

FCC SAR Test Report

Equipment : Lytro Digital Camera
Brand Name : Lytro
Model No. : B5
FCC ID : ZMQBZ
Standard : FCC 47 CFR Part 2 (2.1093)
ANSI/IEEE C95.1-1992
IEEE 1528-2003
Applicant : Lytro, Inc.
1300 Terra Bella Avenue,
Mountain View, CA 94043 USA
Manufacturer : Qisda Corporation
157 Shan-Ying Road,
Gueishan Taoyuan 333, Taiwan

The product sample received on May 19, 2014 and completely tested on Jun. 25, 2014. We, SPORTON INTERNATIONAL INC., would like to declare that the tested sample has been evaluated in accordance with the procedures and shown the compliance with the applicable technical standards.

The test results in this report apply exclusively to the tested model / sample. Without written approval of SPORTON INTERNATIONAL INC., the test report shall not be reproduced except in full.

Reviewed by:

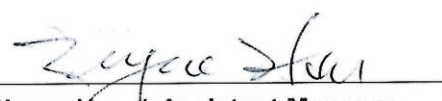

Wayne Hsu / Assistant Manager



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APPENDIX A. Plots of System Performance Check

APPENDIX B. Plots of SAR Measurement

Appendix C. DASY Calibration Certificate

Appendix D. Test setup Photos

Revision History

[illegible]

1 Statement of Compliance

The maximum results of Specific Absorption Rate (SAR) found during testing as follows.

Exposure Position	Frequency Band	Reported 1g SAR (W/kg)	Equipment Class	Highest Reported 1g SAR (W/kg)
Body	WLAN5.2GHz Band	0.35	NII	0.35
	WLAN5.3GHz Band	0.10		
	WLAN5.6GHz Band	0.01		
	WLAN5.8GHz Band	0.03	DTS	0.33
	WLAN2.4GHz Band	0.33		

This device is in compliance with Specific Absorption Rate (SAR) for general population/uncontrolled exposure limits (1.6 W/kg) specified in FCC 47 CFR part 2 (2.1093) and ANSI/IEEE C95.1-1992, and had been tested in accordance with the measurement methods and procedures specified in IEEE 1528-2003.

1.1 Guidance Standard

The Specific Absorption Rate (SAR) testing specification, method, and procedure for this device is in accordance with the following standards:

- FCC 47 CFR Part 2 (2.1093)
- ANSI/IEEE C95.1-1992
- IEEE 1528-2003
- FCC KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r03
- FCC KDB 865664 D02 SAR Reporting v01r01
- FCC KDB 447498 D01 General RF Exposure Guidance v05r02
- FCC KDB 248227 D01 SAR meas for 802 11abg v01r02

1.2 Testing Location Information

Testing Location	
HWA YA	ADD : No. 52, Hwa Ya 1 st Rd., Hwa Ya Technology Park, Kwei-Shan Hsiang, Tao Yuan Hsien, Taiwan, R.O.C. TEL : 886-3-327-3456 FAX : 886-3-327-0973

2 Equipment Under Test (EUT)

2.1 General Information

Product Feature & Specification	
Equipment Name	Lytro Digital Camera
Brand Name	Lytro
Model Name	B5
FCC ID	ZMQBZ
Frequency Range	WLAN 5.2GHz Band: 5150 MHz ~ 5250 MHz WLAN 5.3GHz Band: 5250 MHz ~ 5350 MHz WLAN 5.6GHz Band: 5470 MHz ~ 5725 MHz WLAN 5.8GHz Band: 5725 MHz ~ 5850 MHz WLAN 2.4GHz Band: 2400 MHz ~ 2483.5 MHz Bluetooth: 2400 MHz ~ 2483.5 MHz
EUT Stage	Identical Prototype

Specification of Accessory		
Battery 1	Brand Name	Lytro
	Model Name	B2
	Power Rating	3.7V, 3760mAh, 13.9Wh

2.2 Maximum Tune-up Limit

Band / Frequency (MHz)	IEEE 802.11 Average Power (dBm)			
	11b	11g	HT20	HT40
WLAN 2.4GHz Band	19.50	14.50	13.50	14.00

Band / Frequency (MHz)	IEEE 802.11 Average Power (dBm)					
	a	HT20	HT40	VHT20	VHT40	VHT80
WLAN 5.2GHz Band	14.50	13.50	13.50	13.50	13.50	12.50
WLAN 5.3GHz Band	15.50	14.50	14.50	15.00	15.00	14.50
WLAN 5.6GHz Band	15.50	15.00	15.00	14.50	15.00	15.00
WLAN 5.8GHz Band	15.50	15.00	14.50	15.00	14.50	14.50

3 RF Exposure Limits

3.1 Uncontrolled Environment

Uncontrolled Environments are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

3.2 Controlled Environment

Controlled Environments are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation). In general, occupational/controlled exposure limits are applicable to situations in which persons are exposed as a consequence of their employment, who have been made fully aware of the potential for exposure and can exercise control over their exposure. The exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

Limits for Occupational/Controlled Exposure (W/kg)

Whole-Body	Partial-Body	Hands, Wrists, Feet and Ankles
14.02	13.20	13.13

Limits for General Population/Uncontrolled Exposure (W/kg)

Whole-Body	Partial-Body	Hands, Wrists, Feet and Ankles
0.08	1.6	4.0

1. Whole-Body SAR is averaged over the entire body, partial-body SAR is averaged over any 1gram of tissue defined as a tissue volume in the shape of a cube. SAR for hands, wrists, feet and ankles is averaged over any 10 grams of tissue defined as a tissue volume in the shape of a cube.

4 Specific Absorption Rate (SAR)

4.1 Introduction

SAR is related to the rate at which energy is absorbed per unit mass in an object exposed to a radio field. The SAR distribution in a biological body is complicated and is usually carried out by experimental techniques or numerical modeling. The standard recommends limits for two tiers of groups, occupational/controlled and general population/uncontrolled, based on a person's awareness and ability to exercise control over his or her exposure. In general, occupational/controlled exposure limits are higher than the limits for general population/uncontrolled.

4.2 SAR Definition

The SAR definition is the time derivative (rate) of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dv) of a given density (ρ). The equation description is as below:

$$\text{SAR} = \frac{d}{dt} \left(\frac{dW}{dm} \right) = \frac{d}{dt} \left(\frac{dW}{\rho dv} \right)$$

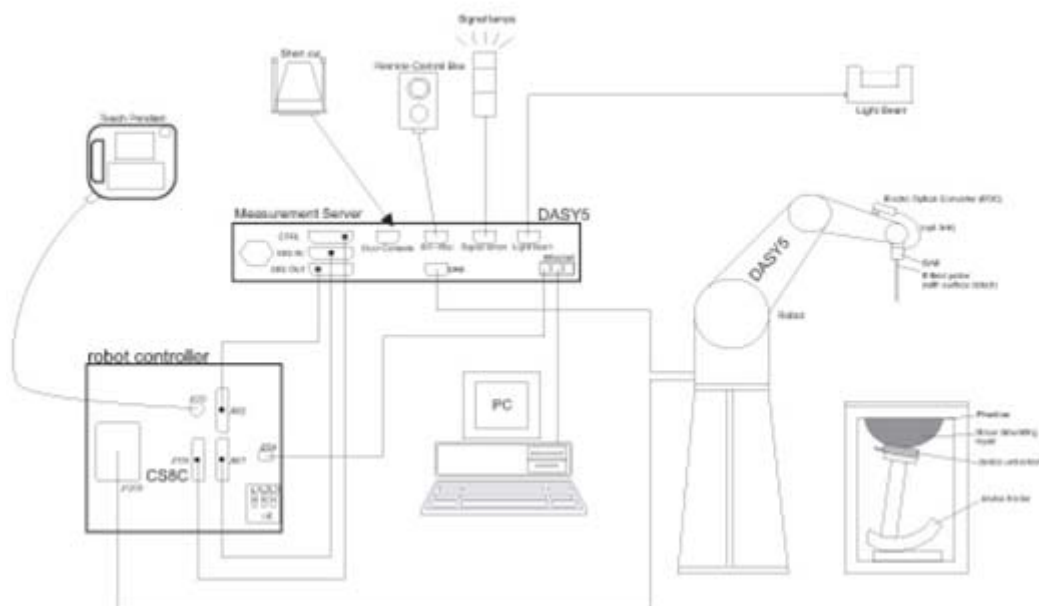
SAR is expressed in units of Watts per kilogram (W/kg)

$$\text{SAR} = \frac{\sigma |E|^2}{\rho}$$

Where: σ is the conductivity of the tissue, ρ is the mass density of the tissue and E is the RMS electrical field strength.

5 System Description and Setup

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 WinXP or Win7 and the DASY5 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.

6 Measurement Procedures

The measurement procedures are as follows:

<Conducted power measurement>

- (a) For WWAN power measurement, use base station simulator to configure EUT WWAN transmission in conducted connection with RF cable, at maximum power in each supported wireless interface and frequency band.
- (b) Read the WWAN RF power level from the base station simulator.
- (c) For WLAN/BT power measurement, use engineering software to configure EUT WLAN/BT continuously transmission, at maximum RF power in each supported wireless interface and frequency band
- (d) Connect EUT RF port through RF cable to the power meter, and measure WLAN/BT output power

<SAR measurement>

- (a) Use base station simulator to configure EUT WWAN transmission in radiated connection, and engineering software to configure EUT WLAN/BT continuously transmission, at maximum RF power, in the highest power channel.
- (b) Place the EUT in the positions as Appendix D demonstrates.
- (c) Set scan area, grid size and other setting on the DASY software.
- (d) Measure SAR results for the highest power channel on each testing position.
- (e) Find out the largest SAR result on these testing positions of each band
- (f) Measure SAR results for other channels in worst SAR testing position if the reported SAR of highest power channel is larger than 0.8 W/kg

According to the test standard, the recommended procedure for assessing the peak spatial-average SAR value consists of the following steps:

- (a) Power reference measurement
- (b) Area scan
- (c) Zoom scan
- (d) Power drift measurement

6.1 Spatial Peak SAR Evaluation

The procedure for spatial peak SAR evaluation has been implemented according to the test standard. It can be conducted for 1g and 10g, as well as for user-specific masses. The DASY software includes all numerical procedures necessary to evaluate the spatial peak SAR value.

The base for the evaluation is a "cube" measurement. The measured volume must include the 1g and 10g cubes with the highest averaged SAR values. For that purpose, the center of the measured volume is aligned to the interpolated peak SAR value of a previously performed area scan.

The entire evaluation of the spatial peak values is performed within the post-processing engine (SEMCAD). The system always gives the maximum values for the 1g and 10g cubes. The algorithm to find the cube with highest averaged SAR is divided into the following stages:

- (a) Extraction of the measured data (grid and values) from the Zoom Scan
- (g) Calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters)
- (b) Generation of a high-resolution mesh within the measured volume
- (c) Interpolation of all measured values from the measurement grid to the high-resolution grid
- (d) Extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface
- (e) Calculation of the averaged SAR within masses of 1g and 10g

6.2 Power Reference Measurement

The Power Reference Measurement and Power Drift Measurements are for monitoring the power drift of the device under test in the batch process. The minimum distance of probe sensors to surface determines the closest measurement point to phantom surface. This distance cannot be smaller than the distance of sensor calibration points to probe tip as defined in the probe properties.

6.3 Area Scan

The area scan is used as a fast scan in two dimensions to find the area of high field values, before doing a fine measurement around the hot spot. The sophisticated interpolation routines implemented in DASY software can find the maximum found in the scanned area, within a range of the global maximum. The range (in dB) is specified in the standards for compliance testing. For example, a 2 dB range is required in IEEE standard 1528 and IEC 62209 standards, whereby 3 dB is a requirement when compliance is assessed in accordance with the ARIB standard (Japan), if only one zoom scan follows the area scan, then only the absolute maximum will be taken as reference. For cases where multiple maximums are detected, the number of zoom scans has to be increased accordingly.

Area scan parameters extracted from FCC KDB 865664 D01v01r03 SAR measurement 100 MHz to 6 GHz v01r01.

	≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	5 ± 1 mm	$\frac{1}{2} \cdot \delta \cdot \ln(2) \pm 0.5$ mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location	$30^\circ \pm 1^\circ$	$20^\circ \pm 1^\circ$
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 \leq the corresponding x or y dimension of the test device with at least one measurement point on the test device.	

6.4 Zoom Scan

Zoom scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1 gram and 10 gram of simulated tissue. The zoom scan measures points (refer to table below) within a cube whose base faces are centered on the maxima found in a preceding area scan job within the same procedure. When the measurement is done, the zoom scan evaluates the averaged SAR for 1 gram and 10 gram and displays these values next to the job's label.

Zoom scan parameters extracted from FCC KDB 865664 D01v01r03 SAR measurement 100 MHz to 6 GHz v01r01.

			≤ 3 GHz	> 3 GHz
Maximum zoom scan spatial resolution: $\Delta x_{\text{Zoom}}, \Delta y_{\text{Zoom}}$			≤ 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: $\Delta z_{\text{Zoom}}(n)$		≤ 5 mm	$3 - 4$ GHz: ≤ 4 mm $4 - 5$ GHz: ≤ 3 mm $5 - 6$ GHz: ≤ 2 mm
	graded grid	$\Delta z_{\text{Zoom}}(1)$: between 1 st two points closest to phantom surface	≤ 4 mm	$3 - 4$ GHz: ≤ 3 mm $4 - 5$ GHz: ≤ 2.5 mm $5 - 6$ GHz: ≤ 2 mm
		$\Delta z_{\text{Zoom}}(n>1)$: between subsequent points	$\leq 1.5 \cdot \Delta z_{\text{Zoom}}(n-1)$	
Minimum zoom scan volume	x, y, z		≥ 30 mm	$3 - 4$ GHz: ≥ 28 mm $4 - 5$ GHz: ≥ 25 mm $5 - 6$ GHz: ≥ 22 mm
Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details.				
* When zoom scan is required and the <u>reported</u> SAR from the <u>area scan based 1-g SAR estimation</u> procedures of KDB 447498 is ≤ 1.4 W/kg, ≤ 8 mm, ≤ 7 mm and ≤ 5 mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.				

6.5 Volume Scan Procedures

The volume scan is used to assess overlapping SAR distributions for antennas transmitting in different frequency bands. It is equivalent to an oversized zoom scan used in standalone measurements. The measurement volume will be used to enclose all the simultaneous transmitting antennas. For antennas transmitting simultaneously in different frequency bands, the volume scan is measured separately in each frequency band. In order to sum correctly to compute the 1g aggregate SAR, the EUT remain in the same test position for all measurements and all volume scan use the same spatial resolution and grid spacing. When all volume scan were completed, the software, SEMCAD postprocessor can combine and subsequently superpose these measurement data to calculating the multiband SAR.

6.6 Power Drift Monitoring

All SAR testing is under the EUT install full charged battery and transmit maximum output power. In DASY measurement software, the power reference measurement and power drift measurement procedures are used for monitoring the power drift of EUT during SAR test. Both these procedures measure the field at a specified reference position before and after the SAR testing. The software will calculate the field difference in dB. If the power drifts more than 5%, the SAR will be retested.

7 Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	2450MHz System Validation Kit	D2450V2	926	2013/12/3	2014/12/2
SPEAG	5000MHz System Validation Kit	D5GHzV2	1167	2013/12/11	2014/12/10
SPEAG	5000MHz System Validation Kit	D5GHzV2	1167	2014/3/13	2015/3/12
SPEAG	Dosimetric E-Field Probe	EX3DV4	3958	2014/3/10	2015/3/9
SPEAG	Dosimetric E-Field Probe	EX3DV4	3958	2014/3/10	2015/3/9
SPEAG	Data Acquisition Electronics	DAE4	1424	2014/2/11	2015/2/10
SPEAG	Device Holder	N/A	N/A	NCR	NCR
Mini-Circuits	Power Amplifier	ZHL-42W+	15542	NCR	NCR
Mini-Circuits	Power Amplifier	ZVE-8G+	605601404	NCR	NCR
Agilent	ENA Series Network Analyzer	E5071C	MY46419201	2014/1/15	2015/1/14
R&S	Spectrum Analyzer	FSP40	100305	2013/10/3	2014/10/2
Signal Generator	R&S	SMR40	100116	2013/6/27	2014/6/26
SPEAG	Dielectric Probe Kit	SM DAK 040CA	1146	NCR	NCR
Anritsu	Power Meter	ML2495A	949003	2014/1/28	2015/1/27
Anritsu	Power sensor	MA2411B	917017	2014/1/28	2015/1/27
SPEAG	Flat Phantom ELI5.0	QD OVA 002 AA	1238	NCR	NCR
Wisewind	Thermometer	HTC1	HTC1	2013/12/25	2014/12/24
Wisewind	Thermometer	YF-160A	130504609	2013/12/25	2014/12/24

General Note:

1. The calibration certificate of DASY can be referred to appendix C of this report.
2. The Insertion Loss calibration of Dual Directional Coupler and Attenuator were characterized via the network analyzer and compensated during system check.
3. In system check we need to monitor the level on the power meter, and adjust the power amplifier level to have precise power level to the dipole; the measured SAR will be normalized to 1W input power according to the ratio of 1W to the input power to the dipole. For system check, the calibration of the power amplifier is deemed not critically required for correct measurement; the power meter is critical and we do have calibration for it
4. Attenuator 1 insertion loss is calibrated by the network Analyzer, which the calibration is valid, before system check.
5. NCR: No calibration request.

8 System Verification

8.1 Tissue Verification

The following tissue formulations are provided for reference only as some of the parameters have not been thoroughly verified. The composition of ingredients may be modified accordingly to achieve the desired target tissue parameters required for routine SAR evaluation.

Frequency (MHz)	Water (%)	Sugar (%)	Cellulose (%)	Salt (%)	Preventol (%)	DGBE (%)	Conductivity (σ)	Permittivity (ϵ_r)
For Head								
2450	55.0	0	0	0	0	45.0	1.80	39.2
For Body								
2450	68.6	0	0	0	0	31.4	1.95	52.7

Simulating Liquid for 5GHz, Manufactured by SPEAG

Ingredients	(% by weight)
Water	64~78%
Mineral oil	11~18%
Emulsifiers	9~15%
Additives and Salt	2~3%

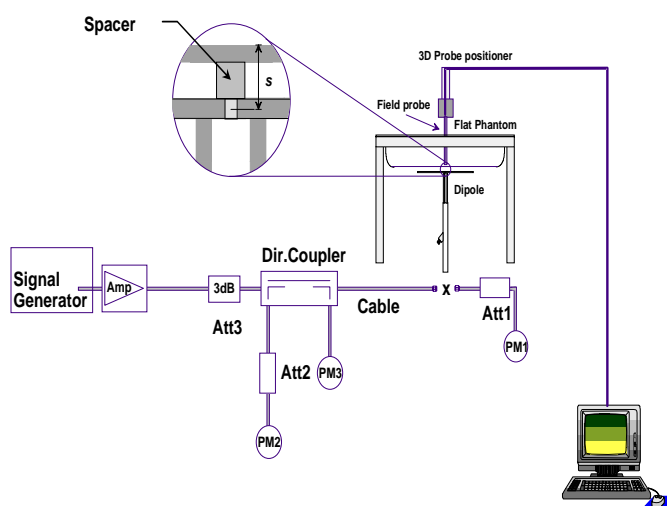
<Tissue Dielectric Parameter Check Results>

Frequency (MHz)	Liquid Temp. (°C)	Conductivity (σ)	Permittivity (ϵ_r)	Conductivity Target (σ)	Permittivity Target (ϵ_r)	Delta (σ) (%)	Delta (ϵ_r) (%)	Limit (%)	Date
2450	20.5	2.047	52.513	1.95	52.7	4.97	-0.35	±5	2014/6/24
5200	20.3	5.418	47.475	5.3	49	2.23	-3.11	±5	2014/6/25
5300	20.3	5.548	47.298	5.42	48.9	2.36	-3.28	±5	2014/6/25
5600	20.3	5.953	46.777	5.77	48.5	3.17	-3.55	±5	2014/6/25
5800	20.3	6.223	46.437	6	48.2	3.72	-3.66	±5	2014/6/25

8.2 System Performance Check Results

Comparing to the original SAR value provided by SPEAG, the verification data should be within its specification of 10 %. Below table shows the target SAR and measured SAR after normalized to 1W input power. The table below indicates the system performance check can meet the variation criterion and the plots can be referred to Appendix A of this report.

Date	Frequency (MHz)	Tissue Type	Input Power (mW)	Dipole S/N	Probe S/N	DAE S/N	Measured SAR (W/kg)	Targeted SAR (W/kg)	Normalized SAR (W/kg)	Deviation (%)
2014/6/24	2450	Body	250	926	3958	1424	12.9	50.20	51.60	2.789
2014/6/25	5200	Body	100	1167	3958	1424	7.73	75.7	77.30	2.114
2014/6/25	5300	Body	100	1167	3958	1424	8.02	74.4	80.20	7.796
2014/6/25	5600	Body	100	1167	3958	1424	8.2	79.5	82.00	3.145
2014/6/25	5800	Body	100	1167	3958	1424	7.53	73.8	75.30	2.033



System Performance Check Setup



Setup Photo



9 RF Exposure Positions

9.1 SAR Testing for Tablet

Please refer to Appendix A. for the test setup photos.

10 Conducted RF Output Power (Unit: dBm)

<Bluetooth Conducted Power>

Mode Band	Average power(dBm)		
	Bluetooth v2.1+EDR	Bluetooth v4.0+LE	Tune up Limit (dBm)
2.4GHz Bluetooth	5.28	0.73	5.5

<WLAN Conducted Power>

General Note:

1. Per FCC KDB 248227 D01 v01r02, choose the highest output power channel to test SAR and determine further SAR exclusion.
2. For each frequency band, testing at higher data rates and higher order modulations is not required when the maximum average output power for each of these configurations is less than 1/4dB higher than those measured at the lowest data rate.
3. Per FCC KDB 248227 D01 v01r02, 11g, 11n-HT20 output power is less than 1/4dB higher than 11b mode, thus the SAR can be excluded.

<2.4GHz WLAN Antenna>

WLAN 2.4GHz 802.11b Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	Data Rate	
		1Mbps	
CH 1	2412	18.99	19.50
CH 6	2437	19.04	
CH 11	2462	19.17	

WLAN 2.4GHz 802.11g Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	Data Rate	
		6Mbps	
CH 1	2412	14.03	14.50
CH 6	2437	14.07	
CH 11	2462	14.06	

WLAN 2.4GHz 802.11n-HT20 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
CH 1	2412	13.29	13.50
CH 6	2437	13.15	
CH 11	2462	13.24	

WLAN 2.4GHz 802.11n-HT40 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
CH 3	2422	13.60	14.00
CH 6	2437	13.19	
CH 9	2452	13.00	

General Note:

1. Per FCC KDB 248227 D01 v01r02, choose the highest output power channel to test SAR and determine further SAR exclusion
2. For each frequency band, testing at higher data rates and higher order modulations is not required when the maximum average output power for each of these configurations is less than 1/4dB higher than those measured at the lowest data rate.
3. Per FCC KDB 248227 D01 v01r02, 11n/ac-HT20/HT40/VHT20/VHT40 output power is less than 1/4dB higher than 11a mode, thus the SAR can be excluded.
4. For 802.11ac SAR evaluation for each frequency band, 802.11ac VHT80 will be verified at the worst case found in 802.11a SAR testing.

<5.2GHz WLAN Antenna>

WLAN 5.2GHz 802.11a Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	Data Rate	
		6Mbps	
CH 36	5180	14.02	14.50
CH 40	5200	13.77	
CH 44	5220	13.82	
CH 48	5240	13.96	

WLAN 5.2GHz 802.11n-HT20 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
CH 36	5180	13.10	13.50
CH 40	5200	13.11	
CH 44	5220	12.94	
CH 48	5240	13.20	

WLAN 5.2GHz 802.11n-HT40 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
CH 38	5190	13.09	13.50
CH 46	5230	13.13	

WLAN 5.2GHz 802.11ac-VHT20 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
CH 36	5180	13.38	13.50
CH 40	5200	13.29	
CH 44	5220	13.25	
CH 48	5240	13.21	

WLAN 5.2GHz 802.11ac-VHT40 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
CH 38	5190	13.17	13.50
CH 46	5230	13.19	

WLAN 5.2GHz 802.11ac-VHT80 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
CH 42	5210	12.12	12.50

<5.3GHz WLAN Antenna>

WLAN 5.3GHz 802.11a Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	Data Rate	
		6Mbps	
CH 52	5260	15.08	15.50
CH 56	5280	15.04	
CH 60	5300	15.02	
CH 64	5320	15.20	

WLAN 5.3GHz 802.11n-HT20 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
CH 52	5260	14.27	14.50
CH 56	5280	14.18	
CH 60	5300	14.22	
CH 64	5320	14.16	

WLAN 5.3GHz 802.11n-HT40 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
CH 54	5270	14.38	
CH 62	5310	14.30	

WLAN 5.3GHz 802.11ac-VHT20 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
CH 52	5260	14.51	15.00
CH 56	5280	14.41	
CH 60	5300	14.38	
CH 64	5320	14.38	

WLAN 5.3GHz 802.11ac-VHT40 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
CH 54	5270	14.57	15.00
CH 62	5310	14.31	

WLAN 5.3GHz 802.11ac-VHT80 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
CH 58	5290	14.37	14.50

<5.6GHz WLAN Antenna>

WLAN 5.6GHz 802.11a Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	Data Rate 6Mbps	
CH 100	5500	15.01	15.50
CH 104	5520	15.19	
CH 108	5540	14.99	
CH 112	5560	14.98	
CH 116	5580	15.03	
CH 132	5660	15.40	
CH 136	5680	15.11	
CH 140	5700	15.37	

WLAN 5.6GHz 802.11n-HT20 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index MCS0	
CH 100	5500	14.55	15.00
CH 104	5520	14.36	
CH 108	5540	14.45	
CH 112	5560	14.52	
CH 116	5580	14.59	
CH 132	5660	14.46	
CH 136	5680	14.60	
CH 140	5700	14.49	

WLAN 5.6GHz 802.11n-HT40 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
CH 102	5510	14.42	15.00
CH 110	5550	14.51	
CH 134	5670	14.19	

WLAN 5.6GHz 802.11n-VHT20 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
CH 100	5500	14.04	14.50
CH 104	5520	14.06	
CH 108	5540	14.11	
CH 112	5560	14.15	
CH 116	5580	14.20	
CH 132	5660	14.14	
CH 136	5680	14.13	
CH 140	5700	14.01	

WLAN 5.6GHz 802.11n-VHT40 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
CH 102	5510	14.46	15.00
CH 110	5550	14.39	
CH 134	5670	14.16	

WLAN 5.6GHz 802.11ac-VHT80 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
106	5530	14.63	15.00
122	5610	14.62	

<5.8GHz WLAN Antenna>

WLAN 5.8GHz 802.11a Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	Data Rate 6Mbps	
CH 149	5745	15.28	15.50
CH 153	5765	15.10	
CH 157	5785	15.25	
CH 161	5805	15.20	
CH 165	5825	15.27	

WLAN 5.8GHz 802.11n-HT20 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index MCS0	
CH 149	5745	14.37	15.00
CH 153	5765	14.50	
CH 157	5785	14.53	
CH 161	5805	14.48	
CH 165	5825	14.47	

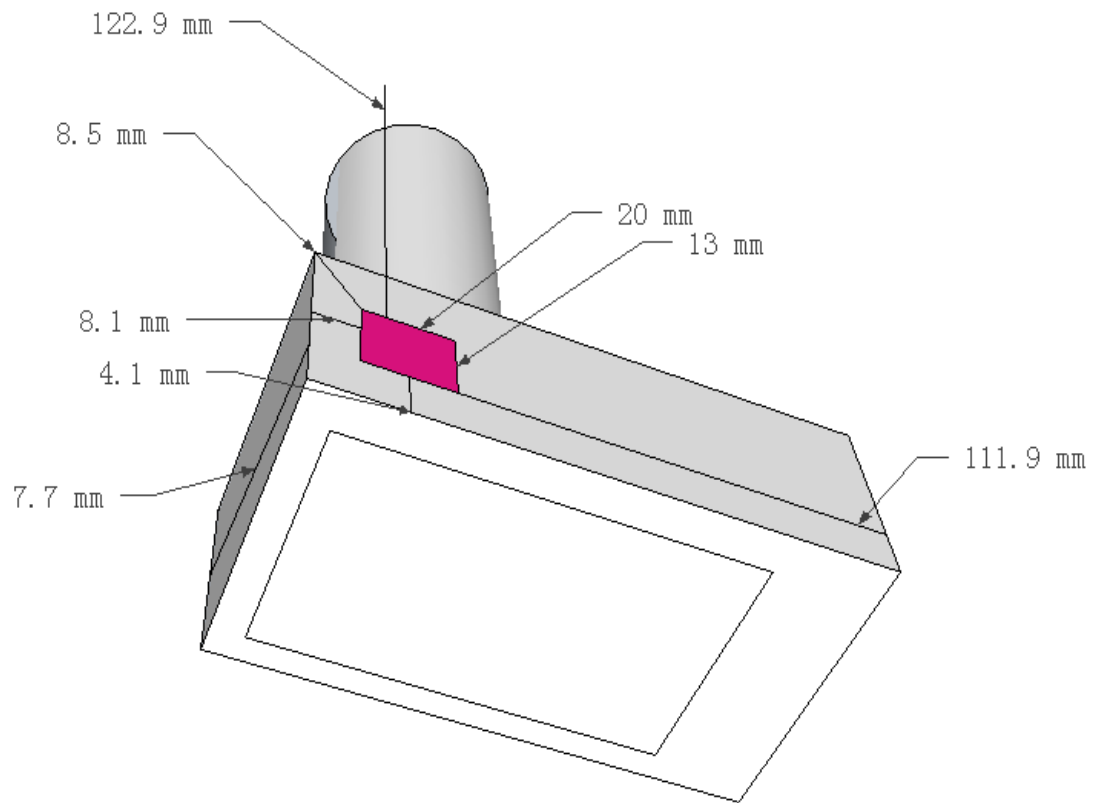
WLAN 5.8GHz 802.11n-HT40 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
CH 151	5755	14.44	14.50
CH 159	5795	14.40	

WLAN 5.8GHz 802.11n-VHT20 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
CH 149	5745	14.05	15.00
CH 153	5765	14.08	
CH 157	5785	14.09	
CH 161	5805	14.30	
CH 165	5825	14.51	

WLAN 5.8GHz 802.11n-VHT40 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
CH 151	5755	14.27	14.50
CH 159	5795	14.33	

WLAN 5.8GHz 802.11ac-VHT80 Average Power (dBm)			Tune up Limit (dBm)
Power vs. Channel			
Channel	Frequency (MHz)	MCS Index	
		MCS0	
155	5775	14.16	14.50

11 Antenna Location



<SAR test exclusion table>
General Note:

1. Above the table, when the distance is < 50 mm exclusion threshold is "Ratio", when the distance is > 50 mm exclusion threshold is "mW"
2. Maximum power is the source-based time-average power and represents the maximum RF output power among production units
3. Per KDB 447498 D01v05r02, for larger devices, the test separation distance of adjacent edge configuration is determined by the closest separation between the antenna and the user.
4. Per KDB 447498 D01v05r02, standalone SAR test exclusion threshold is applied; If the test separation distance is < 5mm, 5mm is used to determine SAR exclusion threshold.
5. Per KDB 447498 D01v05r02, the 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:

$$[(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm})] \cdot [\sqrt{f(\text{GHz})}] \leq 3.0 \text{ for 1-g SAR and } \leq 7.5 \text{ for 10-g extremity SAR}$$
 - f(GHz) is the RF channel transmit frequency in GHz
 - Power and distance are rounded to the nearest mW and mm before calculation
 - The result is rounded to one decimal place for comparison
 - For < 50 mm distance, we just calculate mW of the exclusion threshold value (3.0) to do compare.

This formula is $[3.0] / [\sqrt{f(\text{GHz})}] \cdot [\text{min. test separation distance, mm}] = \text{exclusion threshold of mW}.$
6. Per KDB 447498 D01v05r02, at 100 MHz to 6 GHz and for test separation distances > 50 mm, the SAR test exclusion threshold is determined according to the following
 - a) [Threshold at 50 mm in step 1) + (test separation distance - 50 mm) · (f(MHz)/150)] mW, at 100 MHz to 1500 MHz
 - b) [Threshold at 50 mm in step 1) + (test separation distance - 50 mm) · 10] mW at > 1500 MHz and ≤ 6 GHz

Configuration	Freq (MHz)	Turn-Up Max. (dBm)	TL Limit	Exposure Position	Dis [mm]	TL
2.4GHz WLAN	2462	19.50	3.0	Front Face	5	55.8
2.4GHz Bluetooth	2480	5.5	3.0	Front Face	5	0.8 (w/o test)
5.2GHz WLAN	5240	14.50	3.0	Front Face	5	12.9
5.3GHz WLAN	5320	15.50	3.0	Front Face	5	16.4
5.6GHz WLAN	5700	15.50	3.0	Front Face	5	16.9
5.8GHz WLAN	5745	15.50	3.0	Front Face	5	19.5

12 SAR Test Results

General Note:

1. Per KDB 447498 D01v05r02, the reported SAR is the measured SAR value adjusted for maximum tune-up tolerance.
 - a. Tune-up scaling Factor = tune-up limit power (mW) / EUT RF power (mW), where tune-up limit is the maximum rated power among all production units.
 - b. For SAR testing of WLAN signal with non-100% duty cycle, the measured SAR is scaled-up by the duty cycle scaling factor which is equal to "1/(duty cycle)"
 - c. For WLAN: Reported SAR(W/kg)= Measured SAR(W/kg)*Tune-up Scaling Factor
2. Per KDB 447498 D01v05r02, for each exposure position, testing of other required channels within the operating mode of a frequency band is not required when the *reported* 1-g or 10-g SAR for the mid-band or highest output power channel is:
 - ≤ 0.8 W/kg or 2.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≤ 100 MHz
 - ≤ 0.6 W/kg or 1.5 W/kg, for 1-g or 10-g respectively, when the transmission band is between 100 MHz and 200 MHz
 - ≤ 0.4 W/kg or 1.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≥ 200 MHz
3. Per KDB 616217 D04v01r01, the additional separation introduced by the contour against a flat phantom is < 5 mm and reported SAR is < 1.2 W/kg, a curved or contoured back surface or edge SAR is not required, more detail information please refer to the setup photo.
4. When the WLAN transmission was verified using a spectrum analyzer.

12.1 Body SAR

<DTS WLAN SAR>

Plot No.	Band	Mode	Test Position	Gap (cm)	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Tune-up Scaling Factor	Power Drift (dB)	Measured 1g SAR (W/kg)	Reported 1g SAR (W/kg)
1	802.11b	-	Front Face	0	11	2462	19.17	19.5	1.08	-0.14	0.310	0.33
4	802.11a	-	Front Face	0	36	5180	14.02	14.5	1.12	-0.1	0.315	0.35
14	802.11ac	VHT80	Front Face	0	42	5210	12.12	12.5	1.09	0	0.146	0.16
7	802.11a	-	Front Face	0	64	5320	15.20	15.5	1.07	0	0.070	0.08
15	802.11ac	VHT80	Front Face	0	58	5290	14.37	14.5	1.03	0.2	0.097	0.10
10	802.11a	-	Front Face	0	132	5660	15.40	15.5	1.02	0	0.012	0.01
16	802.11ac	VHT80	Front Face	0	106	5530	14.63	15	1.09	-0.04	0.00483	0.01
11	802.11a	-	Front Face	0	149	5745	15.28	15.5	1.05	0	0.025	0.03
17	802.11ac	VHT80	Front Face	0	155	5775	14.16	14.5	1.08	-0.01	0.025	0.03

13 Uncertainty Assessment

The component of uncertainty may generally be categorized according to the methods used to evaluate them. The evaluation of uncertainty by the statistical analysis of a series of observations is termed a Type A evaluation of uncertainty. The evaluation of uncertainty by means other than the statistical analysis of a series of observation is termed a Type B evaluation of uncertainty. Each component of uncertainty, however evaluated, is represented by an estimated standard deviation, termed standard uncertainty, which is determined by the positive square root of the estimated variance.

A Type A evaluation of standard uncertainty may be based on any valid statistical method for treating data. This includes calculating the standard deviation of the mean of a series of independent observations; using the method of least squares to fit a curve to the data in order to estimate the parameter of the curve and their standard deviations; or carrying out an analysis of variance in order to identify and quantify random effects in certain kinds of measurement.

A type B evaluation of standard uncertainty is typically based on scientific judgment using all of the relevant information available. These may include previous measurement data, experience, and knowledge of the behavior and properties of relevant materials and instruments, manufacture's specification, data provided in calibration reports and uncertainties assigned to reference data taken from handbooks. Broadly speaking, the uncertainty is either obtained from an outdoor source or obtained from an assumed distribution, such as the normal distribution, rectangular or triangular distributions indicated in Table 14.1

Uncertainty Distributions	Normal	Rectangular	Triangular	U-Shape
Multi-plying Factor ^(a)	$1/k^{(b)}$	$1/\sqrt{3}$	$1/\sqrt{6}$	$1/\sqrt{2}$

(a) standard uncertainty is determined as the product of the multiplying factor and the estimated range of variations in the measured quantity

(b) k is the coverage factor

Standard Uncertainty for Assumed Distribution

The combined standard uncertainty of the measurement result represents the estimated standard deviation of the result. It is obtained by combining the individual standard uncertainties of both Type A and Type B evaluation using the usual "root-sum-squares" (RSS) methods of combining standard deviations by taking the positive square root of the estimated variances.

Expanded uncertainty is a measure of uncertainty that defines an interval about the measurement result within which the measured value is confidently believed to lie. It is obtained by multiplying the combined standard uncertainty by a coverage factor. Typically, the coverage factor ranges from 2 to 3. Using a coverage factor allows the true value of a measured quantity to be specified with a defined probability within the specified uncertainty range. For purpose of this document, a coverage factor two is used, which corresponds to confidence interval of about 95 %. The DASY uncertainty Budget is shown in the following tables.

Error Description	Uncertainty Value (±%)	Probability Distribution	Divisor	Ci (1g)	Standard Uncertainty (±%) (1g)
Measurement System					
Probe Calibration	6.0	Normal	1.0	1.0	6.0
Axial Isotropy	4.7	Rectangular	$\sqrt{3}$	0.7	1.9
Hemispherical Isotropy	9.6	Rectangular	$\sqrt{3}$	0.7	3.9
Boundary effects	1.0	Rectangular	$\sqrt{3}$	1.0	0.6
Linearity	4.7	Rectangular	$\sqrt{3}$	1.0	2.7
System Detection Limits	1.0	Rectangular	$\sqrt{3}$	1.0	0.6
Modulation Response	2.4	Rectangular	$\sqrt{3}$	1.0	1.4
Readout Electronics	0.3	Normal	1.0	1.0	0.3
Response Time	0.8	Rectangular	$\sqrt{3}$	1.0	0.5
Integration Time	2.6	Rectangular	$\sqrt{3}$	1.0	1.5
RF Ambient Noise	3.0	Rectangular	$\sqrt{3}$	1.0	1.7
RF Ambient Reflections	3.0	Rectangular	$\sqrt{3}$	1.0	1.7
Probe Positioner	0.4	Rectangular	$\sqrt{3}$	1.0	0.2
Probe Positioning	2.9	Rectangular	$\sqrt{3}$	1.0	1.7
Max. SAR Eval.	2.0	Rectangular	$\sqrt{3}$	1.0	1.2
Dipole Related					
Device Positioning	2.9	Normal	1.0	1.0	2.9
Device Holder	3.6	Normal	1.0	1.0	3.6
Power Drift	5.0	Rectangular	$\sqrt{3}$	1.0	2.9
Power Scaling	0.0	Rectangular	$\sqrt{3}$	1.0	0.0
Phantom and Tissue parameters					
Phantom Uncertainty	6.1	Rectangular	$\sqrt{3}$	1.0	3.5
SAR correction	1.9	Normal	1.0	1.0	1.9
Liquid Conductivity (measurement)	2.0	Normal	1.0	0.8	1.6
Liquid Permittivity (measurement)	2.1	Normal	1.0	0.3	0.5
Temp. unc. - Conduct	3.4	Rectangular	$\sqrt{3}$	0.8	1.5
Temp. unc. - Permittivity	0.4	Rectangular	$\sqrt{3}$	0.2	0.1
Combined Standard Uncertainty					11.2
Coverage Factor for 95 %					Kp=2
Expanded Uncertainty					22.4

Uncertainty Budget for frequency range 30 MHz to 3 GHz

Error Description	Uncertainty Value (±%)	Probability Distribution	Divisor	Ci (1g)	Standard Uncertainty (±%) (1g)
Measurement System					
Probe Calibration	6.6	Normal	1.0	1.0	6.6
Axial Isotropy	4.7	Rectangular	$\sqrt{3}$	0.7	1.9
Hemispherical Isotropy	9.6	Rectangular	$\sqrt{3}$	0.7	3.9
Boundary effects	2.0	Rectangular	$\sqrt{3}$	1.0	1.2
Linearity	4.7	Rectangular	$\sqrt{3}$	1.0	2.7
System Detection Limits	1.0	Rectangular	$\sqrt{3}$	1.0	0.6
Modulation Response	2.4	Rectangular	$\sqrt{3}$	1.0	1.4
Readout Electronics	0.3	Normal	1.0	1.0	0.3
Response Time	0.8	Rectangular	$\sqrt{3}$	1.0	0.5
Integration Time	2.6	Rectangular	$\sqrt{3}$	1.0	1.5
RF Ambient Noise	3.0	Rectangular	$\sqrt{3}$	1.0	1.7
RF Ambient Reflections	3.0	Rectangular	$\sqrt{3}$	1.0	1.7
Probe Positioner	0.8	Rectangular	$\sqrt{3}$	1.0	0.5
Probe Positioning	6.7	Rectangular	$\sqrt{3}$	1.0	3.9
Max. SAR Eval.	4.0	Rectangular	$\sqrt{3}$	1.0	2.3
Dipole Related					
Device Positioning	2.9	Normal	1.0	1.0	2.9
Device Holder	3.6	Normal	1.0	1.0	3.6
Power Drift	5.0	Rectangular	$\sqrt{3}$	1.0	2.9
Power Scaling	0.0	Rectangular	$\sqrt{3}$	1.0	0.0
Phantom and Tissue parameters					
Phantom Uncertainty	6.6	Rectangular	$\sqrt{3}$	1.0	3.8
SAR correction	1.9	Normal	1.0	1.0	1.9
Liquid Conductivity (measurement)	2.0	Normal	1.0	0.8	1.6
Liquid Permittivity (measurement)	2.1	Normal	1.0	0.3	0.5
Temp. unc. - Conduct	3.4	Rectangular	$\sqrt{3}$	0.8	1.5
Temp. unc. - Permittivity	0.4	Rectangular	$\sqrt{3}$	0.2	0.1
Combined Standard Uncertainty					12.3
Coverage Factor for 95 %					Kp=2
Expanded Uncertainty					24.7

Uncertainty Budget for frequency range 3 GHz to 6 GHz

14 References

- [1] Council Recommendation 1999/519/EC of July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz)
- [2] EN 50566:2013, "Product standard to demonstrate compliance of radio frequency fields from handheld and body-mounted wireless communication devices used by the general public (30 MHz - 6 GHz)" March 2013.
- [3] EN 62311:2008, "Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz – 300 GHz)", January 2008
- [4] EN 62209-2:2010, "Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices. Human models, instrumentation, and procedures. Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", August 2010
- [5] EN 62479:2010 "Assessment of the compliance of low power electronic and electrical equipment with the basic restrictions related to human exposure to electromagnetic fields (10 MHz to 300 GHz)", December 2010
- [6] SPEAG DASY System Handbook