FCC SAR Test Report

APPLICANT	**:**	**Realtek Semiconductor Corp.**
EQUIPMENT	**:**	**802.11b/g/n RTL8192EE Combo module**
BRAND NAME	**:**	**REALTEK**
MODEL NAME	**:**	**RTL8192EEBT**
FCC ID	**:**	**TX2RTL8192EEBT**
STANDARD	**:**	**FCC 47 CFR Part 2 (2.1093)** **ANSI/IEEE C95.1-1992** **IEEE 1528-2003**

We, SPORTON INTERNATIONAL INC., would like to declare that the tested sample has been evaluated in accordance with the procedures and had been in 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: Eric Huang / Deputy Manager

Approved by: Jones Tsai / Manager

Testing Laboratory
1190

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Revision History

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
FA332724-24	Rev. 01	Initial issue of report	May 14, 2015

1. Statement of Compliance

The maximum results of Specific Absorption Rate (SAR) found during testing for **Realtek Semiconductor Corp., 802.11b/g/n RTL8192EE Combo module, RTL8192EEBT**, are as follows.

Equipment Class	Frequency Band	Highest SAR Summary	
		Body 1g SAR (W/kg)	Simultaneous Transmission 1g SAR (W/kg)
DTS	2.4GHz WLAN	**0.75**	0.95
Date of Testing:		2015/04/30	

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.

2. Administration Data

Testing Laboratory	
Test Site	SPORTON INTERNATIONAL INC.
Test Site Location	No.52, Hwa Ya 1st Rd., Hwa Ya Technology Park, Kwei-Shan District, Taoyuan City, Taiwan (R.O.C.) TEL: +886-3-327-3456 FAX: +886-3-328-4978

Applicant	
Company Name	Realtek Semiconductor Corp.
Address	No. 2,Innovation Road II, Hsinchu Science Park, Hsinchu 300,Taiwan

Manufacturer	
Company Name	Realtek Semiconductor Corp.
Address	No. 2,Innovation Road II, Hsinchu Science Park, Hsinchu 300,Taiwan

3. 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 802.11 Wi-Fi SAR v02

4. Equipment Under Test (EUT)

4.1 General Information

Product Feature & Specification	
Equipment Name	802.11b/g/n RTL8192EE Combo module
Brand Name	REALTEK
Model Name	RTL8192EEBT
FCC ID	TX2RTL8192EEBT
Wireless Technology and Frequency Range	WLAN 2.4GHz Band: 2412 MHz ~ 2462 MHz Bluetooth: 2402 MHz ~ 2480 MHz
Mode	· 802.11b/g/n HT20/HT40 · Bluetooth v3.0+EDR，Bluetooth v4.0-LE
HW Version	HMC--> 2V0 , NGFF -->3V1
SW Version	HMC -->V15 , NGFF-->V15
EUT Stage	Identical Prototype

Remark:

1. This device supports Tx diversity which the RF exposure evaluation will select highest power of chain 1 perform testing.
2. During MIMO SAR testing, the minimum distance between the chain 1 and chain 2 of the antenna is used 1 cm performing test.

5. RF Exposure Limits

5.1 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.

5.2 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
0.4	8.0	20.0

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.

6. Specific Absorption Rate (SAR)

6.1 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.

6.2 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:

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

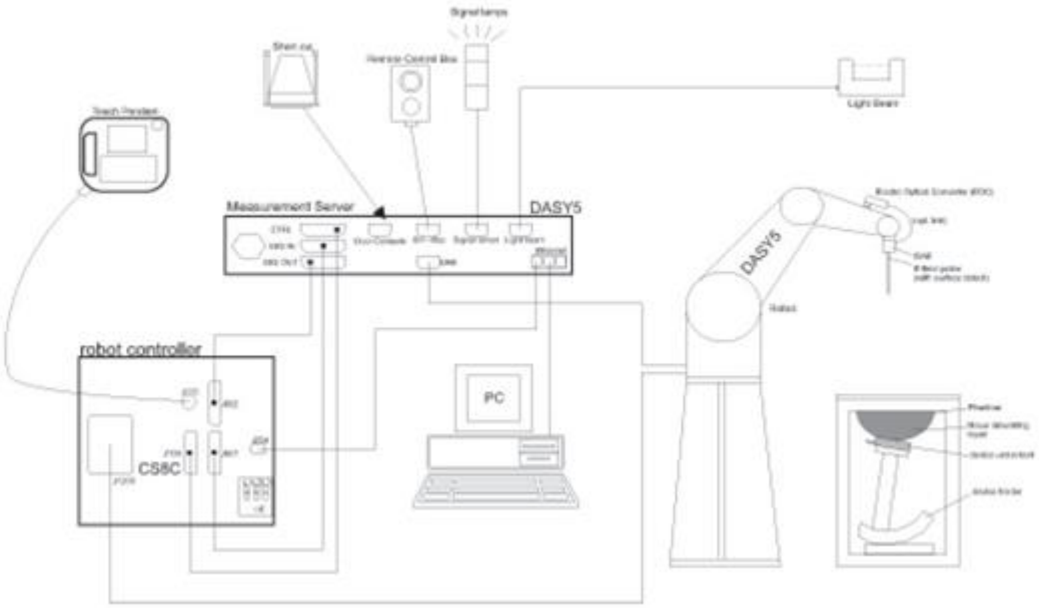
SAR is expressed in units of Watts per kilogram (W/kg)

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

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

7. 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.

8. 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

8.1 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
(b) Calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters)
(c) Generation of a high-resolution mesh within the measured volume
(d) Interpolation of all measured values form the measurement grid to the high-resolution grid
(e) Extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface
(f) Calculation of the averaged SAR within masses of 1g and 10g

8.2 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.

8.3 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 dB0 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.

	≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	5 ± 1 mm	½·δ·ln(2) ± 0.5 mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location	30° ± 1°	20° ± 1°
Maximum area scan spatial resolution: Δx_{Area}, Δy_{Area}	≤ 2 GHz: ≤ 15 mm 2 – 3 GHz: ≤ 12 mm	3 – 4 GHz: ≤ 12 mm 4 – 6 GHz: ≤ 10 mm
	When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be ≤ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	

8.4 Zoom Scan

Zoom scans are used 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 shoes 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.

<table>
<tr><td colspan="3"></td><td>$\leq$ 3 GHz</td><td>> 3 GHz</td></tr>
<tr><td colspan="3">Maximum zoom scan spatial resolution: Δx_{Zoom}, Δy_{Zoom}</td><td>$\leq$ 2 GHz: $\leq$ 8 mm
2 – 3 GHz: $\leq$ 5 mm*</td><td>3 – 4 GHz: $\leq$ 5 mm*
4 – 6 GHz: $\leq$ 4 mm*</td></tr>
<tr><td rowspan="3">Maximum zoom scan spatial resolution, normal to phantom surface</td><td colspan="2">uniform grid: $\Delta z_{Zoom}(n)$</td><td>$\leq$ 5 mm</td><td>3 – 4 GHz: $\leq$ 4 mm
4 – 5 GHz: $\leq$ 3 mm
5 – 6 GHz: $\leq$ 2 mm</td></tr>
<tr><td rowspan="2">graded grid</td><td>$\Delta z_{Zoom}(1)$: between 1st two points closest to phantom surface</td><td>$\leq$ 4 mm</td><td>3 – 4 GHz: $\leq$ 3 mm
4 – 5 GHz: $\leq$ 2.5 mm
5 – 6 GHz: $\leq$ 2 mm</td></tr>
<tr><td>$\Delta z_{Zoom}(n>1)$: between subsequent points</td><td colspan="2">$\leq 1.5 \cdot \Delta z_{Zoom}(n-1)$</td></tr>
<tr><td>Minimum zoom scan volume</td><td colspan="2">x, y, z</td><td>$\geq$ 30 mm</td><td>3 – 4 GHz: $\geq$ 28 mm
4 – 5 GHz: $\geq$ 25 mm
5 – 6 GHz: $\geq$ 22 mm</td></tr>
<tr><td colspan="5">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 area scan based 1-g SAR estimation procedures of KDB 447498 is $\leq$ 1.4 W/kg, $\leq$ 8 mm, $\leq$ 7 mm and $\leq$ 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.</td></tr>
</table>

8.5 Volume Scan Procedures

The volume scan is used for 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.

8.6 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.

9. Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	2450MHz System Validation Kit	D2450V2	924	Nov. 19, 2014	Nov. 18, 2015
SPEAG	Data Acquisition Electronics	DAE4	1279	Jul. 23, 2014	Jul. 22, 2015
SPEAG	Data Acquisition Electronics	DAE3	495	May. 19, 2014	May. 18, 2015
SPEAG	Dosimetric E-Field Probe	EX3DV4	3954	Nov. 21, 2014	Nov. 20, 2015
SPEAG	Dosimetric E-Field Probe	EX3DV4	3925	May. 22, 2014	May. 21, 2015
Wisewind	Thermometer	HTC-1	TM281	Oct. 21, 2014	Oct. 20, 2015
Wisewind	Thermometer	ETP-101	TM225	Oct. 21, 2014	Oct. 20, 2015
SPEAG	Device Holder	N/A	N/A	N/A	N/A
Agilent	ENA Network Analyzer	E5071C	MY46316648	Feb. 11, 2015	Feb. 10, 2016
SPEAG	Dielectric Probe Kit	DAK-3.5	1138	Nov. 18, 2014	Nov. 17, 2015
Anritsu	Power Meter	ML2495A	1419002	May. 16, 2014	May. 15, 2015
Anritsu	Power Sensor	MA2411B	1339124	Jun. 03, 2014	Jun. 02, 2015
Anritsu	Spectrum Analyzer	MS2830A	6201396378	Jun. 03, 2014	Jun. 02, 2015
Agilent	Dual Directional Coupler	778D	50422	Note 1	
Woken	Attenuator 1	WK0602-XX	N/A	Note 1	
PE	Attenuator 2	PE7005-10	N/A	Note 1	
PE	Attenuator 3	PE7005- 3	N/A	Note 1	
AR	Power Amplifier	5S1G4M2	0328767	Note 1	
Mini-Circuits	Power Amplifier	ZVE-3W	162601250	Note 1	

General Note:

1. Prior to system verification and validation, the path loss from the signal generator to the system check source and the power meter, which includes the amplifier, cable, attenuator and directional coupler, was measured by the network analyzer. The reading of the power meter was offset by the path loss difference between the path to the power meter and the path to the system check source to monitor the actual power level fed to the system check source.

10. System Verification

10.1 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 (εr)
For Body								
750	51.7	47.2	0	0.9	0.1	0	0.96	55.5
835	50.8	48.2	0	0.9	0.1	0	0.97	55.2
900	50.8	48.2	0	0.9	0.1	0	1.05	55.0
1800, 1900, 2000	70.2	0	0	0.4	0	29.4	1.52	53.3
2450	68.6	0	0	0	0	31.4	1.95	52.7
2600	68.1	0	0	0.1	0	31.8	2.16	52.5

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)	Tissue Type	Liquid Temp. (℃)	Conductivity (σ)	Permittivity (ε_r)	Conductivity Target (σ)	Permittivity Target (ε_r)	Delta (σ) (%)	Delta (ε_r) (%)	Limit (%)	Date
2450	MSL	22.3	1.987	52.344	1.95	52.70	1.90	-0.68	±5	2015/4/30
2450	MSL	22.3	2.018	52.319	1.95	52.70	3.49	-0.72	±5	2015/4/30

10.2 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 1g SAR (W/kg)	Targeted 1g SAR (W/kg)	Normalized 1g SAR (W/kg)	Deviation (%)
2015/4/30	2450	MSL	250	D2450V2-924	EX3DV4 - SN3954	DAE4 Sn1279	12.20	51.40	48.80	-5.06
2015/4/30	2450	MSL	250	D2450V2-924	EX3DV4 - SN3925	DAE3 Sn495	12.50	51.40	50.00	-2.72

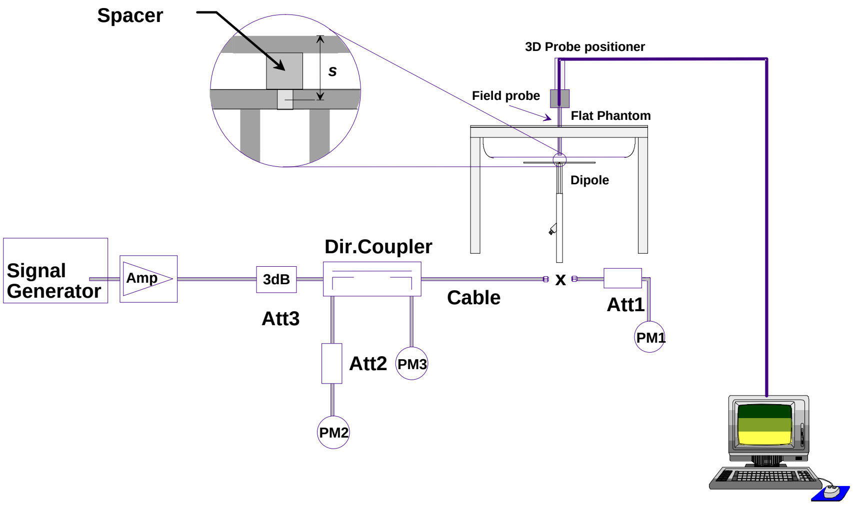


Fig 8.3.1 System Performance Check Setup

Fig 8.3.2 Setup Photo

11. Conducted RF Output Power (Unit: dBm)

General Note:

1. Per KDB 248227 D01v02, SAR test reduction is determined according to 802.11 transmission mode configurations and certain exposure conditions with multiple test positions. In the 2.4 GHz band, separate SAR procedures are applied to DSSS and OFDM configurations to simplify DSSS test requirements. For OFDM, in both 2.4 and 5 GHz bands, an initial test configuration must be determined for each standalone and aggregated frequency band, according to the transmission mode configuration with the highest maximum output power specified for production units to perform SAR measurements. If the same highest maximum output power applies to different combinations of channel bandwidths, modulations and data rates, additional procedures are applied to determine which test configurations require SAR measurement. When applicable, an initial test position may be applied to reduce the number of SAR measurements required for next to the ear, UMPC mini-tablet or hotspot mode configurations with multiple test positions.
2. Per KDB 248227 D01v02, for 2.4 GHz 802.11b DSSS, either the initial test position procedure for multiple exposure test positions or the DSSS procedure for fixed exposure position is applied; these are mutually exclusive. For 2.4 GHz and 5 GHz OFDM configurations, the initial test configuration is applied to measure SAR using either the initial test position procedure for multiple exposure test position configurations or the initial test configuration procedures for fixed exposure test conditions. Based on the reported SAR of the measured configurations and maximum output power of the transmission mode configurations that are not included in the initial test configuration, the subsequent test configuration and initial test position procedures are applied to determine if SAR measurements are required for the remaining OFDM transmission configurations. In general, the number of test channels that require SAR measurement is minimized based on maximum output power measured for the test sample(s).
3. Per KDB 248227 D01v02, for OFDM transmission configurations in the 2.4 GHz and 5 GHz bands, When the same maximum power is specified for multiple transmission modes in a frequency band, the largest channel bandwidth, lowest order modulation, lowest data rate and lowest order 802.11a/g/n/ac mode is used for SAR measurement, on the highest measured output power channel for each frequency band.
4. Per KDB 248227 D01v02, DSSS and OFDM configurations are considered separately according to the required SAR procedures. SAR is measured in the initial test position using the 802.11 transmission mode configuration required by the DSSS procedure or initial test configuration and subsequent test configuration(s) according to the OFDM procedures.18 The initial test position procedure is described in the following:
   - When the reported SAR of the initial test position is ≤ 0.4 W/kg, further SAR measurement is not required for the other test positions in that exposure configuration and 802.11 transmission mode combinations within the frequency band or aggregated band.
   - When the reported SAR of the test position is > 0.4 W/kg, SAR is repeated for the 802.11 transmission mode configuration tested in the initial test position to measure the subsequent next closet/smallest test separation distance and maximum coupling test position on the highest maximum output power channel, until the report SAR is ≤ 0.8 W/kg or all required test position are tested.
   - For all positions/configurations, when the reported SAR is > 0.8 W/kg, SAR is measured for these test positions/configurations on the subsequent next highest measured output power channel(s) until the reported SAR is ≤ 1.2 W/kg or all required channels are tested.

<WLAN Maximum Power>

Mode / Band	IEEE 802.11 Average Power (dBm)										
	Chain 1				Chain 2				Chain 1+2		
WLAN2.4GHz	11b	11g	HT20	HT40	11b	11g	HT20	HT40	11g	HT20	HT40
	15.5				15.5				17.5		

<WLAN Measurement Power>

	Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)
2.4GHz WLAN Chain 1	802.11b	CH 1	2412	1Mbps	15.15
		CH 6	2437		15.37
		CH 11	2462		15.16
	802.11g	CH 1	2412	6Mbps	15.27
		CH 6	2437		15.00
		CH 11	2462		15.36
	802.11n-HT20	CH 1	2412	MCS0	15.36
		CH 6	2437		15.19
		CH 11	2462		15.35
	802.11n-HT40	CH 3	2422	MCS0	15.32
		CH 6	2437		15.14
		CH 9	2452		14.96

	Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)
2.4GHz WLAN Chain 2	802.11b	CH 1	2412	1Mbps	15.26
		CH 6	2437		15.36
		CH 11	2462		14.98
	802.11g	CH 1	2412	6Mbps	15.18
		CH 6	2437		15.34
		CH 11	2462		15.30
	802.11n-HT20	CH 1	2412	MCS0	15.01
		CH 6	2437		15.15
		CH 11	2462		15.09
	802.11n-HT40	CH 3	2422	MCS0	15.35
		CH 6	2437		15.16
		CH 9	2452		15.14

	Mode	Channel	Frequency (MHz)	Data Rate	Average power (dBm)
2.4GHz WLAN Chain1+2	802.11g	CH 1	2412	6Mbps	16.99
		CH 6	2437		17.07
		CH 11	2462		17.05
	802.11n-HT20	CH 1	2412	MCS0	16.90
		CH 6	2437		16.92
		CH 11	2462		16.84
	802.11n-HT40	CH 3	2422	MCS0	16.94
		CH 6	2437		16.88
		CH 9	2452		16.75

<Bluetooth Maximum Power>

Mode Band	Average power(dBm)	
	Bluetoothv3.0+EDR	Bluetooth v4.0+LE
2.4GHz Bluetooth	7.0	7.0

Note:

1. 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:

   [(*max. power of channel, including tune-up tolerance, mW*)/(*min. test separation distance, mm*)] ·[$\sqrt{f(GHz)}$] ≤ 3.0 for 1-g SAR and ≤ 7.5 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

Bluetooth Max Power (dBm)	Separation Distance (mm)	Frequency (GHz)	exclusion thresholds
7	< 5	2.48	1.57

Note:

Per KDB 447498 D01v05r02, when the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion. The test exclusion threshold is 1.57 which is <= 3, SAR testing is not required.

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) * Duty Cycle scaling factor * Tune-up scaling factor
   d. For Bluetooth: Reported SAR(W/kg)= Measured SAR(W/kg * Tune-up scaling factor
2. Per KDB 248227 D01v02, for chain1 802.11g/n SAR testing is not required When the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, and reported SAR is < 0.8 W/kg additional channel is not necessary..
3. Per KDB 248227 D01v02, for chain1+2 OFDM transmission configurations in the 2.4 GHz bands, When the same maximum power is specified for multiple transmission modes in a frequency band, the largest channel bandwidth, lowest order modulation, lowest data rate and lowest order 802.11g/n mode is used for SAR measurement, on the highest measured output power channel for each frequency band and reported SAR is < 0.8 W/kg additional channel is not necessary.
4. During SAR testing the WLAN transmission was verified using a spectrum analyzer.

12.1 Body SAR

<WLAN SAR>

Plot No.	Band	Mode	Test Position	Gap (mm)	Antenna	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Tune-up Scaling Factor	Duty Cycle %	Duty Cycle Scaling Factor	Power Drift (dB)	Measured 1g SAR (W/kg)	Reported 1g SAR (W/kg)
	WLAN 2.4GHz	802.11b 1Mbps	Front	5mm	Chain 1	6	2437	15.37	15.50	1.030	100	1.000	-0.12	0.680	0.701
	WLAN 2.4GHz	802.11b 1Mbps	Back	5mm	Chain 1	6	2437	15.37	15.50	1.030	100	1.000	-0.16	0.720	0.742
	WLAN 2.4GHz	802.11b 1Mbps	Left Side	5mm	Chain 1	6	2437	15.37	15.50	1.030	100	1.000	-0.19	0.611	0.630
	WLAN 2.4GHz	802.11b 1Mbps	Right Side	5mm	Chain 1	6	2437	15.37	15.50	1.030	100	1.000	-0.17	0.125	0.129
	WLAN 2.4GHz	802.11b 1Mbps	Top Side	5mm	Chain 1	6	2437	15.37	15.50	1.030	100	1.000	-0.14	0.053	0.055
	WLAN 2.4GHz	802.11b 1Mbps	Bottom Side	5mm	Chain 1	6	2437	15.37	15.50	1.030	100	1.000	0.03	0.047	0.048
	WLAN 2.4GHz	802.11g 6Mbps	Front	5mm	Chain 1+2	6	2437	17.07	17.50	1.104	100	1.000	-0.05	0.592	0.654
01	WLAN 2.4GHz	802.11g 6Mbps	Back	5mm	Chain 1+2	6	2437	17.07	17.50	1.104	100	1.000	0.04	0.679	0.750
	WLAN 2.4GHz	802.11g 6Mbps	Left Side-1	5mm	Chain 1+2	6	2437	17.07	17.50	1.104	100	1.000	0.15	0.438	0.484
	WLAN 2.4GHz	802.11g 6Mbps	Left Side-2	5mm	Chain 1+2	6	2437	17.07	17.50	1.104	100	1.000	-0.01	0.589	0.650
	WLAN 2.4GHz	802.11g 6Mbps	Right Side-1	5mm	Chain 1+2	6	2437	17.07	17.50	1.104	100	1.000	0.1	0.189	0.209
	WLAN 2.4GHz	802.11g 6Mbps	Right Side-2	5mm	Chain 1+2	6	2437	17.07	17.50	1.104	100	1.000	-0.15	0.234	0.258
	WLAN 2.4GHz	802.11g 6Mbps	Top Side	5mm	Chain 1+2	6	2437	17.07	17.50	1.104	100	1.000	0.15	0.058	0.064
	WLAN 2.4GHz	802.11g 6Mbps	Bottom Side	5mm	Chain 1+2	6	2437	17.07	17.50	1.104	100	1.000	-0.15	0.091	0.100

13. Simultaneous Transmission Analysis

NO.	Simultaneous Transmission Configurations	Support
1.	WLAN 2.4GHz Chain 1 + Bluetooth Chain 2	Yes

General Note:

1. The Scaled SAR summation is calculated based on the same configuration and test position.
2. Per KDB 447498 D01v05r02, simultaneous transmission SAR is compliant if,
   i) Scalar SAR summation < 1.6W/kg.
   ii) SPLSR = (SAR1 + SAR2)^1.5 / (min. separation distance, mm), and the peak separation distance is determined from the square root of [(x1-x2)2 + (y1-y2)2 + (z1-z2)2], where (x1, y1, z1) and (x2, y2, z2) are the coordinates of the extrapolated peak SAR locations in the zoom scan.
   iii) If SPLSR ≤ 0.04, simultaneously transmission SAR measurement is not necessary.
   iv) Simultaneously transmission SAR measurement, and the reported multi-band SAR < 1.6W/kg.
3. For simultaneous transmission analysis, Bluetooth SAR is estimated per KDB 447498 D01v05r02 based on the formula below.
   i) (*max. power of channel, including tune-up tolerance, mW*)/(*min. test separation distance, mm*)]·[$\sqrt{f(GHz)/x}$] W/kg for *test separation distances* ≤ 50 mm; where *x* = 7.5 for 1-g SAR, and *x* = 18.75 for 10-g SAR.
   ii) When the minimum separation distance is < 5mm, the distance is used 5mm to determine SAR test exclusion.
   iii) 0.4 W/kg for 1-g SAR and 1.0 W/kg for 10-g SAR, when the *test separation distances* is > 50 mm.

Bluetooth Max Power	Exposure Position	All Positions
7.0 dBm	Estimated SAR (W/kg)	0.210 W/kg

13.1 Body Exposure Conditions

Exposure Position	1	2	1+2 Summed 1g SAR (W/kg)
	2.4GHz WLAN Chain 1	2.4GHz Bluetooth	
	1g SAR (W/kg)	Estimated 1g SAR (W/kg)	
Front	0.701	0.210	**0.91**
Back	0.742	0.210	**0.95**
Left Side	0.630	0.210	**0.84**
Right Side	0.129	0.210	**0.34**
Top Side	0.055	0.210	**0.27**
Bottom Side	0.048	0.210	**0.26**

13.2 Enhanced Energy Coupling

Note:

1. Pre KDB447498 D01v05r02, The probe tip distance to the phantom should be positioned at a distance of half the probe tip diameter, rounded to the nearest mm.
2. Pre KDB447498 D01v05r02, for transmitters and modules with no host platform restrictions, as described in item 1) of section 5.2.2, it is necessary to determine if additional SAR evaluation is required due to RF energy coupling enhancements at increased test separation distances. For the highest reported SAR of each test configuration, the tip of the SAR probe is positioned at the peak SAR location of the zoom scan, at a distance of half the probe tip diameter, rounded to the nearest mm, from the phantom surface. The test device is initially positioned in direct contact with the phantom and subsequently moved away from the phantom in 5 mm increments. At least three repeated single-point SAR (not 1-g SAR) results should be measured for each device position, until the measured SAR is < 50% of that measured with the device in contact with the phantom. When there is more than 15% variation in the single-point measurements at each position; more measurements are required to ensure a representative high range value is recorded. The highest of the single-point SAR values, adjusted for tune-up tolerance, should be reported for each position. When the highest measured single point SAR among all positions is 25% greater than that measured with the device positioned at Initial from the phantom, a complete 1-g SAR evaluation is required for that test configuration at the device position producing the highest single-point SAR.
3. Percent Change = [Measured Peak Reported SAR - Initial Peak Reported SAR) / Initial Peak Reported SAR] *100%

<SISO Mode>

Band	Exposure Position	Antenna-to-person distance(mm)		Average Power (dBm)	Tune-Up Limit (dBm)	Tune-up Scaling Factor	Measured Peak SAR 1g (W/kg)	Peak Reported SAR(W/kg)	Percent Change
2.4GHz WLAN	Front	Initial	5	15.37	15.50	1.030	0.660	0.680	-
		Step 1	10	15.37	15.50	1.030	0.329	0.339	-50.15
	Back	Initial	5	15.37	15.50	1.030	0.793	0.817	-
		Step 1	10	15.37	15.50	1.030	0.308	0.317	-61.34
	Left Side	Initial	5	15.37	15.50	1.030	0.600	0.618	-
		Step 1	10	15.37	15.50	1.030	0.206	0.212	-65.81
	Right Side	Initial	5	15.37	15.50	1.030	0.341	0.351	-
		Step 1	10	15.37	15.50	1.030	0.164	0.169	-51.71
	Top Side	Initial	5	15.37	15.50	1.030	0.290	0.299	-
		Step 1	10	15.37	15.50	1.030	0.161	0.166	-44.67
		Step 2	15	15.37	15.50	1.030	0.080	0.082	-72.67
	Bottom Side	Initial	5	15.37	15.50	1.030	0.300	0.309	-
		Step 1	10	15.37	15.50	1.030	0.162	0.167	-46.13
		Step 2	15	15.37	15.50	1.030	0.037	0.038	-87.74

<MIMO Mode>

Band	Exposure Position	Antenna-to-person distance(mm)		Average Power (dBm)	Tune-Up Limit (dBm)	Tune-up Scaling Factor	Measured Peak SAR 1g (W/kg)	Peak Reported SAR(W/kg)	Percent Change
2.4GHz WLAN	Front	Initial	5	17.07	17.50	1.104	0.774	0.855	-
		Step 1	10	17.07	17.50	1.104	0.371	0.410	-52.33
	Back	Initial	5	17.07	17.50	1.104	0.700	0.773	-
		Step 1	10	17.07	17.50	1.104	0.324	0.358	-53.51
	Left Side-1	Initial	5	17.07	17.50	1.104	0.815	0.900	-
		Step 1	10	17.07	17.50	1.104	0.313	0.346	-59.77
	Left Side-2	Initial	5	17.07	17.50	1.104	0.828	0.914	-
		Step 1	10	17.07	17.50	1.104	0.348	0.384	-55.35
	Right Side-1	Initial	5	17.07	17.50	1.104	0.212	0.234	-
		Step 1	10	17.07	17.50	1.104	0.084	0.093	-89.19
	Right Side-2	Initial	5	17.07	17.50	1.104	0.224	0.247	-
		Step 1	10	17.07	17.50	1.104	0.101	0.112	-55.20
	Top Side	Initial	5	17.07	17.50	1.104	0.055	0.061	-
		Step 1	10	17.07	17.50	1.104	0.026	0.029	-51.67
	Bottom Side	Initial	5	17.07	17.50	1.104	0.091	0.100	-
		Step 1	10	17.07	17.50	1.104	0.042	0.046	-54.00

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14. Uncertainty Assessment

The component of uncertainly may generally be categorized according to the methods used to evaluate them. The evaluation of uncertainly by the statistical analysis of a series of observations is termed a Type An 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 below.

Uncertainty Distributions	Normal	Rectangular	Triangular	U-Shape
Multi-plying Factor[(a)]	1/k[(b)]	1/√3	1/√6	1/√2

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

(b) *κ* is the coverage factor

Table 14.1. 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)	Ci (10g)	Standard Uncertainty (1g)	Standard Uncertainty (10g)
Measurement System							
Probe Calibration	6.0	Normal	1	1	1	± 6.0 %	± 6.0 %
Axial Isotropy	4.7	Rectangular	√3	0.7	0.7	± 1.9 %	± 1.9 %
Hemispherical Isotropy	9.6	Rectangular	√3	0.7	0.7	± 3.9 %	± 3.9 %
Boundary Effects	1.0	Rectangular	√3	1	1	± 0.6 %	± 0.6 %
Linearity	4.7	Rectangular	√3	1	1	± 2.7 %	± 2.7 %
System Detection Limits	1.0	Rectangular	√3	1	1	± 0.6 %	± 0.6 %
Readout Electronics	0.3	Normal	1	1	1	± 0.3 %	± 0.3 %
Response Time	0.8	Rectangular	√3	1	1	± 0.5 %	± 0.5 %
Integration Time	2.6	Rectangular	√3	1	1	± 1.5 %	± 1.5 %
RF Ambient Noise	3.0	Rectangular	√3	1	1	± 1.7 %	± 1.7 %
RF Ambient Reflections	3.0	Rectangular	√3	1	1	± 1.7 %	± 1.7 %
Probe Positioner	0.4	Rectangular	√3	1	1	± 0.2 %	± 0.2 %
Probe Positioning	2.9	Rectangular	√3	1	1	± 1.7 %	± 1.7 %
Max. SAR Eval.	1.0	Rectangular	√3	1	1	± 0.6 %	± 0.6 %
Test Sample Related							
Device Positioning	2.9	Normal	1	1	1	± 2.9 %	± 2.9 %
Device Holder	3.6	Normal	1	1	1	± 3.6 %	± 3.6 %
Power Drift	5.0	Rectangular	√3	1	1	± 2.9 %	± 2.9 %
Phantom and Setup							
Phantom Uncertainty	4.0	Rectangular	√3	1	1	± 2.3 %	± 2.3 %
Liquid Conductivity (Target)	5.0	Rectangular	√3	0.64	0.43	± 1.8 %	± 1.2 %
Liquid Conductivity (Meas.)	2.5	Normal	1	0.64	0.43	± 1.6 %	± 1.1 %
Liquid Permittivity (Target)	5.0	Rectangular	√3	0.6	0.49	± 1.7 %	± 1.4 %
Liquid Permittivity (Meas.)	2.5	Normal	1	0.6	0.49	± 1.5 %	± 1.2 %
Combined Standard Uncertainty						± 11.0 %	± 10.8 %
Coverage Factor for 95 %						K=2	
Expanded Uncertainty						**± 22.0 %**	**± 21.5 %**

Table 14.2. Uncertainty Budget for frequency range 300 MHz to 3 GHz

15. References

[1] FCC 47 CFR Part 2 "Frequency Allocations and Radio Treaty Matters; General Rules and Regulations"

[2] ANSI/IEEE Std. C95.1-1992, "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz", September 1992

[3] IEEE Std. 1528-2003, "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003

[4] SPEAG DASY System Handbook

[5] FCC KDB 248227 D01 v02, "SAR Guidance for IEEE 802.11 (WiFi) Transmitters", Mar 2015.

[6] FCC KDB 447498 D01 v05r02, "Mobile and Portable Device RF Exposure Procedures and Equipment Authorization Policies", Feb 2014

[7] FCC KDB 865664 D01 v01r03, "SAR Measurement Requirements for 100 MHz to 6 GHz", Feb 2014.

[8] FCC KDB 865664 D02 v01r01, "RF Exposure Compliance Reporting and Documentation Considerations" May 2013.