL International (UK) 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 International (UK) 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 International (UK) Ltd. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL International (UK) 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.

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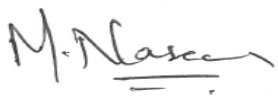
	
Naseer Mirza Lead Project Engineer UL	Masood Khan Test Engineer UL

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
KDB 941225 D01 3G SAR Procedures v03r01

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

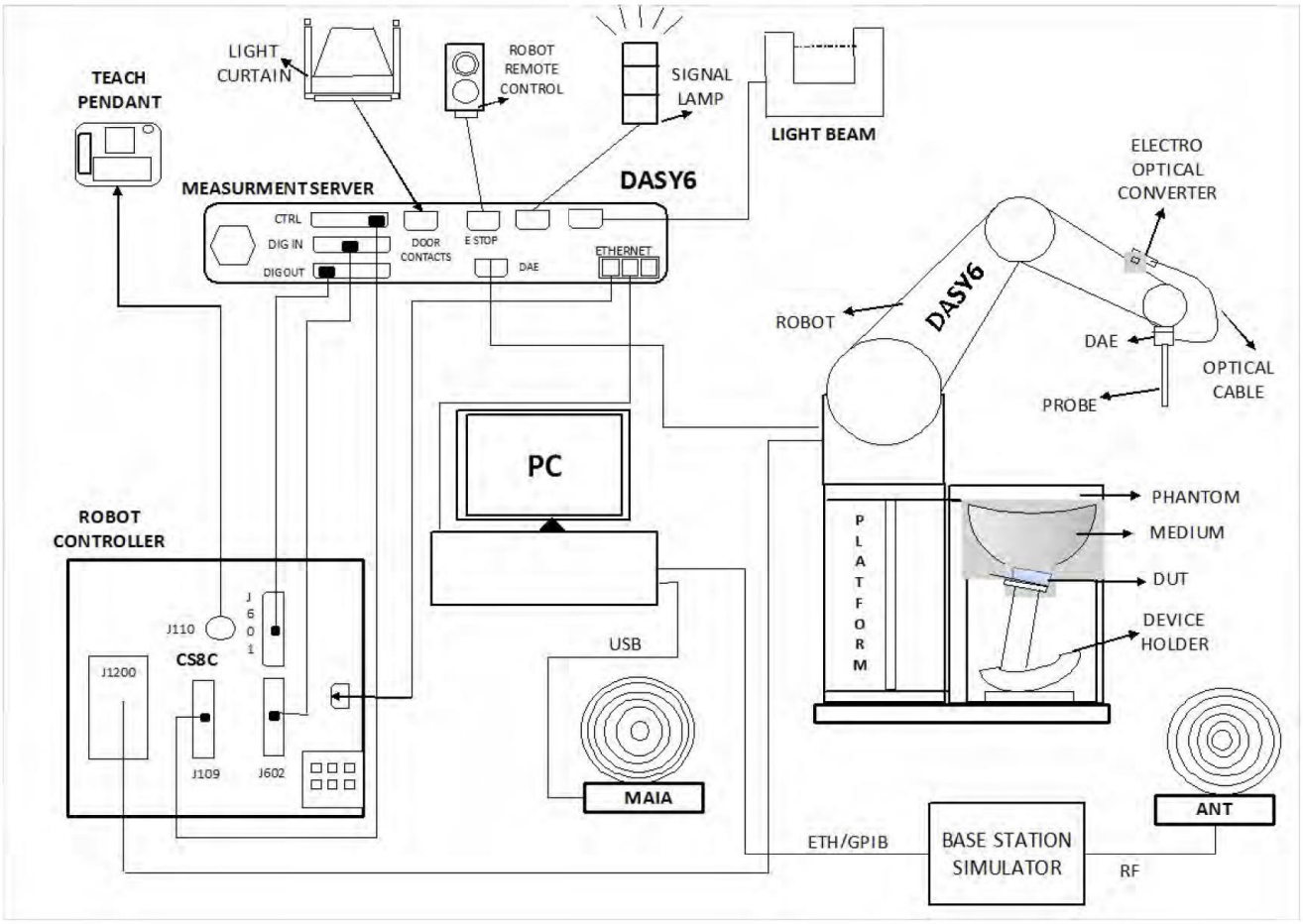
Horizon Unit 1-3, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, UK	Facility Type
SAR Lab 62	Controlled Environment Chamber

UL Verification Services Ltd, is accredited by UKAS (United Kingdom Accreditation Service), Laboratory UKAS Code 5722.

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 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)
PRE0178318	Data Acquisition Electronics	SPEAG	DAE4	1543	11 Mar 2019	12
A2110	Data Acquisition Electronics	SPEAG	DAE4	431	23 May 2019	12
A2201	Dipole	SPEAG	D900V2	035	18 Feb 2019	12
A1237	Dipole	SPEAG	D1900V2	540	14 Oct 2019	12
A1322	Dipole	SPEAG	D2450V2	725	08 Oct 2019	12
PRE0189107	Probe	SPEAG	ES3DV3	3358	21 Jan 2019	12
PRE0194808	Probe	SPEAG	EX3DV4	7549	05 Aug 2019	12
PRE0178119	Robot Power Supply	SPEAG	DASY52	F17/5ETWA1/C/01	Calibrated as part of system	-
PRE0178123	Robot Arm	Staubli	TX60 L	F17/5ETWA1/A/01	Calibrated as part of system	-
A2811	Body Handset Positioner	SPEAG	MD4HACV5	None	Calibrated as part of system	-
M1755	DAK Fluid Probe	SPEAG	SM DAK 040 CA	1089	Calibrated before use	-
M1855	Power Sensor	R & S	NRV-Z51	103246	18 Jan 2019	12
PRE0191906	PowerSource1	SPEAG	SE UMS 160 BA	4012	01 Jun 2019	12
M1015	Network Analyser	Agilent	8753ES	US39172406	25 Oct 2019	12
A2621	Digital Camera	Nikon	S3600	41010357	N/A	-
PRE0179684	Phantom	SPEAG	SAM Twin V8.0 Phantom	1946	Calibrated as part of system	-
PRE0141348	Phantom Support Structure	SPEAG	DASY6 Phantom Table	-	Calibrated as part of system	-
PRE0155857	RS Hygrometer	RS Components	408-6109	612Q19R(2)	20 Mar 2019	12

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):	F17/5ETWA1/A/01	
Reach:	800 mm	
Payload:	2.0 kg	
Control Unit:	CS8C	
Programming Language:	V+	
Data Acquisition Electronic (DAE) System		
Serial Number:	DAE4 SN: 431, 1543	
PC Controller		
PC:	HP EliteDesk800	
Operating System:	Windows 10	
Data Card:	DASY6 Measurement Servers	
Data Converter		
Features:	Signal Amplifier, multiplexer, A/D converted and control logic.	
Software:	DASY6 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:	SAM Phantom	
Shell Material:	Fibreglass	
Thickness:	2.0 ±0.1 mm	
E-Field Probe		
Model:	ES3DV3	EX3DV4
Serial No:	3358	7549
Construction:	Triangular core	Triangular core
Frequency:	10MHz to >4GHz	10MHz to >6GHz
Linearity:	±0.2 dB (30 MHz to 4 GHz)	±0.2 dB (30 MHz to 6 GHz)
Probe Length (mm):	337	337
Probe Diameter (mm):	10	10
Tip Length (mm):	10	9
Tip Diameter (mm):	4	2.5
Sensor X Offset (mm):	2	1
Sensor Y Offset (mm):	2	1
Sensor Z Offset (mm):	2	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 %	±28.54 %

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	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)	10.580	10.580	normal (k=1)	1.0000	0.5543	5.865	5.865	∞
B	Liquid Permittivity (measured value)	5.000	5.000	normal (k=1)	1.0000	0.2261	1.131	1.131	∞
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			14.27	14.27	63
	Expanded uncertainty			k = 2			28.54	28.54	63

6. Device Under Test (DUT) Information

6.1. DUT Description

DUT Description:	DUT is a Luggage Tracker that tracks baggage while travelling. Users can monitor their luggage just by placing the smart gadget inside the luggage. The device is specifically developed for use on aircraft. It switches to airplane mode automatically and doesn't have an on/off switch. Using Cellular , GPS, BT LE, and Mode-S, the Versa tracker gathers information about its whereabouts. This information is then forwarded to the server using only Cellular, after which the location of the tracker is determined. The location is then forwarded to the end-user who can find this information in the app or via messenger services. DUT supports GSM850, PCS1900, WCDMA 2, WCDMA 5 and Bluetooth bands.	
Sample Used:	SAR	IMEI No: 355000080584015 IMEI No: 355000080577548 IMEI No: 355000080569701 IMEI No: 355000080534218 IMEI No: 355000081622210 IMEI No: 355000080506299
	Conducted Power Measurements	IMEI No: 355000080579080 IMEI No: 355000080551295
Hardware Version Number:	1.8.0	
Software Version Number:	V1.1.0	
Country of Manufacture:	Poland	
Device dimension	131 mm x 71 mm x 16 mm	
Date of Receipt:	13 December 2019	

Antenna Type:	Internal integral	
Number of Antenna Positions:	WLAN/WPAN Antenna ~ Wi-Fi 2.4 GHz (Rx Only) / Bluetooth (Tx)	1 fixed
	WWAN ~ Cellular Antenna ~ GSM/WCDMA (Tx)	1 fixed
Battery Type(s):	Embedded Li-ion	

6.2. Wireless Technologies

Wireless Technologies	Frequency Bands	Operating Mode		Duty Cycle
GSM	850 1900	Voice (GMSK), GPRS (GMSK) EGPRS (8PSK)	GPRS Multi-Slot Class: ☐ Class 8 - 1 Up, 4 Down ☒ Class 10 - 2 Up, 4 Down ☐ Class 12 - 4 Up, 4 Down ☐ Class 33 - 4 Up, 5 Down ☐ DTM (Dual Transfer Mode)	GSM Voice: 12.5%; GPRS: 1 Slot: 12.5% 2 Slots: 25%
W-CDMA ☒ (FDD) ☐ (TDD)	Band 2 Band 5	WCDMA Rel. 99 (Voice & Data) HSDPA (Rel. 5) HSUPA (Rel. 6)		100%
Bluetooth	2.4 GHz	Version 4.2 LE		~84.8%

GSM			
Band	**Description**		
GSM850	Frequency Range: 880 - 915 MHz		
	Channel Number	Channel Description	Frequency (MHz)
	128	Low	824.2
	190	Middle	836.6
	251	High	848.8
PCS1900	Frequency Range: 1710 - 1785 MHz		
	Channel Number	Channel Description	Frequency (MHz)
	512	Low	1850.20
	661	Middle	1880.00
	810	High	1909.80

WCDMA			
Band	**Description**		
WCDMA FDD 2	Frequency Range: 1922 - 1978 MHz		
	Channel Number	Channel Description	Frequency (MHz)
	9262	Low	1852.4
	9400	Middle	1880.0
	9538	High	1907.6
WCDMA FDD 5	Frequency Range: 882 - 913 MHz		
	Channel Number	Channel Description	Frequency (MHz)
	4132	Low	826.4
	4183	Middle	836.6
	4233	High	846.6

Wireless Technologies (Continued):

Bluetooth			
Specification	**Description**		
LE	Frequency Range: 2404 - 2478 MHz		
	Channel Number	Channel Description	Frequency (MHz)
	1	Low	2404.0
	19	Middle	2440.0
	38	High	2478.0

6.3.Nominal and Maximum Output power:

Cellular

Technology/Band	Mode	Max Target power (dBm)	Tolerances (±) (dB)
EGSM 900	1Tx uplink (GMSK)	32.5	-1.0 / +0.5
	2Tx uplink (GMSK)	32.5	-1.0 / +0.5
	1Tx uplink (8PSK)	27.0	-1.0 / +0.5
	2Tx uplink (8PSK)	27.0	-1.0 / +0.5
PCS 1900	1Tx uplink (GMSK)	28.5	-1.0 / +0.5
	2Tx uplink (GMSK)	28.5	-1.0 / +0.5
	1Tx uplink (8PSK)	26.0	-1.0 / +0.5
	2Tx uplink (8PSK)	26.0	-1.0 / +0.5
WCDMA FDD 2	RMC Mode	22.0	-1.0 / +0.5
	HSDPA Sub-Test 1 Mode	22.0	-1.0 / +0.5
	HSDPA Sub-Test 2 Mode	22.0	-1.0 / +0.5
	HSDPA Sub-Test 3 Mode	21.5	-1.0 / +0.5
	HSDPA Sub-Test 4 Mode	21.5	-1.0 / +0.5
	HSUPA Sub-Test 1 Mode	22.0	-1.0 / +0.5
	HSUPA Sub-Test 2 Mode	21.0	-1.5 / +1.5
	HSUPA Sub-Test 3 Mode	21.0	-1.0 / +0.5
	HSUPA Sub-Test 4 Mode	21.0	-1.5 / +1.5
	HSUPA Sub-Test 5 Mode	22.0	-1.0 / +0.5
WCDMA FDD 5	RMC Mode	23.0	-1.0 / +0.5
	HSDPA Sub-Test 1 Mode	23.0	-1.0 / +0.5
	HSDPA Sub-Test 2 Mode	23.0	-1.0 / +0.5
	HSDPA Sub-Test 3 Mode	22.5	-1.0 / +0.5
	HSDPA Sub-Test 4 Mode	22.5	-1.0 / +0.5
	HSUPA Sub-Test 1 Mode	23.0	-1.0 / +0.5
	HSUPA Sub-Test 2 Mode	21.5	-1.5 / +1.5
	HSUPA Sub-Test 3 Mode	22.0	-1.0 / +0.5
	HSUPA Sub-Test 4 Mode	21.5	-1.5 / +1.5
	HSUPA Sub-Test 5 Mode	23.0	-1.0 / +0.5

Bluetooth

RF Air interface	Packet Length	Channel	Target + Upper Tolerances (dBm)
Bluetooth (BLE)	255	ALL	10.00
	255	ALL	10.00
	255	ALL	10.00

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
WWAN ~ Cellular	Body	10mm	Front	< 25	Yes
			Back	< 25	Yes
			Edge 1 (Top)	> 25	No
			Edge 2 (Right)	< 25	Yes
			Edge 3 (Bottom)	< 25	Yes
			Edge 4 (Left)	< 25	Yes
WPAN ~ (BT 2.4 GHz)	Body	10mm	Front	< 25	Yes
			Back	< 25	Yes
			Edge 1 (Top)	> 25	No
			Edge 2 (Right)	> 25	No
			Edge 3 (Bottom)	< 25	Yes
			Edge 4 (Left)	< 25	Yes

Note:

1. The Antenna to edge separation distances are indicated in the 'Antenna Schematics' located in Section 12.1 of this report.
2. Prior to the testing, FCC was contacted for test approach and agreed 10mm separation distance for body-worn configuration.

7.2. SAR Test Exclusion Consideration

Frequency Band	Configuration(s)
	Body
Bluetooth	Yes[3]

Note:

1. As per KDB 447498, the frequency Bands with Rated Power including Upper tolerance, which qualify for **Standalone SAR 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.
3. Bluetooth band qualify for test exemption. For accurate SAR simultaneous transmission analysis purpose, standalone SAR test was performed.

8. Conducted Output Power Measurements

8.1.RF Output Average Power Measurement: GSM

GPRS (GMSK) – Coding Scheme: CS1

Band	Channel	Frequency (MHz)	Avg Power (dBm)		Frame Power (dBm)	
			1 Uplink	2 Uplinks	1 Uplink	2 Uplinks
GSM850	128	824.2	31.49	31.40	22.46	25.38
	190	836.6	31.42	31.40	22.39	25.38
	251	848.8	31.40	31.35	22.37	25.33
PCS1900	512	1850.2	28.56	28.56	19.53	22.54
	661	1880.0	28.67	28.68	19.64	22.66
	810	1909.8	28.62	28.62	19.59	22.60

EDGE (GMSK) – Coding Scheme: MCS4

Band	Channel	Frequency (MHz)	Avg Power (dBm)		Frame Power (dBm)	
			1 Uplink	2 Uplinks	1 Uplink	2 Uplinks
GSM850	128	824.2	31.49	31.40	22.46	25.38
	190	836.6	31.42	31.40	22.39	25.38
	251	848.8	31.40	31.35	22.37	25.33
PCS1900	512	1850.2	28.56	28.56	19.53	22.54
	661	1880.0	28.67	28.68	19.64	22.66
	810	1909.8	28.62	28.62	19.59	22.60

EDGE (8PSK) – Coding Scheme: MCS9

Band	Channel	Frequency (MHz)	Avg Power (dBm)		Frame Power (dBm)	
			1 Uplink	2 Uplinks	1 Uplink	2 Uplinks
GSM850	128	824.2	26.25	26.18	17.22	20.16
	190	836.6	26.20	26.18	17.17	20.16
	251	848.8	26.23	26.23	17.20	20.21
PCS1900	512	1850.2	24.72	24.69	15.69	18.67
	661	1880.0	24.83	24.75	15.80	18.73
	810	1909.8	24.80	24.73	15.77	18.71

8.2.RF Output Average Power Measurement: WCDMA

8.2.1.RMC / HSDPA / HSUPA

Modes			HSDPA				HSUPA					WCDMA
Sets			1	2	3	4	1	2	3	4	5	RMC 12.2kbps
Band	Channel	Frequency	Power [dBm]	Power [dBm]	Power [dBm]	Power [dBm]	Power [dBm]	Power [dBm]	Power [dBm]	Power [dBm]	Power [dBm]	Power [dBm]
Band 2 (1900 MHz)	9262	1852.4	22.27	21.31	21.07	20.81	21.59	22.09	21.07	22.18	21.01	22.41
	9400	1880.0	22.24	21.17	21.00	20.75	21.50	21.95	20.89	22.11	21.25	22.30
	9538	1907.6	22.43	21.42	21.21	20.94	21.73	22.19	21.21	22.35	21.25	22.50
Band 5 (850 MHz)	4132	826.4	22.89	21.88	21.64	21.38	22.15	22.67	21.64	22.74	21.81	23.00
	4183	836.6	22.66	21.62	21.38	21.12	21.89	22.41	21.37	22.56	22.07	22.76
	4233	846.6	22.56	21.54	21.30	21.06	21.79	22.30	21.35	22.47	21.95	22.67
ßc			2	12	15	15	11	6	15	2	15	
ßd			15	15	8	4	15	15	9	15	15	
ΔACK, ΔNACK, ΔCQI			8	8	8	8	8	8	8	8	8	
AGV			-	-	-	-	20	12	15	17	21	

8.3. RF Output Average Power Measurement: Bluetooth

8.3.1. Bluetooth(2.4 GHz)

		Avg Power (dBm)	
Channel Number	Frequency (MHz)	1Mbps	Operating Mode
		Body	
0	2404	8.90	BLE
18	2442	9.00	
36	2478	9.00	

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	52.3	0.76	61.9	0.80
300	45.3	0.87	58.2	0.92
450	43.5	0.87	56.7	0.94
750	41.9	0.89	-	-
835	41.5	0.90	55.2	0.97
900	41.5	0.97	55.0	1.05
915	41.5	0.98	55.0	1.06
1450	40.5	1.20	54.0	1.30
1500	40.4	1.23	-	-
1610	40.3	1.29	53.8	1.40
1640	40.2	1.31	-	-
1750	40.1	1.37	-	-
1800	40	1.40	53.3	1.52
1900	40	1.40	53.3	1.52
2000	40	1.40	53.3	1.52
2100	39.8	1.49	-	-
2300	39.5	1.67	-	-
2450	39.2	1.80	52.7	1.95
2600	39	1.96	-	-
3000	38.5	2.40	52.0	2.73
3500	37.9	2.91	-	-
4000	37.4	3.43	-	-
4500	36.8	3.94	-	-
5000	36.2	4.45	49.3	5.07
5100	36.1	4.55	49.1	5.18
5200	36.0	4.66	49.0	5.30
5250	35.9	4.71	48.9	5.36
5300	35.9	4.76	48.9	5.42
5400	35.8	4.86	48.7	5.53
5500	35.6	4.96	48.6	5.65
5600	35.5	5.07	48.5	5.77
5700	35.4	5.17	48.3	5.88
5750	35.4	5.22	48.3	5.94
5800	35.3	5.27	48.2	6.00
6000	35.1	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 (W/kg)	
				1g/10g	Head
D900V2	035	18 Feb 2019	900	1g	11.00
				10g	7.06
D1900V2	540	14 Oct 2019	1900	1g	40.10
				10g	20.90
D2450V2	725	08 Oct 2019	2450	1g	50.70
				10g	23.80

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

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System check 900 Head

Date: 17/12/2019
Validation dipole and Serial Number: D900V2 / SN: 035

Simulant	Frequency (MHz)	Room Temp (℃)	Liquid Temp (℃)	Parameters	Target Value	Measured Value	Deviation (%)	Limit (%)
Head	900	21.0	18.5	εr	41.50	41.74	0.57	10.00
				Σ	0.97	0.93	-4.13	10.00
				1g (W/kg)	10.90	10.55	-3.16	10.00
				10g (W/kg)	6.99	6.80	-2.66	10.00

System check 1900 Head

Date: 17/02/2020
Validation dipole and Serial Number: D1900V2 / SN: 540

Simulant	Frequency (MHz)	Room Temp (℃)	Liquid Temp (℃)	Parameters	Target Value	Measured Value	Deviation (%)	Limit (%)
Head	1900	20.1	19.7	εr	40.00	39.77	-0.58	10.00
				Σ	1.40	1.48	5.68	10.00
				1g (W/kg)	39.70	42.29	6.54	10.00
				10g (W/kg)	20.50	21.74	6.08	10.00

Date: 21/02/2020
Validation dipole and Serial Number: D1900V2 / SN: 540

Simulant	Frequency (MHz)	Room Temp (℃)	Liquid Temp (℃)	Parameters	Target Value	Measured Value	Deviation (%)	Limit (%)
Head	1900	20.4	21.0	εr	40.00	38.96	-2.61	10.00
				Σ	1.40	1.50	7.43	10.00
				1g (W/kg)	39.70	41.90	5.54	10.00
				10g (W/kg)	20.50	21.74	6.08	10.00

System check 2450 Head

Date: 10/01/2020
Validation dipole and Serial Number: D2450V2 / SN: 725

Simulant	Frequency (MHz)	Room Temp (℃)	Liquid Temp (℃)	Parameters	Target Value	Measured Value	Deviation (%)	Limit (%)
Head	2450	22.0	21.2	εr	39.20	38.87	-0.85	10.00
				Σ	1.80	1.87	3.88	10.00
				1g (W/kg)	52.40	52.27	-0.23	10.00
				10g (W/kg)	24.00	24.34	1.42	10.00

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 and body and extremity.

10. Measurements, Examinations and Derived Results

10.1. General Comments

SAR test was performed in accordance with the criteria in KDB 248227 D01 and KDB 941225 D01.

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 and body and extremity.

10.2. Specific Absorption Rate - Test Results - Cellular

10.2.1. GSM850 Body 1g

Max Reported SAR = 0.66 (W/kg)

					For LTE Only		Power (dBm)		1g: SAR Results (W/kg)			
Mode	Dist. (mm)	EUT Position	Channel Number	Freq (MHz)	#RB	Start RB	Tune Up Limit	Meas.	Meas. SAR Level	Reported SAR	Notes	Plot No.
2 TX	10	Front	190	836.6	N/A	N/A	33.00	31.40	0.30	0.44	-	-
2 TX	10	Back	190	836.6	N/A	N/A	33.00	31.40	0.37	0.53	-	-
2 TX	10	Edge 2	190	836.6	N/A	N/A	33.00	31.40	0.18	0.26	-	-
2 TX	10	Edge 3	190	836.6	N/A	N/A	33.00	31.40	0.04	0.06	-	-
2 TX	10	Edge 4	190	836.6	N/A	N/A	33.00	31.40	0.10	0.15	-	-
2 TX	10	Back	128	824.2	N/A	N/A	33.00	31.40	0.31	0.45	-	-
2 TX	10	Back	251	848.8	N/A	N/A	33.00	31.35	0.45	0.66	-	001

Note(s):

10.2.2. PCS1900 Body 1g

Max Reported SAR = 1.06 (W/kg)

					For LTE Only		Power (dBm)		1g: SAR Results (W/kg)			
Mode	Dist. (mm)	EUT Position	Channel Number	Freq (MHz)	#RB	Start RB	Tune Up Limit	Meas.	Meas. SAR Level	Reported SAR	Notes	Plot No.
2 TX	10	Front	661	1880.0	N/A	N/A	29.00	28.68	0.86	0.93	-	-
2 TX	10	Front	512	1850.0	N/A	N/A	29.00	28.56	0.88	0.97	-	-
2 TX	10	Front	810	1909.8	N/A	N/A	29.00	28.62	0.76	0.83	-	-
2 TX	10	Back	661	1880.0	N/A	N/A	29.00	28.68	0.94	1.01	-	-
2 TX	10	Back	512	1850.0	N/A	N/A	29.00	28.56	0.96	1.06	-	002
2 TX	10	Back	810	1909.8	N/A	N/A	29.00	28.62	0.83	0.91	-	-
2 TX	10	Edge 2	661	1880.0	N/A	N/A	29.00	28.68	0.32	0.35	-	-
2 TX	10	Edge 3	661	1880.0	N/A	N/A	29.00	28.68	0.69	0.74	-	-
2 TX	10	Edge 3	512	1850.0	N/A	N/A	29.00	28.56	0.69	0.76	-	-
2 TX	10	Edge 3	810	1909.8	N/A	N/A	29.00	28.62	0.65	0.70	-	-
2 TX	10	Edge 4	661	1880.0	N/A	N/A	29.00	28.68	0.17	0.18	-	-

Note(s):

10.2.3. WCDMA 2 Body 1g
Max Reported SAR = 1.19 (W/kg)

					For LTE Only		Power (dBm)		1g: SAR Results (W/kg)			
Mode	Dist. (mm)	EUT Position	Channel Number	Freq (MHz)	#RB	Start RB	Tune Up Limit	Meas.	Meas. SAR Level	Reported SAR	Notes	Plot No.
RMC	10	Front	9538	1907.6	N/A	N/A	22.50	22.50	0.85	0.85	-	-
RMC	10	Front	9262	1852.4	N/A	N/A	22.50	22.41	0.98	1.00	-	-
RMC	10	Front	9400	1880.0	N/A	N/A	22.50	22.30	0.94	0.98	-	-
RMC	10	Back	9538	1907.6	N/A	N/A	22.50	22.50	1.00	1.00	-	-
RMC	10	Back	9262	1852.4	N/A	N/A	22.50	22.41	1.17	1.19	-	003
RMC	10	Back	9400	1880.0	N/A	N/A	22.50	22.30	1.05	1.10	-	-
RMC	10	Edge 2	9538	1907.6	N/A	N/A	22.50	22.50	0.47	0.47	-	-
RMC	10	Edge 3	9538	1907.6	N/A	N/A	22.50	22.50	0.87	0.87	-	-
RMC	10	Edge 3	9262	1852.4	N/A	N/A	22.50	22.41	0.74	0.76	-	-
RMC	10	Edge 3	9400	1880.0	N/A	N/A	22.50	22.30	0.79	0.83	-	-
RMC	10	Edge 4	9538	1907.6	N/A	N/A	22.50	22.50	0.20	0.20	-	-

Note(s):

10.2.4. WCDMA 5 Body 1g
Max Reported SAR = 0.46 (W/kg)

					For LTE Only		Power (dBm)		1g: SAR Results (W/kg)			
Mode	Dist. (mm)	EUT Position	Channel Number	Freq (MHz)	#RB	Start RB	Tune Up Limit	Meas.	Meas. SAR Level	Reported SAR	Notes	Plot No.
RMC	10	Front	4132	826.4	N/A	N/A	23.50	23.00	0.22	0.24	-	-
RMC	10	Back	4132	826.4	N/A	N/A	23.50	23.00	0.27	0.31	-	-
RMC	10	Back	4183	836.6	N/A	N/A	23.50	22.76	0.32	0.37	-	-
RMC	10	Back	4233	846.6	N/A	N/A	23.50	22.67	0.38	0.46	-	004
RMC	10	Edge 2	4132	826.4	N/A	N/A	23.50	23.00	0.15	0.17	-	-
RMC	10	Edge 3	4132	826.4	N/A	N/A	23.50	23.00	0.04	0.04	-	-
RMC	10	Edge 4	4132	826.4	N/A	N/A	23.50	23.00	0.08	0.09	-	-

Note(s):

10.3. Specific Absorption Rate - Test Results – WPAN

10.3.1. Bluetooth Body 1g

Max Reported SAR = 0.01 (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.
LE	10	Front	18	2442.0	10.00	9.00	0.00	0.00	Ant 2	-	-
LE	10	Back	18	2442.0	10.00	9.00	0.00	0.00	Ant 2	-	-
LE	10	Edge 3	18	2442.0	10.00	9.00	0.00	0.00	Ant 2	-	-
LE	10	Edge 4	18	2442.0	10.00	9.00	0.01	0.01	Ant 2	-	006
LE	10	Edge 4	0	2404.0	10.00	8.90	0.01	0.01	Ant 2	-	-
LE	10	Edge 4	36	2478.0	10.00	9.00	0.00	0.00	Ant 2	-	-

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.

Exposure Configuration	Technology Band	Measured 1g -SAR (W/Kg)	Equipment Class	Max Meas. Source base Avg Power [dBm]	Ratio of Largest to Smallest SAR Measured
BODY (Separation Distance 0mm)	PCS1900	1.06	PCE	29.00	1.02
		1.04			
	WCDMA 2	1.19		22.41	1.08
		1.10			

11.Highest Standalone and Simultaneous Transmission analysis

11.1. Highest Standalone SAR

Individual Transmitter Evaluation per Band: Cellular

Exposure Configuration	Technology Band	Reported 1g - SAR (W/Kg)	Equipment Class	Highest Reported 1g SAR (W/Kg)
BODY-WORN (Separation Distance 10mm)	GSM850	0.66	PCE	1.19
	PCS1900	1.06		
	WCDMA FDD 2	1.19		
	WCDMA FDD 5	0.46		

Individual Transmitter Evaluation per Band: Bluetooth

Exposure Configuration	Technology Band	Reported 1g - SAR (W/Kg)	Equipment Class	Highest Reported 1g SAR (W/Kg)
BODY-WORN (Separation Distance 10mm)	Bluetooth	0.01	DSS	0.01

11.2. Simultaneous Transmission Analysis

Simultaneous transmission SAR test exclusion 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:

1. Cellular + BT

Worst Case Simultaneous Transmission SAR Analysis:

Exposure Configuration	Case(s)	Technology Band	Highest Reported 1g SAR (W/kg)	Equipment Class	Highest Reported Sum-SAR 1g-SAR (W/kg)
Bodyworn (Separation Distance 10 mm)	1	Cellular	1.19	PCE	1.20
		Bluetooth	0.01	DSS	