SAR Evaluation Report
for
FCC OET Bulletin 65 Supplement C

Report No.: SESF1207032

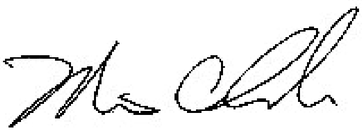
Client	:	BROADCOM CORPORATION
Product	:	802.11g/DRAFT 802.11n WLAN+BLUETOOTH PCI-E MINICARD
Model	:	BCM94313HMGB
FCC ID	:	QDS-BRCM1051I
Manufacturer/ supplier	:	BROADCOM CORPORATION
Date test item received	:	July 6, 2012
Date test campaign completed	:	July 25, 2012
Date of issue	:	July 27,2012
Test Result	:	■Compliance □Not Compliance

Statement of Compliance:

The SAR values measured for the test sample are below the maximum recommended level of 1.6 W/kg averaged over any 1g tissue according to FCC OET Bulletin 65 Supplement C(Edition 01-01, June 2001)

The test result only corresponds to the tested sample. It is not permitted to copy this report, in part or in full, without the permission of the test laboratory.

Total number of pages of this test report: 33 pages

Test Engineer:		Approved by:
		
Jeff Fang		Miro Chueh

The testing described in this report has been carried out to the best of our knowledge and ability, and our responsibility is limited to the exercise of reasonable care. This certification is not intended to believe the sellers from their legal and/or contractual obligations.

Applicant Information

Client	:	BROADCOM CORPORATION
Address	:	190 MATHILDA PLACE SUNNYVALE,CA 94086,U.S.A.
Manufacturer	:	BROADCOM CORPORATION
Address	:	190 MATHILDA PLACE SUNNYVALE,CA 94086,U.S.A.
EUT	:	802.11g/DRAFT 802.11n WLAN+BLUETOOTH PCI-E MINICARD
Model No.	:	BCM94313HMGB
Standard Applied	:	FCC OET 65 Supplement C (Edition 01-01, June 2001) IEEE Standard 1528-2003
Laboratory	:	CERPASS TECHNOLOGY CORP. No.66,Tangzhuang Road, Suzhou Industrial Park, Jiangsu 215006, China.
Test Location	:	No.789, Pu Xing Road, Shanghai, China
Test Result	:	Maximum SAR Measurement 802.11b mode 2472MHz :0.311w/kg

The EUT is in compliance with the FCC Report, and the tests were performed according to the FCC OET65c for uncontrolled exposure.

Contents

Executive Summary

The EUT is a 802.11g/DRAFT 802.11n WLAN+BLUETOOTH PCI-E MINICARD.The product operating in 2.4G frequency ranges. This device contains Wireless function that is operational in 2.4G mode. The measurement was conducted by CERPASS and carried out with the dosimetric assessment system under ALSAS-10-U.

The measurements were conducted according to FCC OET 65 Supplement C [Reference 5] for evaluating compliance with requirements of FCC Report .

1. General Information

1.1. Description of Equipment under Test

EUT Type	Production unit ☒ Identical prototype ☐
EUT	802.11g/DRAFT 802.11n WLAN+BLUETOOTH PCI-E MINICARD
Model Name	BCM94313HMGB
WIFI	
TX Frequency	2412-2472 MHz
RX Frequency	2412-2472 MHz
Antenna Type	Internal PIFA
Device Category	Mobile
RF Exposure Environment	General Population/ Uncontrolled
Crest Factor	1
Bluetooth	
Bluetooth Frequency	2402~2480MHz
Bluetooth Version	V4.0
Type of modulation	FHSS
Data Rate	1Mbps(GFSK), 2Mbps(Pi/4 DQPSK), 3Mbps (8DPSK)

1.2. Description of support units

The SAR evaluation was performed on the following hosts:

Host#	Description	Manufacturer	Model	Overall Dimension
1	Notebook Computer	Lenovo	20191XXXX ; 4941XXXX(X=0-9,A-Z)	N/A

Cable#	Description	Manufacturer	Type	Length
1	N/A	N/A	N/A	N/A

1.3. Environment Condition

Item	Target	Measured
Ambient Temperature(℃)	18~25	22±1
Temperature of Simulant(℃)	20~24	22±1
Relative Humidity(%RH)	30~70	60~70

1.4. FCC Requirement of SAR Compliance Testing

According to the FCC order “Guidelines for Evaluating the Environmental Effects of RF Radiation”, for consumer products, the SAR limit is **1.6 W/kg** for an uncontrolled environment and **8.0 W/kg** for an occupational/controlled environment. Pursuant to the Supplement C of OET Bulletin 65 “Evaluating Compliance with FCC Guide-lines for Human Exposure to Radio frequency Electromagnetic Fields”, released on June 29, 2001 by FCC, the equipment under test should be evaluated at maximum output power (radiated from the antenna) under “worst-case” conditions for intended or normal operation, incorporating normal antenna operating positions, equipment undet test peak performance frequencies and positions for maximum RF power coupling.

1.6.1 RF Exposure Limits

	Whole-Body	Partial-Body	Arms and Legs
Population/ Uncontrolled Environments(W/kg)	0.08	1.6	4.0
Occupational/ Controlled Environments(W/Kg)	0.4	8.0	20.0

Notes:

1. Population/Uncontrolled Environments: Locations where there is the exposure of individuals who have no sense or control of their exposure.
2. Occupational/Controlled Environments: Locations where there is exposure that may be incurred by people who have knowledge of the potential for exposure.
3. Whole-Body: SAR is averaged over the entire body.
4. Partial-Body: SAR is averaged over any 1g of tissue volume as defined in specification.
5. Arms and Legs: SAR is averaged over 10g of tissue volume as defined in specification.

1.5. The SAR Measurement Procedure

1.7.1 General Requirements

The test should be performance in a laboratory without influence on SAR measurements by ambient RF sources and any reflection from the environment inside. The ambient temperature should be kept in the range of 20°C to 22°C with a maximum variation within ± 2°C during the test.

1.7.2 Phantom Requirements

The phantoms used in test are simplified representations of the human head and body as a specific shaped container for the head or body simulating liquids. The physical characteristics of the phantom models should resemble the head and the body of a mobile user since the shape is a dominant parameter for exposure. The shell of the phantom should be made of low loss and low permittivity material and the thickness tolerance should be less than 0.2 mm. In addition, the phantoms should provide simulations of both right and left hand operations.

1.7.3 Test Positions

1. The horizontal-down and horizontal-up of EUT contact to the flat phantom. The transmitted antenna of the EUT located under the reference point of the flat phantom. The separation distance is 5mm between the top of the EUT and the bottom of the flat phantom. The area scan size is 41 x 61 points.
2. The vertical-back and vertical-front of EUT contact to the flat phantom. The transmitted antenna of the EUT located under the reference point of the flat phantom. The separation distance is 5mm between the top of the EUT and the bottom of the flat phantom. The area scan size is 31 x 61 points.

1.7.4 Test Procedures

The EUT working at 2.4G mode. Then record the conducted power before the testing. Place the EUT to the specific test location. After the testing, must writing down the conducted power of the EUT into the report. The SAR value was calculated via the 3D spine interpolation algorithm that has been implemented in the software of ALSAS-10-U SAR measurement system manufactured and calibrated by APREL.

2. Description of the Test Equipment

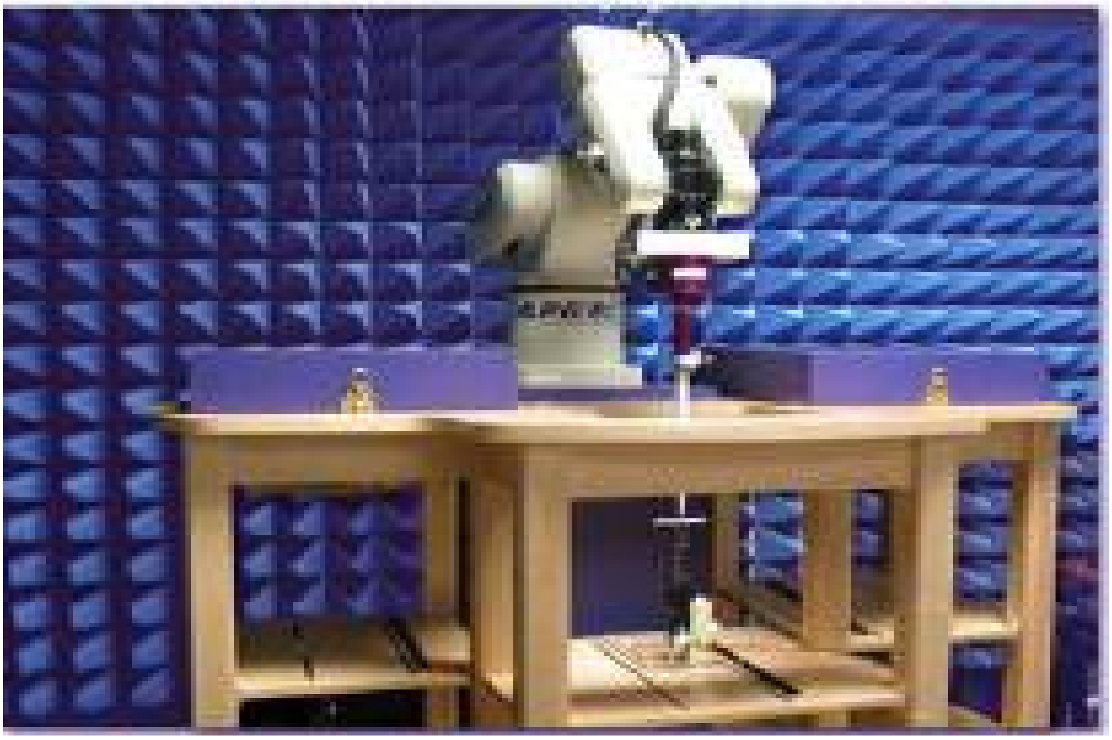
ALSAS-10-U is fully compliant with the technical and scientific requirements of IEEE 1528, IEC 62209, CENELEC, ARIB, ACA, and the Federal Communications Commission. The system comprises of a six axes articulated robot which utilizes a dedicated controller. ALSAS-10U uses the latest methodologies and FDTD order to provide a platform which is repeatable with minimum uncertainty. Applications:Predefined measurement procedures compliant with the guidelines of CENELEC, IEEE, IEC, FCC, etc are utilized during the assessment for the device. Automatic detection for all SAR maxima are embedded within the core architecture for the system, ensuring that peak locations used for centering the zoom scan are within a 1mm resolution and a 0.05mm repeatable position. System operation range currently is available up to 6 GHz in simulated tissue.

2.1. Test Equipment List

Instrument	Manufacture	Model No.	Serial No.	Calibration Date	Valid Date.
Universal Work Station	Aprel	ALS-UWS	100-00154	NCR	NCR
Data Acquisition Package	Aprel	ALS-DAQ-PAQ-3	110-00215	NCR	NCR
Probe Mounting Device and Boundary Detection Sensor System	Aprel	ALS-PMDPS-3	120-00265	NCR	NCR
Miniature isotropic RF Probe	Aprel	E-020	500-00273	Oct.01,2011	Oct.01,2012
Left ear SAM Phontom	Aprel	ALS-P-SAM-L	130-00312	NCR	NCR
Right ear SAM Phontom	Aprel	ALS-P-SAM-R	140-00362	NCR	NCR
Universal SAM Phontom	Aprel	ALS-P-SU-1	150-00410	NCR	NCR
Reference Validation Dipole 835MHz	Aprel	ALS-D-835-S-2	180-00556	May.17,2012	May.17,2013
Reference Validation Dipole 1900MHz	Aprel	ALS-D-1900-S-2	210-00707	May.16,2012	May.16,2013
Reference Validation Dipole 2450MHz	Aprel	ALS-D-2450-S-2	220-00755	May19,2012	May19,2013
Dielectric Probe Kit	Aprel	ALS-PR-DIEL	260-00955	NCR	NCR
Device Holder 2.0	Aprel	ALS-H-E-SET-2	170-00506	NCR	NCR
SAR software	Aprel	ALS-SAR-AL-10	Ver.2.3.6	NCR	NCR
CRS C500C Controller	Thermo	ALS-C500	RCF0504291	NCR	NCR
CRS F3 Robot	Aprel	ALS-F3-SW	N/A	NCR	NCR
Power Amplifier	Mini-Circuit	SN0974	040306	Jul.13,2012	Jul.13,2013
Directional Coupler	Agilent	778D-012	N/A	Jul.13,2012	Jul.13,2013
Universal Radio Communication Tester	Rohde&Schwarz	CMU200	104845	Mar.11,2012	Mar.11,2013
Vector Network	Anritsu	MS4623B	N/A	Jul.18,2012	Jul.18,2013
Signal Generator	Agilent	E8257D	N/A	Dec.14,2011	Dec.14,2012
Power Meter	Rohde&Schwarz	NRP	N/A	Dec.14,2011	Dec.14,2012

2.2. ALSAS-10-U Measurement System

The ALSAS-10-U Measurement System



The ALSAS-10-U system consists of the following items:

- A fixed-on-ground high precision 6-axis robot with controller and software and an arm extension for moving the DAQ-PAQ and Probe.
- A dosimetric probe, an isotropic E-field probe optimized and calibrated for usage in head or body tissue simulating liquids. Some of the probes are equipped with an optical surface detector system.
- A DAQ-PAQ performing the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. DAQ-PAQ is powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- A unit to operate the optical surface detector which is connected to Electro-Optical Coupler (EOC).
- The EOC performs the conversion from the optical into a digital electric signal of the DAQ-PAQ. The EOC is connected to the ALSAS-10-U measurement server.
- The ALSAS-10-U measurement server performing all real-time data evaluation for field measurements and surface detection, controlling robot movements and handling safety operation..
- Remote control with teach panel and additional circuitry for robot safety such as warning lamps, etc.
- The generic twin phantom enabling the testing of left-hand and right-hand usage.
- The device holder for handheld mobile phones.
- Tissue simulating liquid mixed well according to the given recipes.
- System validation dipoles is used to validate the proper functioning of the system

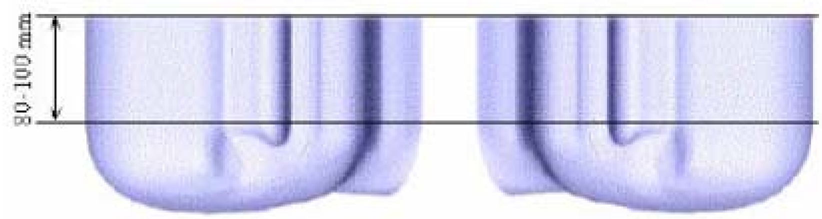
2.3. DAQ-PAQ (Analog to Digital Electronics)

ALSAS-10U incorporates a fully calibrated SAQ-PAQ (analog to digital conversion system) which has a 4 channel input stage, sent via a 2 stage auto-set amplifier module. The input signal is amplified accordingly so as to offer a dynamic range from 5μV to 800mV. Integration of the fields measured is carried out at board level utilizing a Co-Processor which then sends the measured fields down into the main computational module in digitized form via a RS232 communications port. Probe linearity and duty cycle compensation is carried out within the main DAQ-PAQ module.

ADC	12 Bit
Amplifier Range	20mV to 200mV and 150mV to 800mV
Field Integration	Local Co-Processor utilizing proprietary integration algorithms
Number of Input Channels	4 in total 3 dedicated and 1 spare
Communication	Packet data via RS232

2.4. APREL Phantom

The SAM phantoms developed using the IEEE SAM CAD file. They are fully compliant with the requirements for both IEEE 1528 and FCC Supplement C. Both the left and right SAM phantoms are interchangeable, transparent and include the IEEE 1528 grid with visible NF and MB lines



APREL Laboratories Universal Phantom

The Universal Phantom is used on the ALSAS-10U as a system validation phantom. The Universal Phantom has been fully validated both experimentally from 800MHz to 6GHz and numerically using XFDTD numerical software. The shell thickness is 2mm overall, with a 4mm spacer located at the NF/MB intersection providing an overall thickness of 6mm in line with the requirements of IEEE-1528.

The design allows for fast and accurate measurements, of handsets, by allowing the conservative SAR to be evaluated at on frequency for both left and right head experiments in one measurement.

2.5. Device Holder

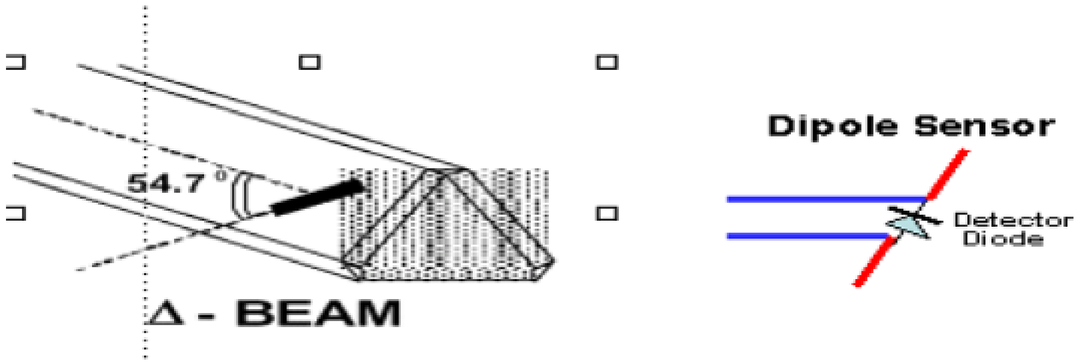
The universal device positioner allows complete freedom of movement of the EUT. Developed to hold a EUT in a free-space scenario any additional loading attributable to the material used in the construction of the positioner has been eliminated. Repeatability has been enhanced through the linear scales which form the design used to indicate positioning for any given test scenario in all major axes. A 15°tilt movements for head SAR analysis. Overall uncertainty for measurements has been reduced due to the design of the Universal device positioner, which allows positioning of a device in as near to a free-space scenario as possible, and by providing the means for complete repeatability.

2.6. Specification of probes

The isotropic E-Field probe has been fully calibrated and assessed for isotropic, and boundary effect within a controlled environment. Depending on the frequency for which the probe is calibrated the method utilized for calibration will change. A number of methods is used for calibrating probes, and these are outlined in the table below:

Calibration Frequency	Air Calibration	Tissue Calibration
900MHz	TEM Cell	Temperature
1800MHz	TEM Cell	Temperature

The E-Field probe utilizes a triangular sensor arrangement as detailed in the diagram below:



SAR is assessed with a calibrated probe which moves at a default height of 5mm from the center of the diode, which is mounted to the sensor, to the phantom surface (in the Z Axis). The 5mm offset height has been selected so as to minimize any resultant boundary effect due to the probe being in close proximity to the phantom surface.

The following algorithm is an example of the function used by the system for linearization of the output from the probe when measuring complex modulation schemes.

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

Calibration in Air	Frequency Dependent Below 2GHz Calibration in air performed in a TEM Cell Above 2GHz Calibration in air performed in waveguide
Sensitivity	0.70 μV/(V/m)^2 to 0.85 μV/(V/m)^2
Dynamic Range	0.0005 W/kg to 100W/kg
Isotropic Response	Better than 0.2dB
Diode Compression point (DCP)	Calibration for Specific Frequency
Probe Tip Radius	< 5mm
Sensor Offset	1.56 (+/- 0.02mm)
Probe Length	290mm
Video Bandwidth	@ 500 Hz: 1dB @1.02 KHz: 3dB
Boundary Effect	Less than 2% for distance greater than 2.4mm
Spatial Resolution	Diameter less than 5mm Compliant with Standards

Boundary detection Unit and Probe Mounting Device

ALSAS-10U incorporates a boundary detection unit with a sensitivity of 0.05mm for detecting all types of surfaces. The robust design allows for detecting during probe tilt (probe normalize) exercises, and utilizes a second stage emergency stop. The signal electronics are directly into the robot controller for high accuracy surface detection in lateral and axial detection modes (X, Y, &Z).

The probe is mounted directly onto the Boundary Detection unit for accurate tooling and displacement calculations controlled by the robot kinematics. The probe is connected to an isolated probe interconnect where the output stage of the probe is fed directly into the amplifier stage of the DAQ-PAQ.

2.7. SAR Measurement Procedures in ALSAS-10-U

Step 1 Setup a transmit

Establish a transmit at the required power in line with product specification, at each frequency relating to the LOW, MID, and HIGH channel settings.

Step 2 Power Reference Measurements

To measure the local E-field value at a fixed location which value will be taken as a reference value for calculating a possible power drift.

Step 3 Area Scan

To measure the SAR distribution with a grid with spacing of 15 mm x 15 mm and kept with a constant distance to the inner surface of the phantom. Additional all peaks within 3 dB of the maximum SAR are searched.

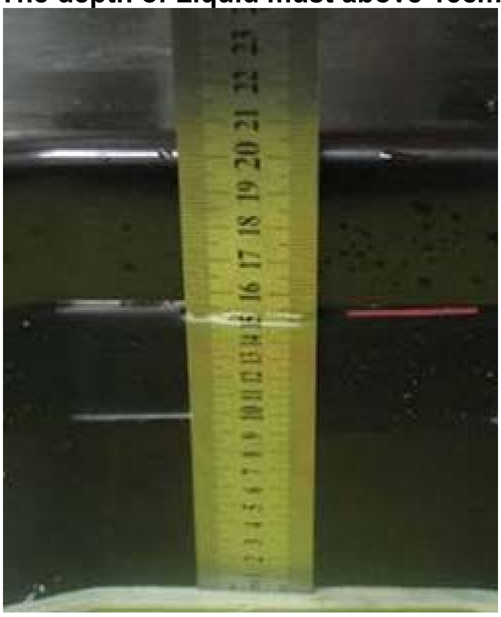
Step 4 Zoom Scan

At these points (maximum number of SAR peaks is two), a cube of 30 mm x 30 mm x 30 mm is applied to and measured with 7 x 7 x 7 points. With these measured data, a peak spatial-average SAR value can be calculated by APREL software.

Step 5 Power Drift Measurements

Repetition of the E-field measurement at the fixed location mentioned in Step 1 to make sure the two results differ by less than ± 0.2 dB.

The depth of Liquid must above 15cm



2.8. System Performance Check

2.8.1 Purpose

1. To verify the simulating liquids are valid for testing.
2. To verify the performance of testing system is valid for testing.

2.8.2 System Performance Check Procedure

The ALSAS-10-U installation includes predefined files with recommended procedures for measurements and the system performance check. They are read-only document files and destined as fully defined but unmeasured masks, so the finished system performance check must be saved under a different name. The system performance check document requires the SAM Twin Phantom, so this phantom must be properly installed in your system. (User defined measurement procedures can be created by opening a new document or editing an existing document file). Before you start the system performance check, you need only to tell the system with which components (probe, medium, and device) you are performing the system performance check; the system will take care of all parameters.

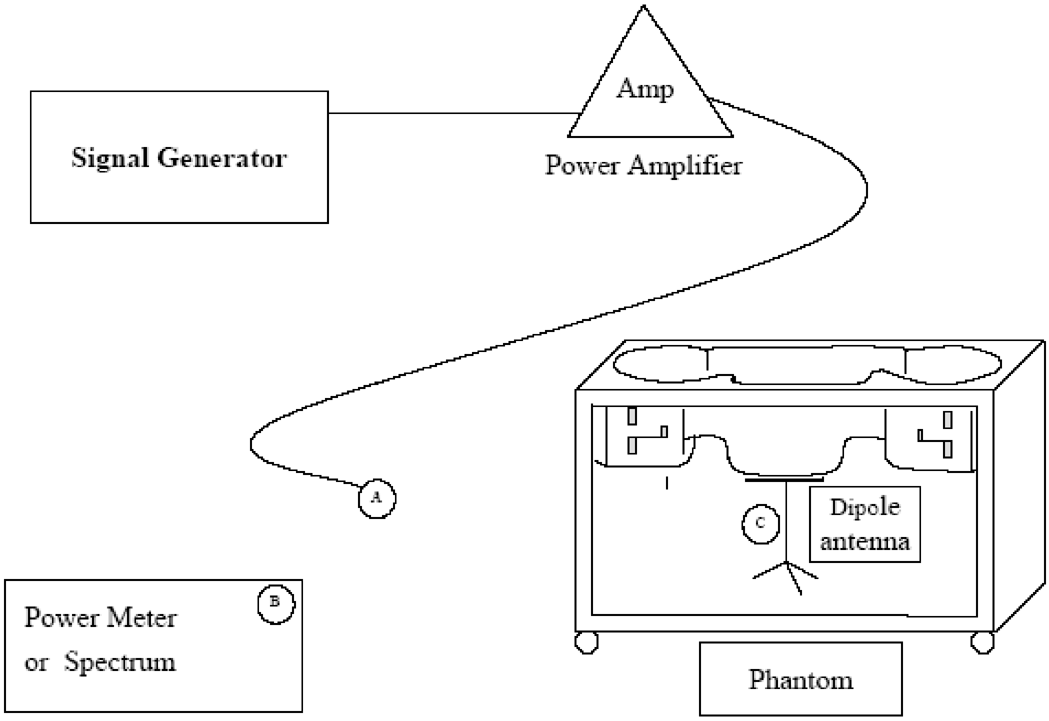
• **The Power Reference Measurement and Power Drift Measurement** jobs are located at the beginning and end of the batch process. They measure the field drift at one single point in the liquid over the complete procedure. The indicated drift is mainly the variation of the amplifier output power. If it is too high (above ±0.1 dB), the system performance check should be repeated; some amplifiers have very high drift during warm-up. A stable amplifier gives drift results in the ALSAS-10-U system below ±0.02 dB.

• **The Surface Check** job tests the optical surface detection system of the ALSAS-10-U system by repeatedly detecting the surface with the optical and mechanical surface detector and comparing the results. The output gives the detecting heights of both systems, the difference between the two systems and the standard deviation of the detection repeatability. Air bubbles or refraction in the liquid due to separation of the sugar-water mixture gives poor repeatability (above ±0.1mm). In that case it is better to abort the system performance check and stir the liquid.

• **The Area Scan** job measures the SAR above the dipole on a plane parallel to the surface. It is used to locate the approximate location of the peak SAR. The proposed scan uses large grid spacing for faster measurement; due to the symmetric field, the peak detection is reliable. APREL Lab, ALSAS-10-U Manual, System Performance Check Application Notes If a finer graphic is desired, the grid spacing can be reduced. Grid spacing and orientation have no influence on the SAR result.

• **The Zoom Scan** job measures the field in a volume around the peak SAR value assessed in the previous Area Scan job (for more information see the application note on SAR evaluation). If the system performance check gives reasonable results, the SAR peak, 1 g and 10 g spatial average SAR values normalized to 1W dipole input power give reference data for comparisons. The next sections analyze the expected uncertainties of these values, as well as additional checks for further information or troubleshooting.

2.8.3 System Performance Check Setup



Note：

1. A connected to B is used to make sure whether the input power is 250mW for target frequency..
2. A connected to C is used to input the measured power to dipole antenna

2.8.4 Result of System Performance Check: Valid Result

Test date:2012-7-25

Date of Measurement And Reference Value	SAR@1g [W/kg]	Dielectric Parameters		Temperatures [℃]
		ε r	σ [S/m]	
Body 2450MHz Recommended Value	52.592±10% [49.962~55.222]	52.7 ±10% [50.065~55.335]	1.95 ± 5% [1.852~2.048]	20.0 ± 2 [18 ~ 22]
	51.292	53.45	1.97	20.7

2.9. Tissue Dielectric Parameters for Head and Body Phantoms

The head tissue dielectric parameters recommended by the IEEE SCC-34/SC-2 in PP1528 have been incorporated in the following table. These head parameters are derived from planar layer models simulating the highest expected SAR for the dielectric properties and tissue thickness variations in a human head. Other head and body tissue parameters that have not been specified in P1428 are derived from the tissue dielectric parameters computed from the 4-Cole-Cole equations described in Reference [12] and extrapolated according to the head parameters specified in P1528.

Target Frequency	Head		Body	
(MHz)	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
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
1610	40.3	1.29	53.8	1.40
1800 – 2000	40.0	1.40	53.3	1.52
2450	39.2	1.80	52.7	1.95
3000	38.5	2.40	52.0	2.73
5800	35.3	5.27	48.2	6.00

(ε_γ=relative permittivity, σ=conductivity and ρ=1000 Kg/m^3)

2.10. Probe Calibration Method

Probes are calibrated using the following methods.
<1000MHz
TEM Cell for sensitivity in air
Standard phantom using temperature transfer method for sensitivity in tissue
>1000MHz
Waveguide* method to determine sensitivity in air and tissue
*Waveguide is numerically (simulation) assessed to determine the field distribution and power
The boundary effect for the probe is assessed using a standard flat phantom where the probe output is compared against a numerically simulated series of data points

References

o IEEE Standard 1528 (2003) including Amendment 1
IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques
o EN 62209-1 (2006)
Human Exposure to RF Fields from hand-held and body-mounted wireless communication devices - Human models. instrumentation, and procedures-Part 1: Procedure to measure the Specific Absorption Rate (SAR) for hand-held mobile wireless devices
o IEC 62209-2 Ed. 1.0 (2010-03)
Human exposure to RF fields from hand-held and body-mounted wireless devices - Human models, instrumentation, and procedures - Part 2: specific absorption rate (SAR) for wireless communication devices (30 MHz - 6 GHz)
o TP-D01-032-E020-V2 E-Field probe calibration procedure
o D22-012-Tissue dielectric tissue calibration procedure
o D28-002-Dipole procedure for validation of SAR system using a dipole
o IEEE 1309 Draft Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas, from 9kHz to 40GHz

3. Results

3.1. Summary of Test Results

No deviations form the technical specification(s) were ascertained in the course of the tests performed	■
The deviations as specified in this chapter were ascertained in the course of the tests Performed.	□

3.2. Description for EUT test position

The following procedure had been used to prepare the EUT for the SAR test.

o The client supplied a special driver to program the EUT, allowing it to continually transmit the specified maximum power and change the channel frequency.

o The output power(dBm) we measured before SAR test in different channel

o Performing the highest output power channel first

o SAR test Tip edge and Bottom Flat mode.

3.3. Conducted power:

Test mode	Channel No.	Frequency(MHz)	Average power(dBm)
802.11b	01	2412	14.46
	06	2437	14.64
	13	2472	14.91
802.11g	01	2412	9.28
	06	2437	9.76
	13	2472	10.02
802.11n (20MHz)	01	2412	9.15
	06	2437	9.58
	13	2472	9.93

Note: 1. Average Power test was verified over all data rates of each mode, and the data rates listed above showed the worst case for average power.

2. According to the KDB 248227. SAR is not required for 802.11g/n channels when the maximum average output power is less than 1/4 dB higher than that measured on the corresponding 802.11b channels.

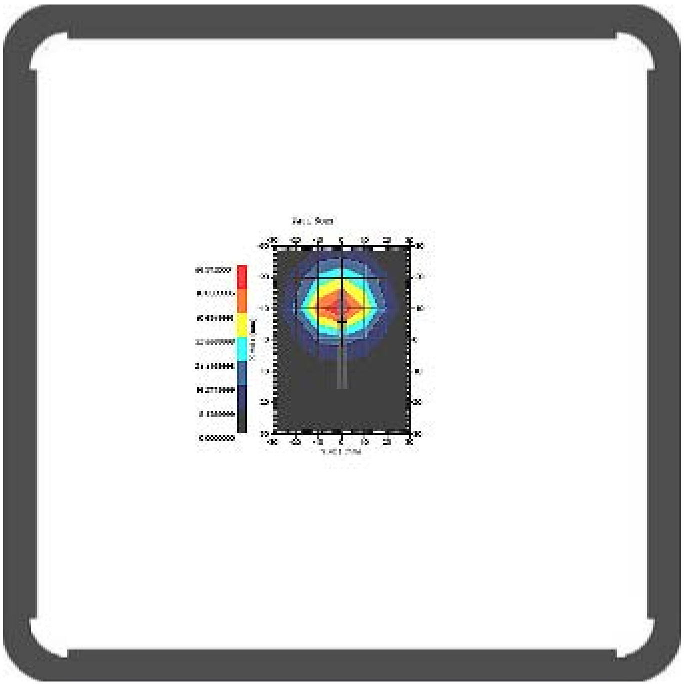
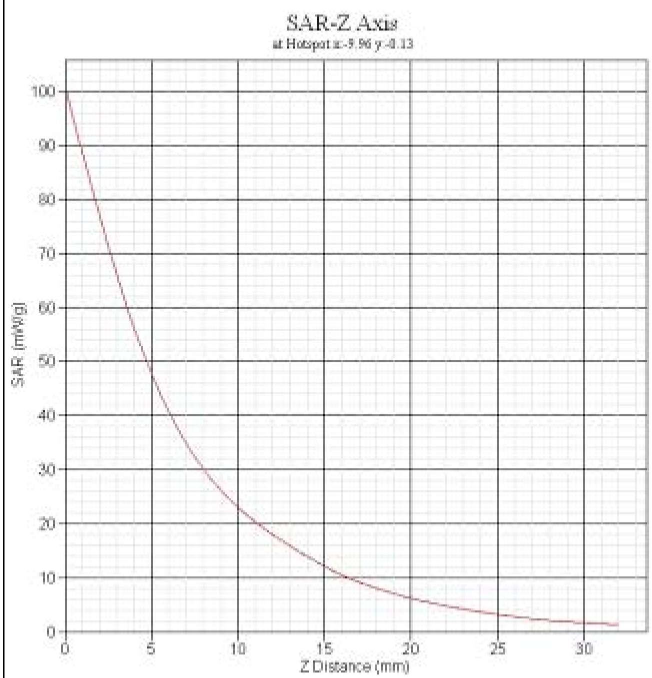
3.4. Co-located SAR

Bluetooth output power is less than Pref, and the distance between WiFi and BT is 104mm.Therefore, standalone SAR and simultaneous SAR for Bluetooth is not required.

3.5. Check the position for the worst result

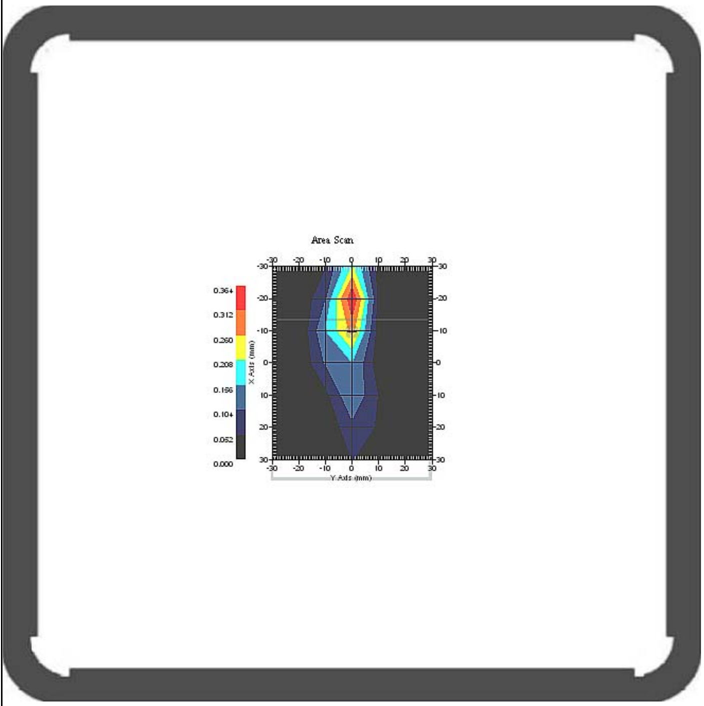
SAR MEASUREMENT					
Test date:2012-7-25					
Ambient Temperature (°C): 21.2 ± 2			Relative Humidity (%): 46		
Liquid Temperature (°C): 20.5 ± 2			Depth of Liquid (cm):>15		
Test Mode: 802.11b					
Test Position Body	Antenna Position	Frequency		SAR 1g (W/kg)	Limit (W/kg)
		Channel	MHz		
Bottom	Internal	1	2412	0.269	1.6
Bottom	Internal	6	2437	0.292	1.6
Bottom	Internal	13	2472	0.311	1.6
Test Mode: 802.11g					
Test Position Body	Antenna Position	Frequency		SAR 1g (W/kg)	Limit (W/kg)
		Channel	MHz		
Bottom	Internal	13	2472	0.057	1.6
Test Mode: 802.11n					
Test Position Body	Antenna Position	Frequency		SAR 1g (W/kg)	Limit (W/kg)
		Channel	MHz		
Bottom	Internal	13	2472	0.020	1.6

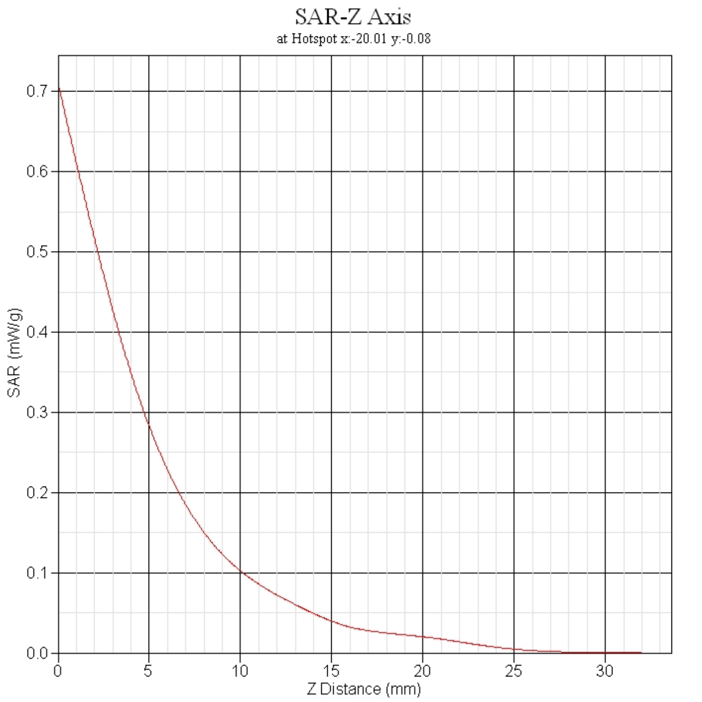
SAR System Validation Data

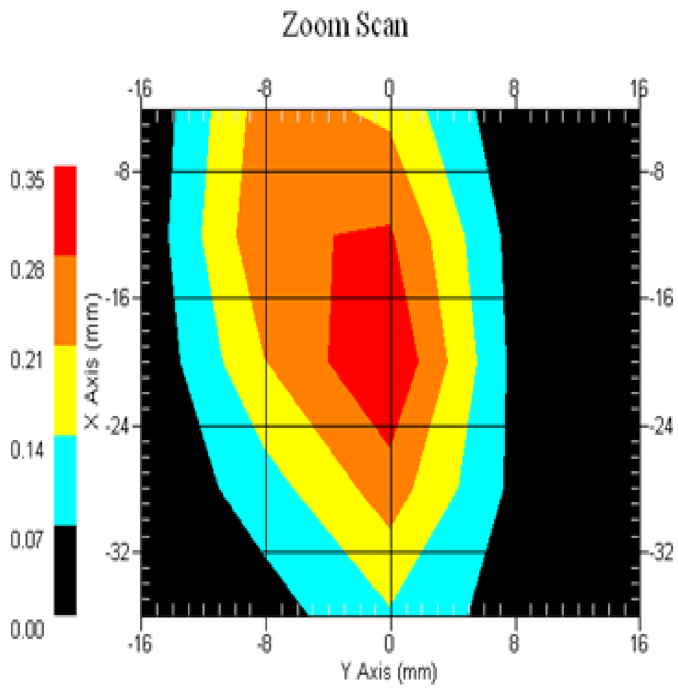
Frequency(MHz)	2450
Medium	MSL2450
Relative permittivity(real part)	53.45
Conductivity(S/m)	1.97
Variation(%)	-0.234
Duty Cycle Factor	1
Crest factor	1
Conversion Fator	4.4
Probe Sensitivity	1.20 1.20 1.20 µV/(V/m)2
Area Scan	7x7x1 : Measurement x=10mm, y=10mm, z=4mm
Zoom Scan	5x5x8 : Measurement x=8mm, y=8mm, z=4mm
Data	2012-07-25
	
SAR 1g(W/Kg)	51.292
SAR 10g(W/Kg)	24.317
Area Scan Peak SAR(W/Kg)	56.972
Zoom Scan Peak SAR(W/Kg)	100.860

SAR Measurement Data

802.11b CH1	
Frequency(MHz)	2412
Medium	MSL2450
Relative permittivity(real part)	53.45
Conductivity(S/m)	1.97
Variation(%)	-2.146
Duty Cycle Factor	1
Crest factor	1
Conversion Fator	4.4
Probe Sensitivity	1.20 1.20 1.20 μV/(V/m)2
Area Scan	7x7x1 : Measurement x=10mm, y=10mm, z=4mm
Zoom Scan	5x5x8 : Measurement x=8mm, y=8mm, z=4mm
Data	2012-07-25

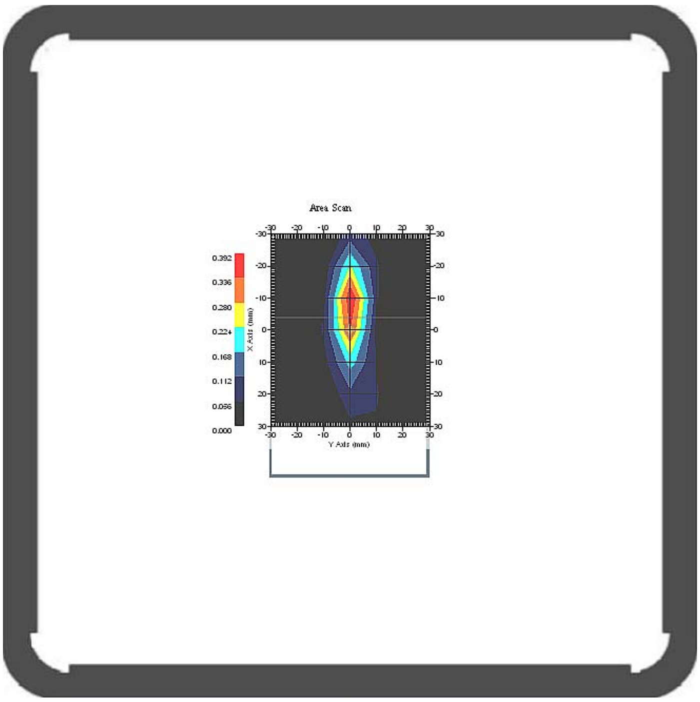


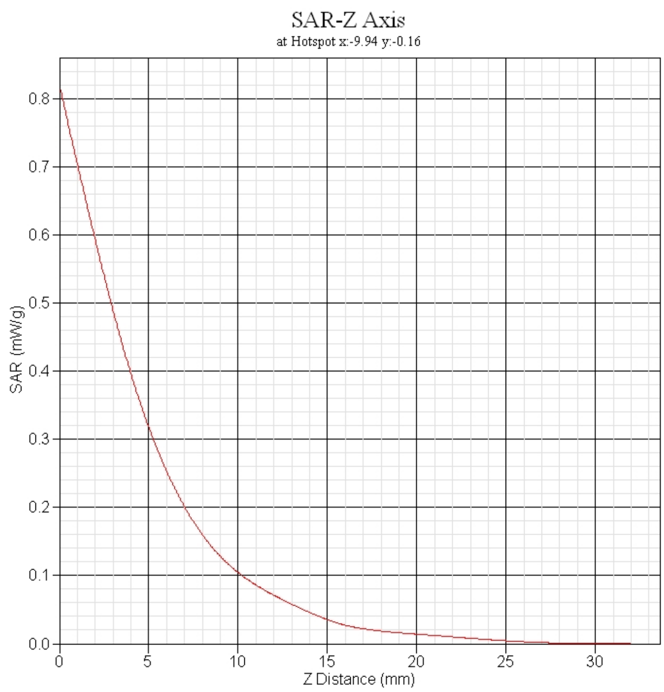


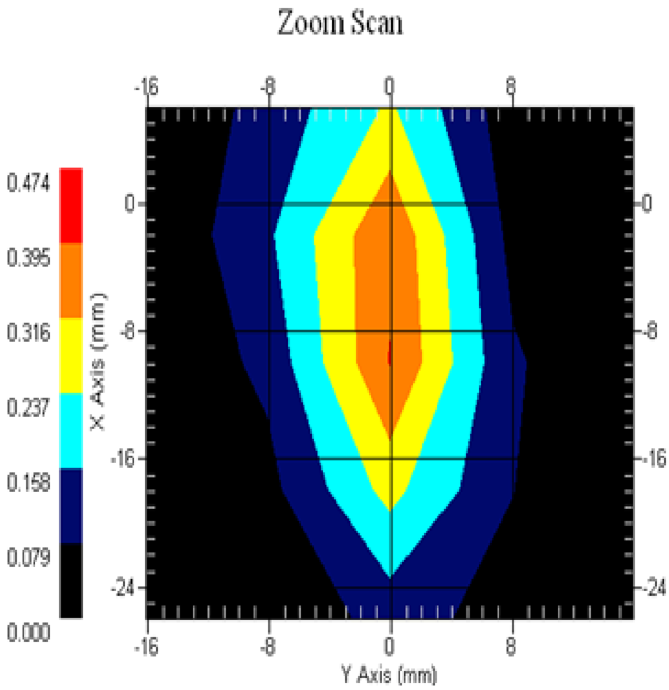


SAR 1g(W/Kg)	0.269
SAR 10g(W/Kg)	0.096
Area Scan Peak SAR(W/Kg)	0.362
Zoom Scan Peak SAR(W/Kg)	0.710

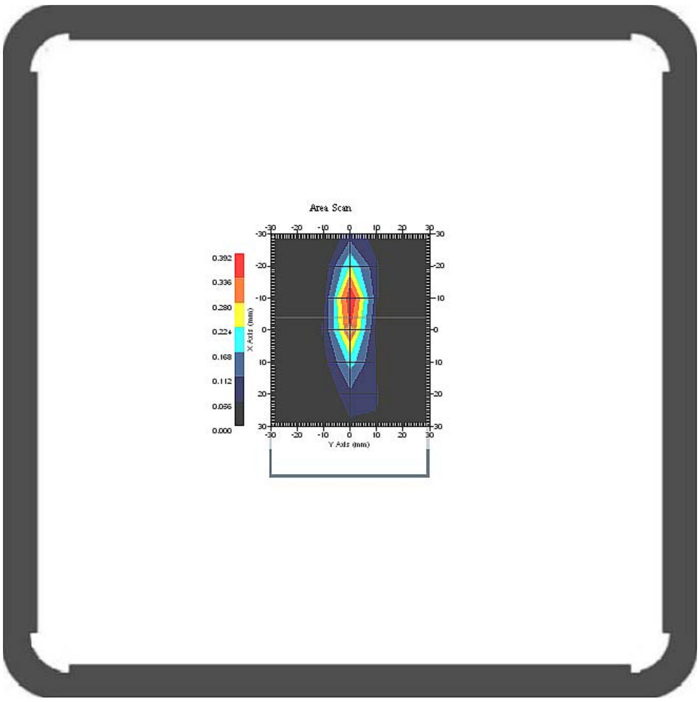
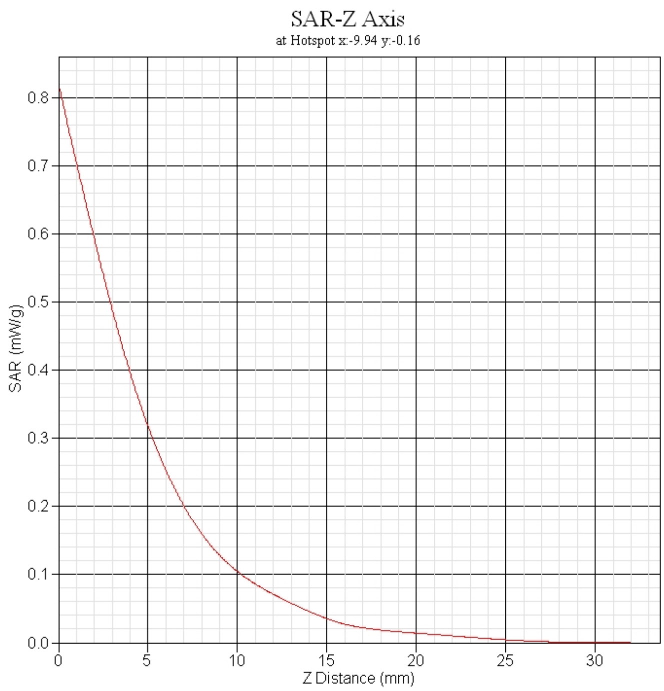
802.11b CH6	
Frequency(MHz)	2437
Medium	MSL2450
Relative permittivity(real part)	53.45
Conductivity(S/m)	1.97
Variation(%)	-2.463
Duty Cycle Factor	1
Crest factor	1
Conversion Fator	4.65
Probe Sensitivity	1.20 1.20 1.20 μV/(V/m)2
Area Scan	7x7x1 : Measurement x=10mm, y=10mm, z=4mm
Zoom Scan	5x5x8 : Measurement x=8mm, y=8mm, z=4mm
Data	2012-07-25

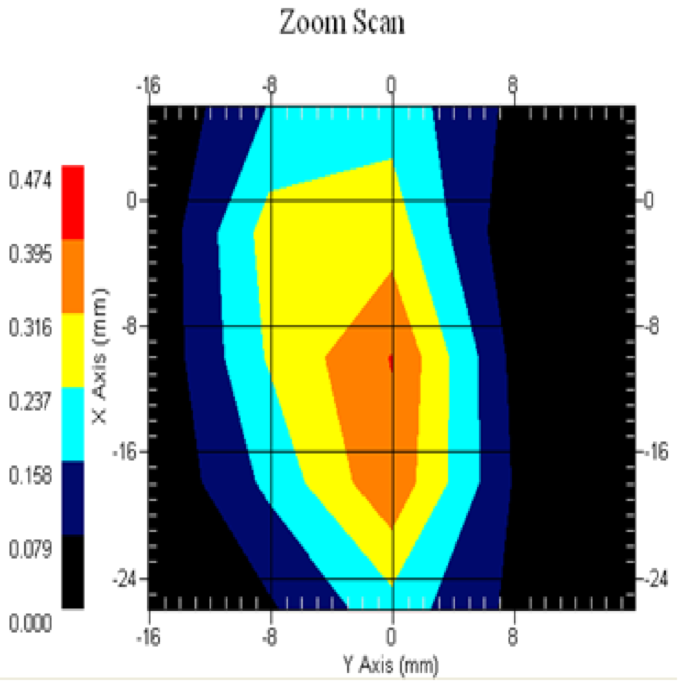




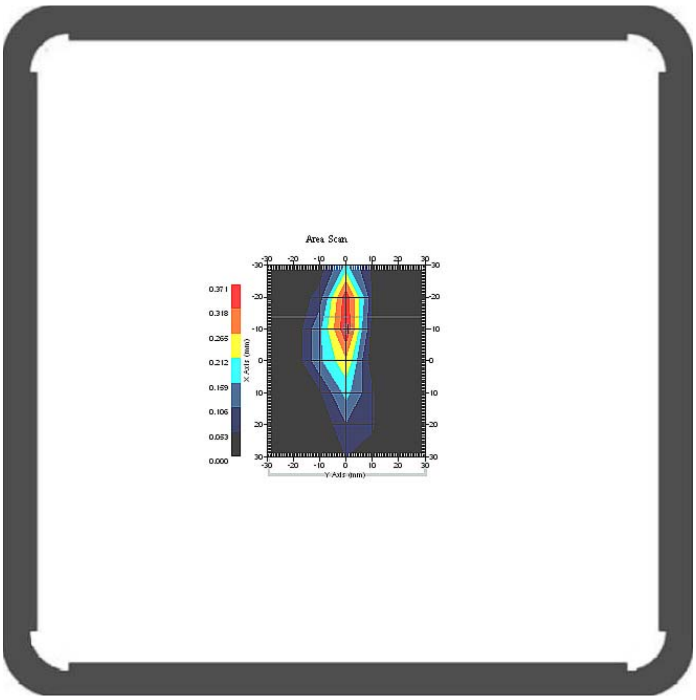
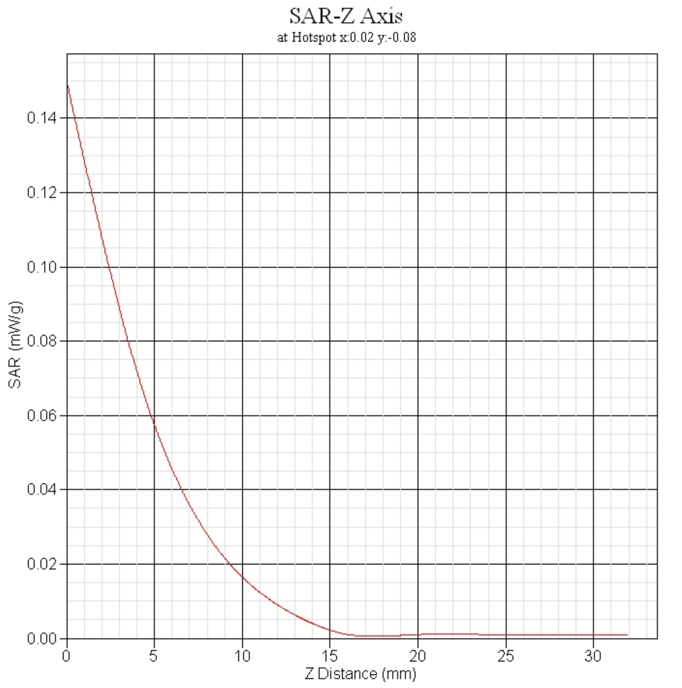


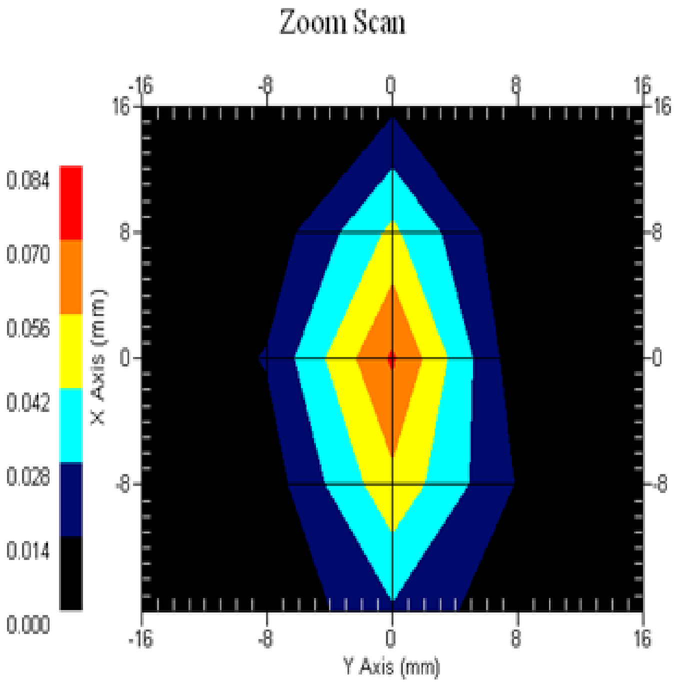
SAR 1g(W/Kg)	0.292
SAR 10g(W/Kg)	0.090
Area Scan Peak SAR(W/Kg)	0.391
Zoom Scan Peak SAR(W/Kg)	0.820

802.11b CH13	
Frequency(MHz)	2472
Medium	MSL2450
Relative permittivity(real part)	53.45
Conductivity(S/m)	1.97
Variation(%)	-1.451
Duty Cycle Factor	1
Crest factor	1
Conversion Fator	4.65
Probe Sensitivity	1.20 1.20 1.20 μV/(V/m)2
Area Scan	7x7x1 : Measurement x=10mm, y=10mm, z=4mm
Zoom Scan	5x5x8 : Measurement x=8mm, y=8mm, z=4mm
Data	2012-07-25
	



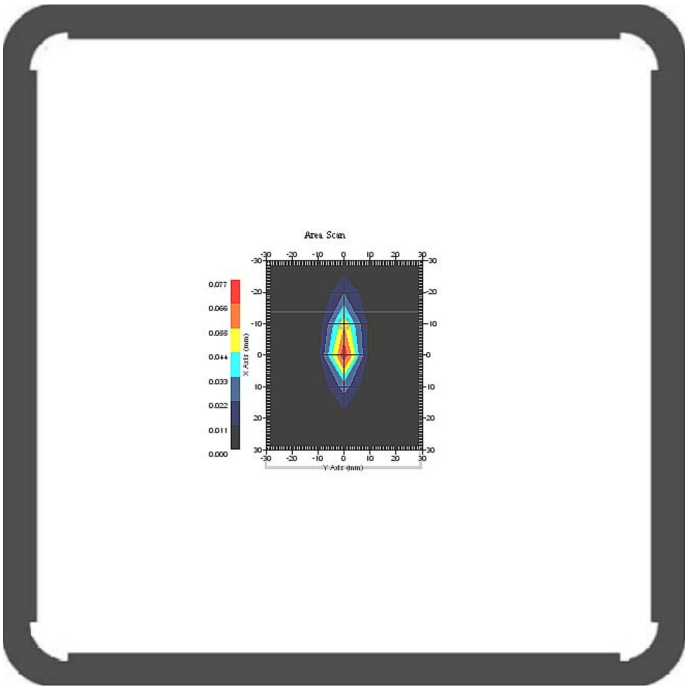
SAR 1g(W/Kg)	0.311
SAR 10g(W/Kg)	0.107
Area Scan Peak SAR(W/Kg)	0.358
Zoom Scan Peak SAR(W/Kg)	0.826

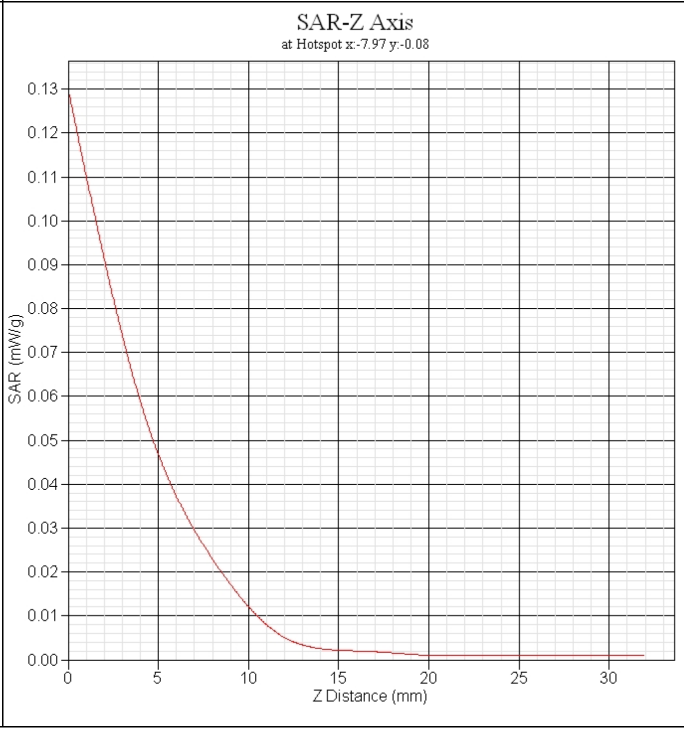
802.11g CH13	
Frequency(MHz)	2472
Medium	MSL2450
Relative permittivity(real part)	53.45
Conductivity(S/m)	1.97
Variation(%)	-1.356
Duty Cycle Factor	1
Crest factor	1
Conversion Fator	4.65
Probe Sensitivity	1.20 1.20 1.20 μV/(V/m)2
Area Scan	7x7x1 : Measurement x=10mm, y=10mm, z=4mm
Zoom Scan	5x5x8 : Measurement x=8mm, y=8mm, z=4mm
Data	2012-07-25
	

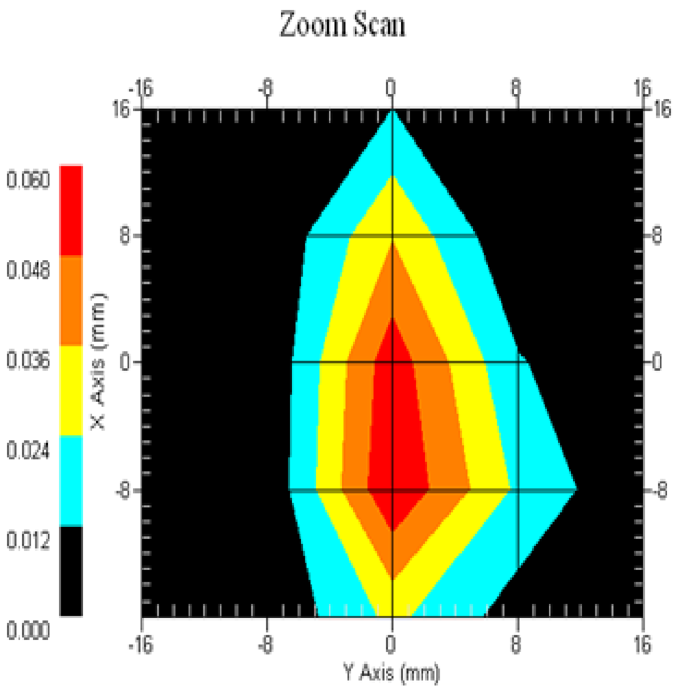


SAR 1g(W/Kg)	0.057
SAR 10g(W/Kg)	0.021
Area Scan Peak SAR(W/Kg)	0.079
Zoom Scan Peak SAR(W/Kg)	0.162

802.11n CH13	
Frequency(MHz)	2472
Medium	MSL2450
Relative permittivity(real part)	53.45
Conductivity(S/m)	1.97
Variation(%)	-1.412
Duty Cycle Factor	1
Crest factor	1
Conversion Fator	4.4
Probe Sensitivity	1.20 1.20 1.20 μV/(V/m)2
Area Scan	7x7x1 : Measurement x=10mm, y=10mm, z=4mm
Zoom Scan	5x5x8 : Measurement x=8mm, y=8mm, z=4mm
Data	2012-07-25







SAR 1g(W/Kg)	0.020
SAR 10g(W/Kg)	0.017
Area Scan Peak SAR(W/Kg)	0.061
Zoom Scan Peak SAR(W/Kg)	0.142

4. The Description of Test Procedure for FCC

4.1. Scan Procedure

First coarse scans were used for determination of the field distribution. Next a cube scan, 5x5x7 points covering a volume of 32x32x30mm was performed around the highest E-field value to determine the averaged SAR value. Drift was determined by measuring the same point at the start of the coarse scan and again at the end of the cube scan.

4.2. SAR Averaging Methods

The maximum SAR value was averaged over a cube of tissue using interpolation and extrapolation. The interpolation, extrapolation and maximum search routines within ALSAS-10-U are all based on the modified Quadratic Shepard's method (Robert J. Renka, "Multivariate Interpolation Of Lagre Sets Of Scattered Data", University of North Texas ACM Transactions on Mathematical Software, vol. 14, no. 2, June 1988, pp. 139-148).

The interpolation scheme combines a least-square fitted function method with a weighted average method. A trivariate 3-D / bivariate 2-D quadratic function is computed for each measurement point and fitted to neighbouring points by a least-square method. For the cube scan, inverse distance weighting is incorporated to fit distant points more accurately. The interpolating function is finally calculated as a weighted average of the quadratics. In the cube scan, the interpolation function is used to extrapolate the Peak SAR from the deepest measurement points to the inner surface of the phantom.

4.3. Data Storage

The ALSAS-10-U software stores the assessed data from the data acquisition electronics as raw data (in microvolt readings from the probe sensors), together with all the necessary software parameters for the data evaluation (probe calibration data, liquid parameters and device frequency and modulation data) in measurement files with the extension .DA4. The post processing software evaluates the desired unit and format for output each time the data is visualized or exported. This allows verification of the complete software setup even after the measurement and allows correction of erroneous parameter settings.

The measured data can be visualized or exported in different units or formats, depending on the selected probe type (e.g., [V/m], [A/m] or [W/kg]). Some of these units are not available in certain situations or give meaningless results, e.g., a SAR-output in a lossless media will always be zero. Raw data can also be exported to perform the evaluation with other software packages.

4.4. Data Evaluation

The ALSAS-10-U post processing software automatically executes the following procedures to calculate the field units from the microvolt readings at the probe connector. The parameters used in the evaluation are stored in the configuration modules of the software:

Probe parameters:	- Sensitivity	$Norm_i$, a_{i0}, a_{i1}, a_{i2}
	- Conversion factor	$ConvF_i$
	- Diode compression point	dcp_i
Device parameters:	- Frequency	f
	- Crest factor	cf
Media parameters:	- Conductivity	σ
	- Density	ρ

These parameters must be set correctly in the software. They can be found in the component documents or be imported into the software from the configuration files issued for the ALSAS-10-U components. In the direct measuring mode of the multi-meter option, the parameters of the actual system setup are used. In the scan visualization and export modes, the parameters stored in the corresponding document files are used.

The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics. If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power. The formula for each channel can be given as:

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

with	V_i	= Compensated signal of channel i	(i = x, y, z)
	U_i	= Input signal of channel i	(i = x, y, z)
	cf	= Crest factor of exciting field	(ALSAS-10-U parameter)
	dcp_i	= Diode compression point	(ALSAS-10-U parameter)

From the compensated input signals the primary field data for each channel can be evaluated:

E-field probes: $$E_i = \sqrt{\frac{V_i}{Norm_i \bullet ConvF}}$$

H-field probes: $$H_i = \sqrt{Vi} \cdot \frac{a_{i10} + a_{i11} f + a_{i12} f^2}{f}$$

with V_i = Compensated signal of channel i (i = x, y, z)

$Norm_i$ = Sensor sensitivity of channel i (i = x, y, z)

μV/(V/m)^2 for E0field Probes

ConvF = Sensitivity enhancement in solution

aij = Sensor sensitivity factors for H-field probes

f = Carrier frequency (GHz)

Ei = Electric field strength of channel i in V/m

Hi = Magnetic field strength of channel i in A/m

The RSS value of the field components gives the total field strength (Hermitian magnitude):

$$E_{tot} = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

The primary field data are used to calculate the derived field units.

$$SAR = E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1000}$$

with *SAR* = local specific absorption rate in mW/g

E_{tot} = total field strength in V/m

σ = conductivity in [mho/m] or [Siemens/m]

ρ = equivalent tissue density in g/cm^3

Note that the density is normally set to 1 (or 1.06), to account for actual brain density rather than the density of the simulation liquid.

The power flow density is calculated assuming the excitation field as a free space field.

$$P_{pwe} = \frac{E_{tot}^2}{3770} \quad \text{or} \quad P_{pwe} = H_{tot}^2 \cdot 37.7$$

with P_{pwe} = Equivalent power density of a plane wave in mW/cm^2

E_{tot} = total electric field strength in V/m

H_{tot} = total magnetic field strength in A/m

5. Measurement Uncertainty

Exposure Assessment Measurement Uncertainty

Source of Uncertainty	Tolerance Value	Probability Distribution	Divisor	c_i^1 (1-g)	c_i^1 (10-g)	Standard Uncertainty (1-g) %	Standard Uncertainty (10-g) %
Measurement System							
Probe Calibration	3.5	normal	1	1	1	3.5	3.5
Axial Isotropy	3.7	rectangular	√3	$(1-cp)^{1/2}$	$(1-cp)^{1/2}$	1.5	1.5
Hemispherical Isotropy	10.9	rectangular	√3	√cp	√cp	4.4	4.4
Boundary Effect	1.0	rectangular	√3	1	1	0.6	0.6
Linearity	4.7	rectangular	√3	1	1	2.7	2.7
Detection Limit	1.0	rectangular	√3	1	1	0.6	0.6
Readout Electronics	1.0	normal	1	1	1	1.0	1.0
Response Time	0.8	rectangular	√3	1	1	0.5	0.5
Integration Time	1.7	rectangular	√3	1	1	1.0	1.0
RF Ambient Condition	3.0	rectangular	√3	1	1	1.7	1.7
Probe Positioner Mech.	0.4	rectangular	√3	1	1	0.2	0.2
Restriction							
Probe Positioning with respect to Phantom Shell	2.9	rectangular	√3	1	1	1.7	1.7
Extrapolation and Integration	3.7	rectangular	√3	1	1	2.1	2.1
Test Sample Positioning	4.0	normal	1	1	1	4.0	4.0
Device Holder Uncertainty	2.0	normal	1	1	1	2.0	2.0
Drift of Output Power	0.6	rectangular	√3	1	1	0.3	0.3
Phantom and Setup							
Phantom Uncertainty(shape & thickness tolerance)	3.4	rectangular	√3	1	1	2.0	2.0
Liquid Conductivity(target)	5.0	rectangular	√3	0.7	0.5	2.0	1.4
Liquid Conductivity(meas.)	0.0	normal	1	0.7	0.5	0.0	0.0
Liquid Permittivity(target)	5.0	rectangular	√3	0.6	0.5	1.7	1.4
Liquid Permittivity(meas.)	2.4	normal	1	0.6	0.5	1.4	1.2
Combined Uncertainty		RSS				9.3	9.2
Combined Uncertainty (coverage factor=2)		Normal(k=2)				18.7	18.3

6. Reference

1. **[ANSI/IEEE C95.1-1992]**
Safety Levels with Respect to Human Exposure to Radio Frrequency Electromagnetic Fields, 3 kHz to 300 GHz. The Institute of Electrical and Electronics Engineers, Inc. (IEEE), 1992.

2. **[ANSI/IEEE C95.3-1992]**
Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave". The Institute of Electrical and Electronics Engineers, Inc. (IEEE), 1992.

3. **[FCC Report and Order 96-326]**
Federal Communications Commission, \Report and order: Guidelines for evaluating the environ mental effects of radiofrequency radiation", Tech. Rep. FCC 96-326, 1996.

4. **[FCC OET Bulletin 65]**
Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields. OET Bulletin 65 Edition 97-01, August 1997. Federal Communications Commission (FCC), Office of Engineering & Technology. (OET)

5. **[FCC OET Bulletin 65 Supplement C]**
Additional Information for Evaluating Compliance of Mobile and Portable Device with FCC Limits for Human Exposure to Radiofrequency Emissions. Supplement C (Edition 01-01) to OET Bulletin 65, June 2001. Federal Communications Commission (FCC), Office of Engineering & Technology. (OET)

6. **[ALSAS-10-U 4]**
Schmid & Partner Engineering AG: ALSAS-10-U 4 Manual, September 2005.

7. **[IEEE 1528-2003]**
IEEE Std 1528-2003: IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wirless Communications Devices: Measurement Techniques. 1528-2003, 19th December, 2003, The Institute of Electrical and Electronics Engineers, Inc. (IEEE).