FCC OET BULLETIN 65 SUPPLEMENT C
SAR EVALUATION REPORT

FOR

INTEL WIFI/WIMAX LINK 5150 SERIES
(TESTED INSIDE OF LENOVO U150)

FCC ID: PD9512ANXHU
MODEL: 512ANXHMW

REPORT NUMBER: 09U12725-3G2

ISSUE DATE: MARCH 17, 2010

Prepared for

INTEL CORPORATION
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Prepared by

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NVLAP LAB CODE 200065-0

Revision History

Rev.	Issue Date	Revisions	Revised By
--	August 7, 2009	Initial Issue	--
A	Nov.02, 2009	Change DL:UL ratio based upon PBA response from FCC	Cho Yen
B	Dec. 10, 2009	Modify the Test Report based upon FCC PBA response	Sunny Hsih
C	Dec. 16, 2009	Modify the Test Report based upon FCC/Applicant conference call	Sunny Hsih
D	Dec. 18, 2009	Redo SAR linearly tests in section 16	Sunny Hsih
D1	Jan. 04, 2010	Update scale up factor	Sunny Hsih
E	Jan. 26, 2010	Update scaling factor	Sunny Hsih
F	March 09, 2010	Fixed typo error on FCC ID and Model Number	Aliza Zaffar
G	March 15, 2010	Modifications based upon March 15 conference call with FCC	Mike Kuo
G1	March 16, 2010	Update Page 8 and Page 40	Mike Kuo
G2	March 17, 2010	Update Page 8 Probe Calibration error %	Mike Kuo

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: INTEL CORPORATION.
2111 N.E. 25TH AVENUE
HILLSBORO, OR 97124, USA

EUT DESCRIPTION: INTEL WIFI LINK 5150 SERIES

MODEL: 512ANXHMW

DEVICE CATEGORY: Portable

EXPOSURE CATEGORY: General Population/Uncontrolled Exposure

DATE TESTED: July 22 - 29, 2009

HIGHEST SAR VALUES: See table below

FCC / IC Rule Parts	Frequency Range [MHz]	The Highest SAR Values (1g_mW/g)	Limit (mW/g)
27	2498.5 – 2687.5	0.012	1.6

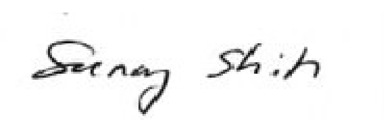
APPLICABLE STANDARDS:

STANDARD	TEST RESULTS
FCC OET BULLETIN 65 SUPPLEMENT C	Pass

Compliance Certification Services, Inc. (CCS) tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by CCS based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by CCS and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by CCS will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government (NIST Handbook 150, Annex A). This report is written to support regulatory compliance of the applicable standards stated above.

Approved & Released For CCS By:



SUNNY SHIH
ENGINEERING SUPERVISOR
COMPLIANCE CERTIFICATION SERVICES

Tested By:

CHAO YEN LIN
EMC ENGINEER
COMPLIANCE CERTIFICATION SERVICES

2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC OET Bulletin 65 Supplement C, Specific FCC Procedure KDB 248227 SAR Measurement Procedure for 802.11abg Transmitters and KDB 447498_RF Exposure Requirements and Procedures for mobile and portable devices and 802.16e/WiMAX Permit-But-Ask and SAR Guidance.

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 Benicia Street, Fremont, California, USA.

CCS is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at http://www.ccsemc.com

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4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

Name of Equipment	Manufacturer	Type/Model	Serial Number	Cal. Due date		
				MM	DD	Year
Robot - Six Axes	Stäubli	RX90BL	N/A	N/A		
Robot Remote Control	Stäubli	CS7MB	3403-91535	N/A		
DASY4 Measurement Server	SPEAG	SEUMS001BA	1041	N/A		
Probe Alignment Unit	SPEAG	LB (V2)	261	N/A		
SAM Phantom (SAM1)	SPEAG	QD000P40CA	1185	N/A		
SAM Phantom (SAM2)	SPEAG	QD000P40CA	1050	N/A		
Oval Flat Phantom (ELI 4.0)	SPEAG	QD OVA001 B	1003	N/A		
Electronic Probe kit	HP	85070C	N/A	N/A		
S-Parameter Network Analyzer	Agilent	8753ES-6	MY40001647	11	14	2009
Signal Generator	Agilent	8753ES-6	MY40001647	11	14	2009
E-Field Probe	SPEAG	EX3DV4	3686	3	23	2010
Thermometer	ERTCO	639-1S	1718	5	1	2010
Data Acquisition Electronics	SPEAG	DAE3 V1	427	10	20	2009
System Validation Dipole	SPEAG	D2600V2	1006	4	22	2011
MXA Signal Analyzer	Agilent	N9020A	US48350984	10	23	2009
ESG Vector Signal Generator	Agilent	E4438C	US44271090	9	17	2010
Power Meter	Giga-tronics	8651A	8651404	1	11	2010
Power Sensor	Giga-tronics	80701A	1834588	1	11	2010
Amplifier	Mini-Circuits	ZVE-8G	90606	N/A		
Amplifier	Mini-Circuits	ZHL-42W	D072701-5	N/A		
Simulating Liquid	CCS	M2600	N/A	Within 24 hrs of first test		

4.2. MEASUREMENT UNCERTAINTY

Measurement uncertainty for 300 MHz – 3000 MHz

Specific Absorption Rate (SAR) uncertainty calculation					
300 MHz to 3 GHz averaged over 1 gram					
Component	**error, %**	**Distribution**	**Divisor**	**Sensitivity**	**U (Xi), %**
Measurement System					
Probe Calibration (k=1)@2600 MHz	5.5	Normal	1	1	5.5
Axial Isotropy	1.15	Rectangular	1.732	0.7071	0.47
Hemispherical Isotropy	2.30	Rectangular	1.732	0.7071	0.94
Boundary Effect	0.90	Rectangular	1.732	1	0.52
Probe Linearity	3.45	Rectangular	1.732	1	1.99
System Detection Limits	1.00	Rectangular	1.732	1	0.58
Readout Electronics	0.30	Normal	1	1	0.30
Response Time	0.80	Rectangular	1.732	1	0.46
Integration Time	2.60	Rectangular	1.732	1	1.50
RF Ambient Conditions - Noise	3.00	Rectangular	1.732	1	1.73
RF Ambient Conditions - Reflections	3.00	Rectangular	1.732	1	1.73
Probe Positioner Mechanical Tolerance	0.40	Rectangular	1.732	1	0.23
Probe Positioning with respect to Phantom	2.90	Rectangular	1.732	1	1.67
Extrapolation, Interpolation and Integration	1.00	Rectangular	1.732	1	0.58
Test Sample Related					
Test Sample Positioning	2.90	Normal	1	1	2.90
Device Holder Uncertainty	3.60	Normal	1	1	3.60
Output Power Variation - SAR Drift	5.00	Rectangular	1.732	1	2.89
Phantom and Tissue Parameters					
Phantom Uncertainty (shape and thickness)	4.00	Rectangular	1.732	1	2.31
Liquid Conductivity - deviation from target	5.00	Rectangular	1.732	0.64	1.85
Liquid Conductivity - measurement	1.01	Normal	1	0.64	0.65
Liquid Permittivity - deviation from target	5.00	Rectangular	1.732	0.6	1.73
Liquid Permittivity - measurement uncertainty	1.01	Normal	1	0.6	0.61
Combined Standard Uncertainty Uc(y)					9.48
Expanded Uncertainty U, Coverage Factor = 2, > 95 % Confidence = 18.96%					
Expanded Uncertainty U, Coverage Factor = 2, > 95 % Confidence = 1.51dB					

5. EQUIPMENT UNDER TEST

Intel WiFi/Wimax Link 5150 Series (Tested inside of LENOVO U150)

Normal operation:	Lap-held only Note: SAR test with display open at 90° to the keyboard
Antenna tested:	Quanta, TX 1 Antenna, Part Number: LL2ANT00100 Antenna-to-User Separation Distance:18.5 cm

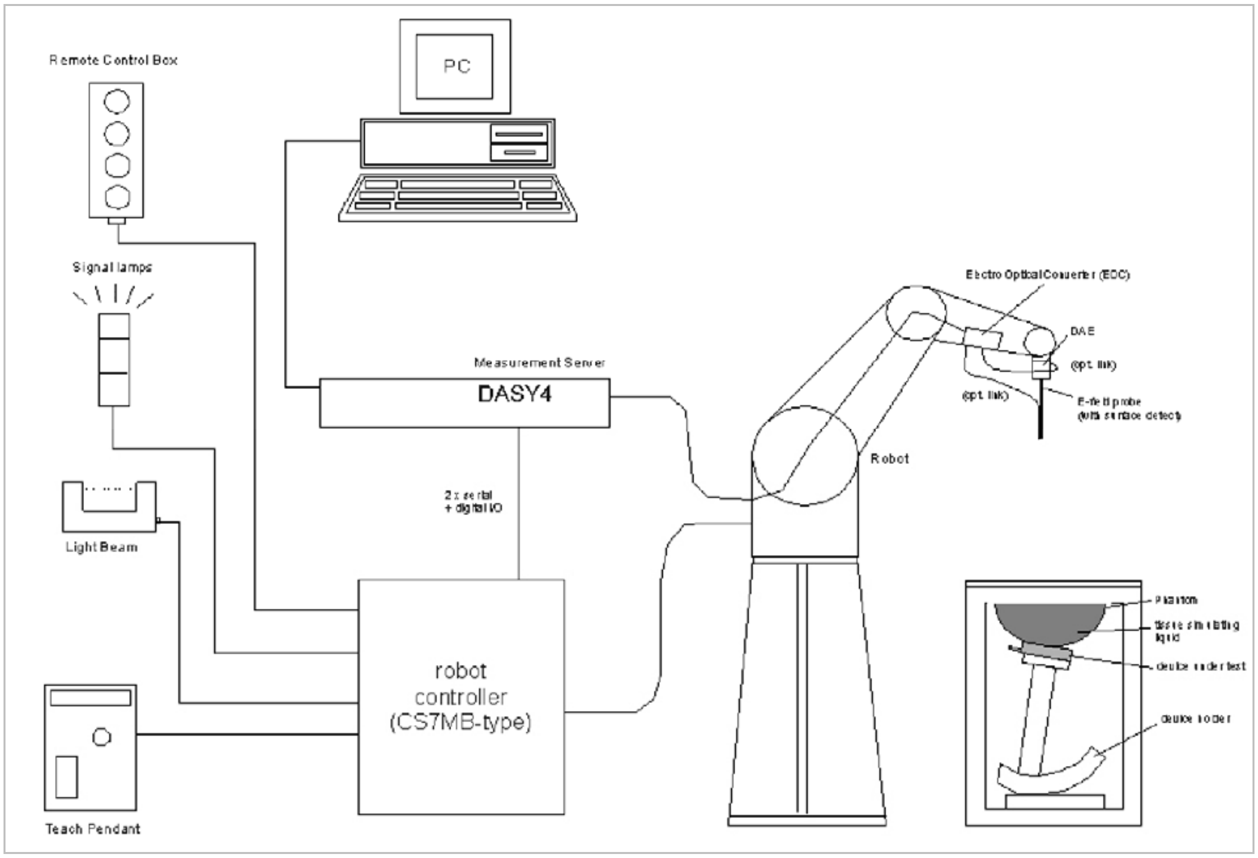
The Intel WiFi/WiMax Link 5150 is an embedded IEEE 802.16e and 802.11a/b/g/n wireless network adapter that operates in the 2.4 GHz and 5 GHz spectra for WiFi and 2.6 GHz for WiMAX. The adapter is installed inside the Lenovo host. This adapter is capable of delivering up to 300 Mbps Tx/Rx over WiFi and up to 4 Mbps UL/10 Mbps DL over WiMAX.

Link 5150 transmits on 5 ms frames using 5 MHz and 10 MHz channels. The 10 MHz channel bandwidth uses 1024 sub-carriers and 35 sub-channels, with 184 null sub-carriers and 840 available for transmission, consisting of 560 data sub-carriers and 280 pilot sub-carriers. The 5 MHz channel bandwidth uses 512 sub-carriers and 17 sub-channels, with 104 null sub-carriers and 408 available for transmission, consisting 272 data sub-carriers and 136 pilot sub-carriers.

WiMAX and 802.11 a/b/g/n co-location conditions:

The 802.16e WiMAX and 802.11 a/b/g/n WiFi radio will not transmit simultaneously. When the 512ANXMMW is installed in the typical laptop computer, once the network is chosen by the end user during WiMAX/WiFi network, only the WiMAX radio or WiFi radio will transmit.

6. SYSTEM DESCRIPTION



The DASY4 system for performing compliance tests consists of the following items:

- A standard high precision 6-axis robot (Stäubli RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- A dosimetric probe, i.e., an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.
- 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 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.
- A probe alignment unit which improves the (absolute) accuracy of the probe positioning.
- A computer operating Windows 2000 or Windows XP.
- DASY4 software.
- Remote controls with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
- The SAM twin phantom enabling testing left-hand and right-hand usage.
- The device holder for handheld mobile phones.
- Tissue simulating liquid mixed according to the given recipes.
- Validation dipole kits allowing to validate the proper functioning of the system.

7. COMPOSITION OF INGREDIENTS FOR TISSUE SIMULATING LIQUIDS

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.

Ingredients (% by weight)	Frequency (MHz)										
	450		835		915		1900		2450		2600
Tissue Type	Head	Body	Head	Body	Head	Body	Head	Body	Head	Body	Body
Water	38.56	51.16	41.45	52.4	41.05	56.0	54.9	40.4	62.7	73.2	73.2
Salt (NaCl)	3.95	1.49	1.45	1.4	1.35	0.76	0.18	0.5	0.5	0.04	0.05
Sugar	56.32	46.78	56.0	45.0	56.5	41.76	0.0	58.0	0.0	0.0	0.0
HEC	0.98	0.52	1.0	1.0	1.0	1.21	0.0	1.0	0.0	0.0	0.0
Bactericide	0.19	0.05	0.1	0.1	0.1	0.27	0.0	0.1	0.0	0.0	0.0
Triton X-100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.8	0.0	0.0
DGBE	0.0	0.0	0.0	0.0	0.0	0.0	44.92	0.0	0.0	26.7	27.2
Dielectric Constant	43.42	58.0	42.54	56.1	42.0	56.8	39.9	54.0	39.8	52.5	52.5
Conductivity (S/m)	0.85	0.83	0.91	0.95	1.0	1.07	1.42	1.45	1.88	1.78	2.16

Salt: 99+% Pure Sodium Chloride Sugar: 98+% Pure Sucrose
Water: De-ionized, 16 MΩ+ resistivity HEC: Hydroxyethyl Cellulose
DGBE: 99+% Di(ethylene glycol) butyl ether, [2-(2-butoxyethoxy)ethanol]
Triton X-100 (ultra pure): Polyethylene glycol mono [4-(1,1, 3, 3-tetramethylbutyl)phenyl]ether

8. SIMULATING LIQUID CHECK

The simulating liquids should be checked at the beginning of a series of SAR measurements to determine of the dielectric parameters are within the tolerances of the specified target values. The relative permittivity and conductivity of the tissue material should be within ± 5% of the values given in the table below.

Reference Values of Tissue Dielectric Parameters for Body Phantom

The body tissue dielectric parameters recommended by the IEEE SCC-34/SC-2 in IEEE Standard 1528 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 body. Other head and body tissue parameters that have not been specified in P1528 are derived from the tissue dielectric parameters computed from the 4-Cole-Cole equations and extrapolated according to the head parameters specified in IEEE Standard 1528.

Target Frequency (MHz)	Body	
	ε_r	σ (S/m)
2450	52.7	1.95
2500	52.6	2.02
2600	52.5	2.16
2690	52.4	2.29

(ε_r = relative permittivity, σ = conductivity and ρ = 1000 kg/m^3)

8.1. SIMULATING LIQUID CHECK RESULTS

Simulating Liquid Dielectric Parameter Check Result @ Muscle 2600 MHz

Room Ambient Temperature = 23°C; Relative humidity = 40% Measured by: Chaoyen Lin

Simulating Liquid		Parameters			Measured	Target	Deviation (%)	Limit (%)
f (MHz)	Depth (cm)							
2500	15	e'	53.1328	Relative Permittivity (ϵ_r):	53.1328	52.6	1.01	± 5
		e"	14.5098	Conductivity (σ):	2.01800	2.02	-0.10	± 5
2590	15	e'	52.8267	Relative Permittivity (ϵ_r):	52.8267	52.5	0.62	± 5
		e"	14.7705	Conductivity (σ):	2.12821	2.15	-1.01	± 5
2600	15	e'	52.8212	Relative Permittivity (ϵ_r):	52.8212	52.5	0.59	± 5
		e"	14.8705	Conductivity (σ):	2.15089	2.16	-0.46	± 5
2690	15	e'	52.4162	Relative Permittivity (ϵ_r):	52.4162	52.4	0.03	± 5
		e"	15.1909	Conductivity (σ):	2.27329	2.29	-0.73	± 5

Liquid Check
Ambient temperature: 25 deg. C; Liquid Temperature: 24 deg. C
July 27, 2009 08:33 AM

Frequency	e'	e''
2450000000	53.2933	14.4436
2460000000	53.2169	14.4482
2470000000	53.1313	14.4104
2480000000	53.1003	14.4021
2490000000	53.1146	14.428
2500000000	**53.1328**	**14.5098**
2510000000	53.1009	14.6351
2520000000	53.0604	14.7329
2530000000	53.0411	14.8096
2540000000	52.9851	14.8624
2550000000	52.9261	14.892
2560000000	52.8433	14.8421
2570000000	52.8035	14.7759
2580000000	52.8071	14.7333
2590000000	**52.8267**	**14.7705**
2600000000	**52.8212**	**14.8705**
2610000000	52.7757	14.9813
2620000000	52.7211	15.0986
2630000000	52.6337	15.1873
2640000000	52.5455	15.241
2650000000	52.4793	15.2335
2660000000	52.4579	15.2052
2670000000	52.4416	15.1741
2680000000	52.4351	15.1706
2690000000	**52.4162**	**15.1909**
2700000000	52.3798	15.2562

The conductivity (σ) can be given as:

$$\sigma = \omega \varepsilon_0 e'' = 2 \pi f \varepsilon_0 e''$$

where f = target f * 10^6

$\varepsilon_0 = 8.854 * 10^{-12}$

9. SYSTEM PERFORAMCE CHECK

The system performance check is performed prior to any usage of the system in order to verify SAR measurement accuracy. The system performance check verifies that the system operates within its specifications of ±10%.

System Performance Check Measurement Conditions

- The measurements were performed in the flat section of the SAM twin phantom filled with Body simulating liquid of the following parameters.
- The DASY4 system with an isotropic E-filed Probe EX3DV4 was used for the measurements.
- The dipole was mounted on the small tripod so that the dipole feed point was positioned below the center marking of the flat phantom section and the dipole was oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 10 mm (above 1 GHz) and 15 mm (below 1 GHz) from dipole center to the simulating liquid surface.
- The coarse grid with a grid spacing of 15 mm was aligned with the dipole.
  For 5 GHz band - The coarse grid with a grid spacing of 10 mm was aligned with the dipole.
- Special 7x7x7 (2.4 GHz) fine cube was chosen for cube integration.
- Distance between probe sensors and phantom surface was set to 3 mm.
- The dipole input power (forward power) was 250 mW±3%.
- The results are normalized to 1 W input power.

Reference SAR Values for body-tissue

The reference SAR values based on SPEAG's Calibration Certificate, Certificate No: D2600V2-1006_APR09.

SAR result with Body TSL

SAR averaged over 1 cm^3 (1 g) of Body TSL	condition	
SAR measured	250 mW input power	14.4 mW / g
SAR normalized	normalized to 1W	57.6 mW / g
SAR for nominal Body TSL parameters [1]	normalized to 1W	**57.7 mW / g ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.46 mW / g
SAR normalized	normalized to 1W	25.8 mW / g
SAR for nominal Body TSL parameters [1]	normalized to 1W	**25.9 mW / g ± 16.5 % (k=2)**

9.1. SYSTEM PERFORMANCE CHECK RESULTS

System Validation Dipole: D2600V2 SN:1006

Date: July 27, 2009

Ambient Temperature = 24°C; Relative humidity = 40% Measured by: Chaoyen Lin

Medium	CW Signal (MHz)	Forward power (mW)	Measured (Normalized to 1 W)		Target	Delta (%)	Tolerance (%)
Body	2600	250	1g SAR:	56.1	57.6	-2.60	±10
			10g SAR:	25	25.8	-3.10	

10. WIMAX / 802.16e DEVICE SPECIFICATION

10.1. WiMAX Zone Types

The device and its system are both transmitting using only PUSC zone type. This enables multiple users to transmit simultaneously within the system. FUSC, AMC and other zone types are not used by Link 5150 for uplink transmission. The maximum DL:UL symbol ratio can be determined according to the PUSC requirements. The system transmit an odd number of symbols using DL-PUSL consisting of even multiples of traffics and control symbols plus one symbol for the preamble. Multiples of three symbols are transmitted by the device using UL-PUSC. The OFDMA symbol time allows up to 48 downlink and uplink symbols in each 5 ms frame. TTG and RTG are also included in each frame as DL/UL transmission gaps; therefore, the system can only allow 47 or less symbols per frame. The maximum DL:UL symbol ratio is determined according to these PUSC parameters for evaluating SAR compliance.

WiMAX chipset is capable of supporting the following Downlink / Uplink based upon 802.16e.

Description	Down Link	Up Link
Number of OFDM Symbols in Down Link and Up Link for 5 MHz and 10 MHz Bandwidth	**35**	**12**
	34	13
	32	15
	31	16
	30	17
	29	**18**
	28	19
	27	20
	26	21

10.2. Duty Factor and Scaling Considerations

a. All Test Vectors are performing with all UL symbols at maximum power

b. Although the chipset can supply higher downlink-to-uplink (DL/UL) symbol ratios, Link 5150 is scaled up or down based upon BRS/EBS WiMAX operators with agreements to transmit at a maximum DL/UL symbol ratio of 29:18 Vs actual UL traffic symbols were used during SAR measurement. Therefore, the maximum transmission duty factor supported by the chipset is not applicable for this device. The system can transmit up to 48 OFDMA symbols in each 5 ms frame, including 1.6 symbols for TTG and RTG.

c. UL Burst Max. Average Power: was measured using spectrum analyzer gated to measure the power only during TX "ON" stage.

   i. 10 MHz/16QAM: 23.1 dBm / **204.17mW**

   ii. 10 MHz / QPSK: 23.29 dBm / **213.3mW**

   iii. 5 MHz / 16QAM:23.83 dBm / 241.55mW

   iv. 5 MHz:/QPSK: 23.63 dBm / 230.67mW

d. The control channels may occupy up to 5 slots during normal operation. A slot is a sub-channel with the duration of 3 symbols. There are a total of 35 slots in the 10 MHz channel configuration.

e. The control channels may occupy up to 5 slots during normal operation. A slot is a sub-channel with the duration of 3 symbols. There are a total of 17 slots in the 5 MHz channel configuration.

f. Max. Rated / Certified Power:

Modulation	Channel Bandwidth	Power
16QAM	10 MHz	200mW
QPSK	10 MHz	205mW
16QAM	5 MHz	**242mW**
QPSK	5 MHz	**240mW**

g. By comparing to the measured output power (section 10.2 item c) Vs the Max. Rated / Certified Power (section 10.2 item f), the following max. power is used to calculate the scaling factor

Max. Power Used to Calculate the Scaling Factor		
Modulation	Channel Bandwidth	Power
16QAM	10 MHz	**204.17mW**
QPSK	10 MHz	**213.3mW**
16QAM	5 MHz	**242mW**

QPSK	5 MHz	**240mW**

h. When the device is transmitting at max. rated power, the output power for the control symbol is:

   i. 10 MHz/16QAM : (**204.17mW**x5)/35=29.17mW
   ii. 10 MHz/QPSK: (**213.3mW**x5)/35=30.47mW
   iii. 5 MHz/16QAM : (**242mW**x5)/17=71.18mW
   iv. 5 MHz/QPSK : (**240mW**x5)/17=70.59mW

i. The target output power for DL:UL ratio of 29:18 is calculated as the following:

Modulation	Channel Bandwidth	29:18 DL:UL Ratio Power /mW
16QAM	10 MHz	(29.17 x 3)+(**204.17**x15)=3150.06
QPSK	10 MHz	(30.47x3)+(**213.3**X15)=3290.91
16QAM	5 MHz	(71.18 X 3) +(**242**X15)=3843.54
QPSK	5 MHz	(70.59X3) +(**240**X15)=3811.77

j. Test Vector waveform power

DQ4_12_UQ16_12_10M(32:15 DL:UL Ratio) 10 MHz BW/ 16 QAM				
Channel No	Frequency/MHz	Measured Power	Number of Traffic Symbols	Traffic Symbols Power
0	2501	186.21mW	12	2234.52mW
368	2593	188.36mW	12	2260.32mW
736	2685	204.17mW	12	2450.04mW
DQ64_UQ4_12_21S_10M (23:24 DL:UL Ratio) 10 MHz BW / QPSK				
0	2501	203..70mW	21	4277.7mW
368	2593	206.06mW	21	4327.26mW
736	2685	213.30mW	21	4479.3mW
DQ4_12_UQ16_34_5M (26:21 DL:UL Ratio) 5 MHz BW / 16QAM				

0	2498.5	220.80mW	18	3974.4mW
378	2593	232.27mW	18	4180.86mW
756	2687.5	241.55mW	18	4347.9mW
DQ64_56_UQ4_12_5M(26:21 DL:UL Ratio) **5 MHz BW/ QPSK**				
0	2498.5	216.77mW	18	3901.86mW
378	2593	225.94mW	18	4066.92mW
756	2687.5	230.67mW	18	4837.5mW

10.3. Duty-Factor Scaling to DL:UL Ratio of 29:18

DQ4_12_UQ16_12_10M(32:15 DL:UL Ratio) **10 MHz BW/ 16 QAM**				
Channel No	Frequency/MHz	29:18 Rated Power	32:15 Traffic Symbol Power	Scaling Factor (rated power/traffic power)
0	2501	3150.06mW	2234.52mW	1.41
368	2593	3150.06mW	2260.32mW	1.39
736	2685	3150.06mW	2450.04mW	1.29
DQ64_UQ4_12_21S_10M (23:24 DL:UL Ratio) **10 MHz BW / QPSK**				
0	2501	3290.91mW	4277.7mW	0.77
368	2593	3290.91mW	4327.26mW	0.76
736	2685	3290.91mW	4479.3mW	0.74
DQ4_12_UQ16_34_5M (26:21 DL:UL Ratio) **5 MHz BW / 16QAM**				
0	2498.5	3843.54mW	3974.4mW	0.97
378	2593	3843.54mW	4180.86mW	0.92
756	2687.5	3843.54mW	4347.9mW	0.88

DQ64_56_UQ4_12_5M(26:21 DL:UL Ratio) 5 MHz BW/ QPSK				
0	2498.5	3811.77mW	3901.86mW	0.98
378	2593	3811.77mW	4066.92mW	0.94
756	2687.5	3811.77mW	4837.5mW	0.79

.

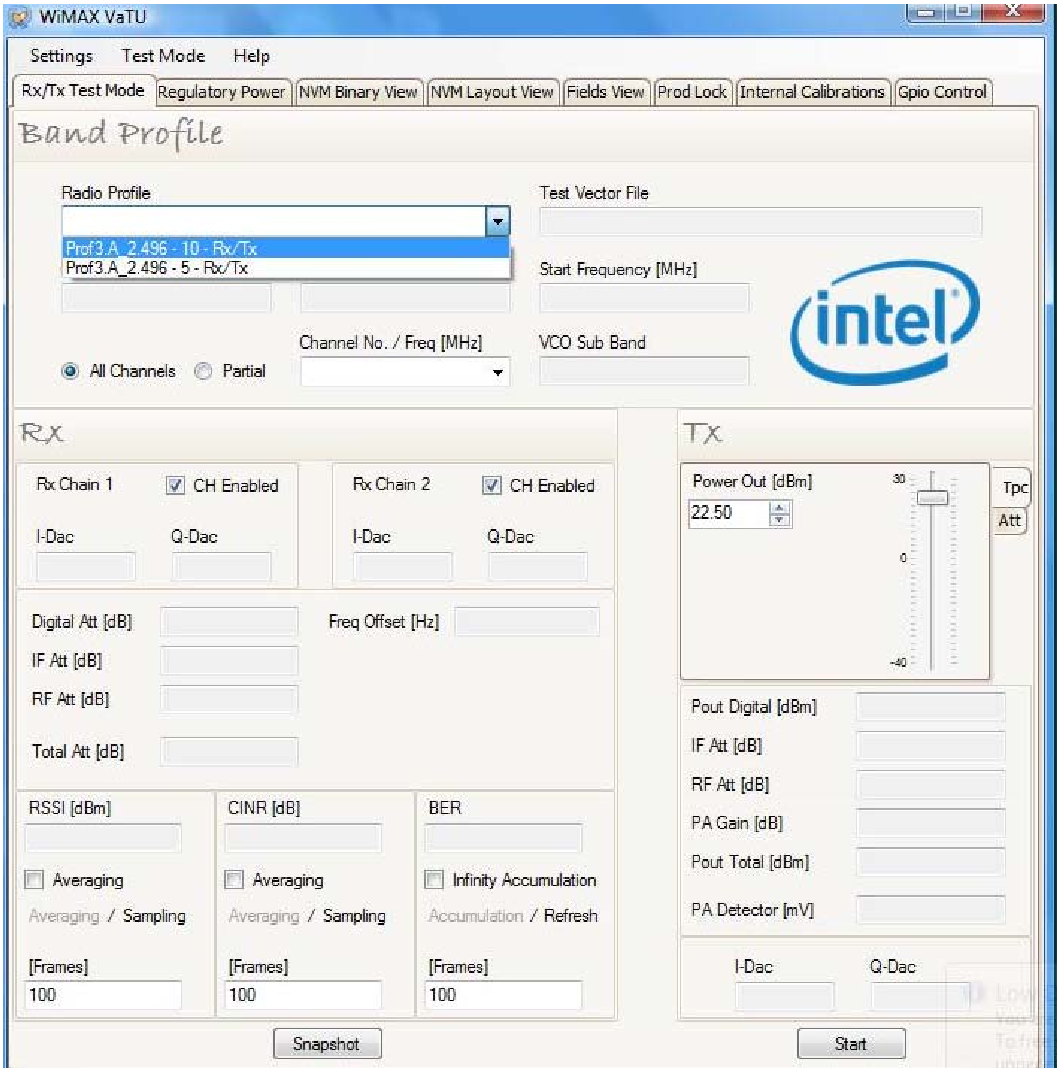
10.3.1. Conversion Factor

Test Vector File Name	BW	DL/UL	Duty Cycle	Conversion Factor	UL Modulation
DQ4_12_UQ16_12_10M	10 MHz	32:15	24.7%	4.05	16QAM R1/2
DQ64_UQ4_12_21S_10M	10 MHz	23:24	43.2%	2.32	QPSK R1/2
DQ4_12_UQ16_34_5M	5 MHz	26:21	37%	2.7	16QAM R3/4
DQ64_56_UQ4_12_5M	5 MHz	26:21	37%	2.7	QPSK R1/2

Conversion Factor = 1 / (duty factor). Duty Factor =(number of uplink traffic symbols x 102.857us)/5000us).

11. TEST SOFTWARE

The test software tool (WiMAX VaTU SW application) is installed on the Lenovo U150 Netbook computer to configure the test device, Intel WiFi/WiMAX Link 5150, to transmit at max. output power. During normal operation, the output power of WiFi/WiMAX client module is controlled by a WiMAX basestation, which also determines the characteristics of the transmission. For testing purposes, the device output power is kept at this max. using WiMAX VATU SW application loaded in the Lenovo U150 Netbook. The uplink transmission is maintained at a stable condition by the radio profile loaded in Vector signal generator. This enables the WiFi/WiMAX module to transmit at max. power with a constant duty factor according to the specific radio profile as documented in the section 3. The test software serves only one purpose, to configure the WiFi/WiMAX module to transmit at the max. power during SAR measurement.

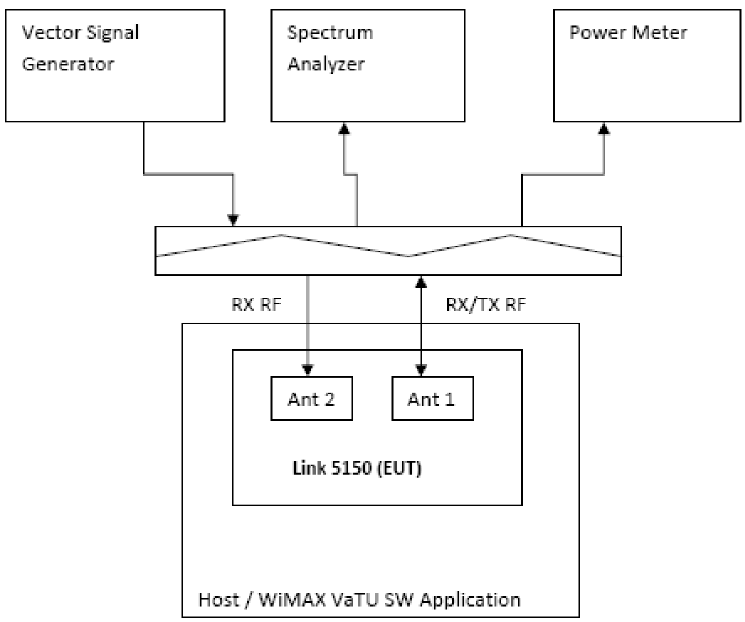

WiMAX VaTU
Settings
Test Mode
Help
Rx/Tx Test Mode
Regulatory Power
NVM Binary View
NVM Layout View
Fields View
Prod Lock
Internal Calibrations
Gpio Control
Band Profile
Radio Profile
Prof3.A_2.496 - 10 - Rx/Tx
Prof3.A_2.496 - 5 - Rx/Tx
Test Vector File
Start Frequency [MHz]
All Channels
Partial
Channel No. / Freq [MHz]
VCO Sub Band
RX
Rx Chain 1
CH Enabled
I-Dac
Q-Dac
Rx Chain 2
CH Enabled
I-Dac
Q-Dac
Digital Att [dB]
Freq Offset [Hz]
IF Att [dB]
RF Att [dB]
Total Att [dB]
RSSI [dBm]
Averaging
Averaging / Sampling
[Frames]
100
CINR [dB]
Averaging
Averaging / Sampling
[Frames]
100
BER
Infinity Accumulation
Accumulation / Refresh
[Frames]
100
Snapshot
TX
Power Out [dBm]
22.50
30
0
-40
Tpc
Att
Pout Digital [dBm]
IF Att [dB]
RF Att [dB]
PA Gain [dB]
Pout Total [dBm]
PA Detector [mV]
I-Dac
Q-Dac
Start

12. SIGNAL GENERATEOR DETAILS

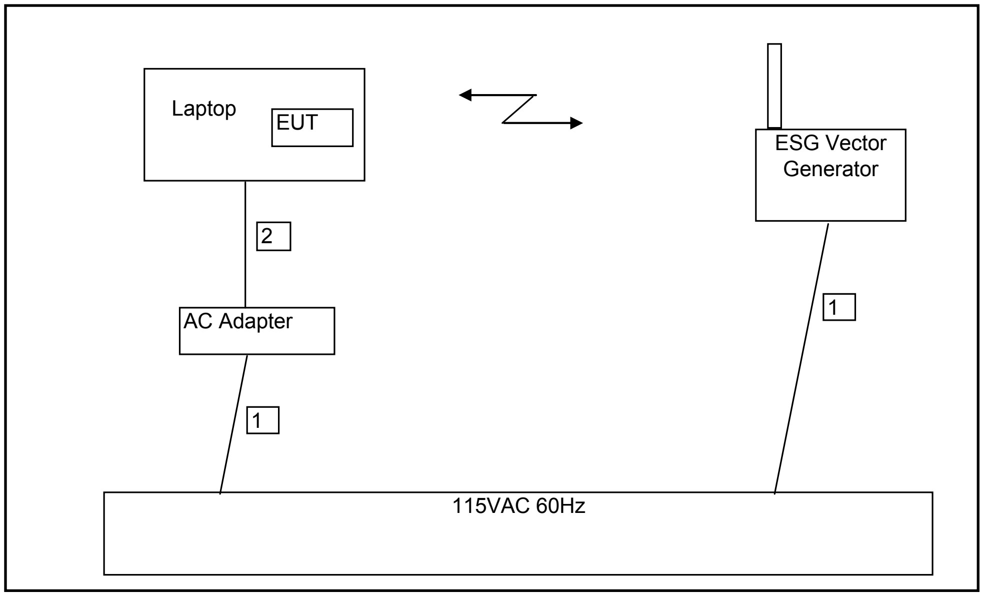
a. Frame Profile loaded in Vector Signal Generator:

Test Vector File Name	BW	DL:UL	Duty Cycle	DL Modulation	UL Modulation
DQ64_UQ4_12_21S_10M	10 MHz	23:24	43.2%	QAM64 R5/6	QPSK R1/2
DQ4_12_UQ16_12_10M	10 MHz	32:15	24.7%	QPSK R1/2	QAM16 R3/4
DQ64_56_UQ4_12_5M	5 MHz	26:21	37%	QAM64 R5/6	QPSK R1/2
DQ4_12_UQ16_34_5M	5 MHz	26:21	37%	QPSK R1/2	QAM16 R3/4

b. Connection Diagram- RF conducted Power Measurement



SAR Measurement



Agilent ESG Vector Signal Generator / Model :E4438C is used in conjunction with Intel supplied radio profile to configure the WiFi/WiMAX module for the SAR evaluation. ESG Vector Signal Generator is loaded with the downlink signal, containing the respective FCH, DL-MAP and UL-MAP required by the test device to configure the uplink transmission. The waveform is configured with 12 uplink symbols with max power for 10 MHz/16QAM; 21 uplink symbols with max. max. power for 10MHz/QPSK and 18 uplink symbols at max. power for 5 MHz/16QAM and QPSK using Intel Signal Waveform Software for 802.16 WiMAX, on the PC and downloaded to the VSG. The test device can synchronize itself to the signal received from VSG, both in frequency and time. It then modulates the DL-MAP and UL-MAP transmitted in the downlink sub-frame and determine the DL:UL symbol ratio. The downlink burst is repeated in each frame, every 5 ms, to simulate the normal transmission from a WiMAX base station. The UL-MAP received by the device is used to configure the uplink burst with all data symbols and sub-channels active. Since this is a one-way communication configuration, control channel transmission is neither requested nor transmitted.

For TDD systems, both uplink and downlink transmissions are at the same frequency. The output power of the VSG is kept at least 80 dB lower than the test device to avoid interfering with the SAR measurements. In addition, a horn antenna is used for the VSG and it is kept more than 1 meter away from the test device to further minimize unnecessary pickup by the SAR probe.

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13. COMMUNICATION TEST SET DETAILS

Modulation and channel bandwidth selection is loaded to Vector Signal Generator. For example, when evaluating 16QAM with 10 MHz channel Bandwidth, radio profile name "DQ4_12_UQ16_12_10M " is active on the Vector Signal Generator.

Parameter / Value	Frame definition for 10 MHz FCC		
	Test vector name		
	DQ4_12_UQ16_12_10M	DQ64_UQ4_12_21S_10M	Remark
Band Width	10MHz	10MHz	
FFT size	1024	1024	
UL Symbols at Max. Power	12	21	
Down link			
Zone profiles	Zone 1 – PUSC	Zone 1 – PUSC	single zone
Burst profile / MCS	MCS : QPSK R1/2	MCS : QAM64 R5/6	Single DIUC
Up link			
SAR compensation factor used during SAR measurement	4.05	2.32	
Zone profiles	Zone 1 – PUSC	Zone 1 – PUSC	single zone
Burst profile / MCS	MCS : QAM16 R1/2	MCS : QPSK R1/2	Single DIUC

Parameter / Value	Frame definition for 5MHz FCC		
	Test vector name		Remarks
	DQ64_56_UQ4_12_5M	DQ4_12_UQ16_34_5M	
Band Width	5MHz	5MHz	
FFT size	512	512	
UL Symbols at Max. Power	18	18	
Down link			
Zone profiles	Zone 1 – PUSC	Zone 1 – PUSC	single zone
Burst profile / MCS	MCS : QAM64 R5/6	MCS : QPSK R1/2	Single DIUC
Up link			

SAR compensation factor used during SAR measurement	2.7	2.7	
Zone profiles	Zone 1 – PUSC	Zone 1 – PUSC	single zone
Burst profile / MCS	MCS : QPSK R1/2	MCS : QAM16 R3/4	Single DIUC

14. OUTPUT POWER, DUTY CYCLE AND PEAK TO AVERAGE RATIO

The max average conducted output power is measured for the uplink durst in the difference modulation and channel bandwidth. Conducted average output power were measured with the module embedded in the Lenovo laptop with over-to-air communication link to Vector Signal generator.

The EUT driver software installed in the host support equipment during testing was WiMAX VaTU, version: 3.0.0.0

The modes with highest output power channel were chosen for the conducted output power measurement.

10 MHz

Mode	Test Vector file name	Number of Control Symbol at reduced power	Number of UL traffic Symbols at Max. Power
16QAM R1/2	DQ4_12_UQ16_12_10M	0	12
QPSK R1/2	DQ64_UQ4_12_21S_10M	0	21

5 MHz

Mode	Test Vector file name	Number of Control Symbol at reduced power	Number of UL traffic Symbols at Max. Power
16QAM R3/4	DQ4_12_UQ16_34_5M	0	18
QPSK R1/2	DQ64_56_UQ4_12_5M	0	18

AVERAGE OUTPUT POWER

10 MHz

Mode	Test Vector file name	Ch. No	f (MHz)	AVG Output power/dBm	AVG Output power/mW	Drift/dB
16QAM	DQ4_12_UQ16_12_10M	0	2501	22.70	186.21	
		368	2593	22.75	188.36	
		736	2685	**23.10**	**204.17**	0.17
QPSK	DQ64_UQ4_12_21S_10M	0	2501	23.09	203.70	
		368	2593	23.14	206.06	
		736	2685	**23.29**	**213.30**	0.11

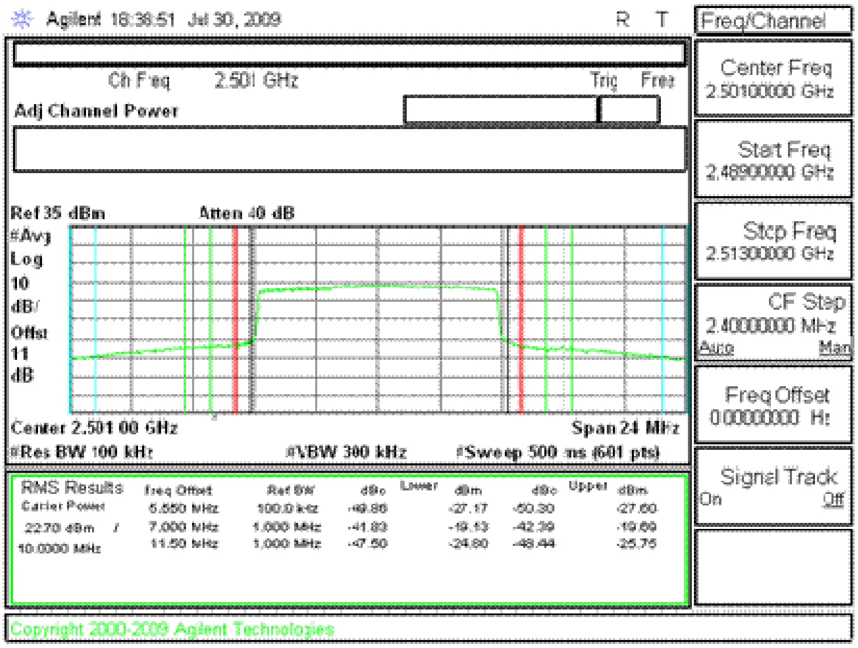
5 MHz

Mode	Test Vector file name	Ch. No	f (MHz)	AVG Output power/dBm	AVG Output power/mW	Drift/dB
16QAM	DQ4_12_UQ16_34_5M	0	2498.5	23.44	220.80	
		378	2593	23.66	232.27	
		756	2687.5	**23.83**	**241.55**	0.16
QPSK	DQ64_56_UQ4_12_5M	0	2498.5	23.36	216.77	
		378	2593	23.54	225.94	
		756	2687.5	**23.63**	**230.67**	0.1

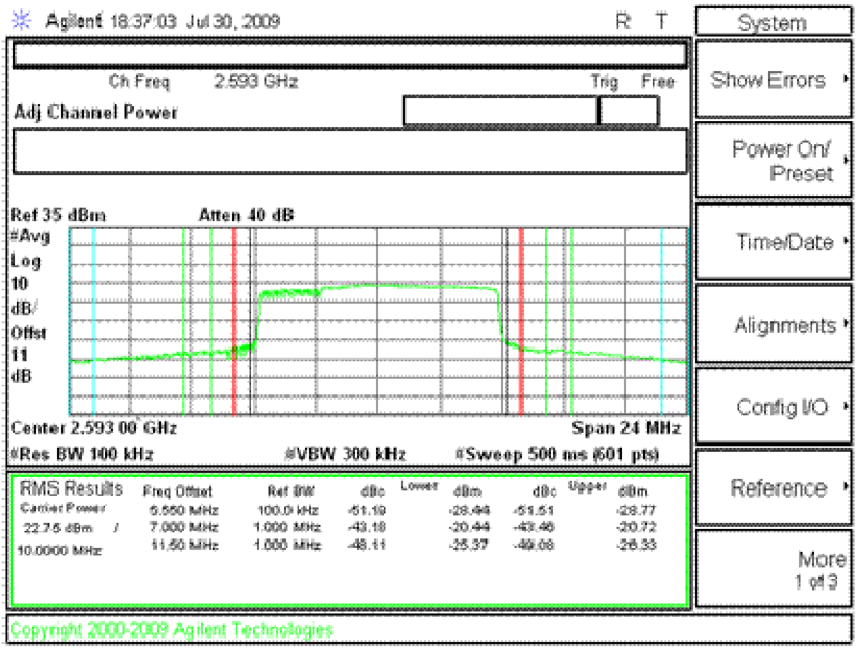
Drift: Per the requirement stated in IEEE1528 section 6.3.3., power drift shall be recorded the absolute value between step 1 and step 4. However, with repeat testing, it is not possible to obtain meaningful absolute value. In order to determine if device output has been stable during a SAR measurement, conducted power were measured before and after based upon the length of time of each SAR test to verify if the output changes are within the 5% drift (< 0.25 dB).

Average Power Plots for 10 MHz

10 MHz_16QAM Low CH

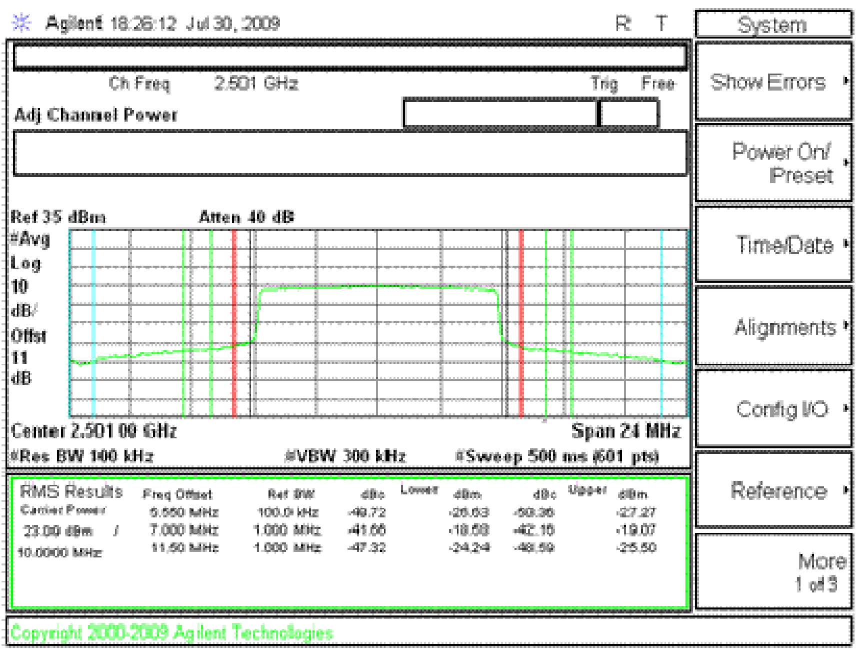


10 MHz_16QAM Mid CH



10 MHz_16QAM High CH

10 MHz_QPSK Low CH



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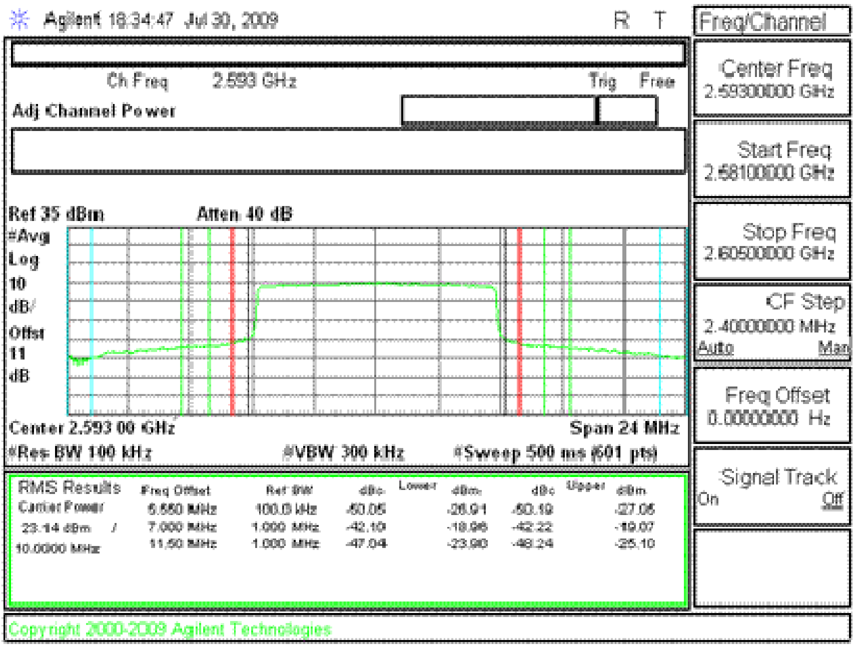
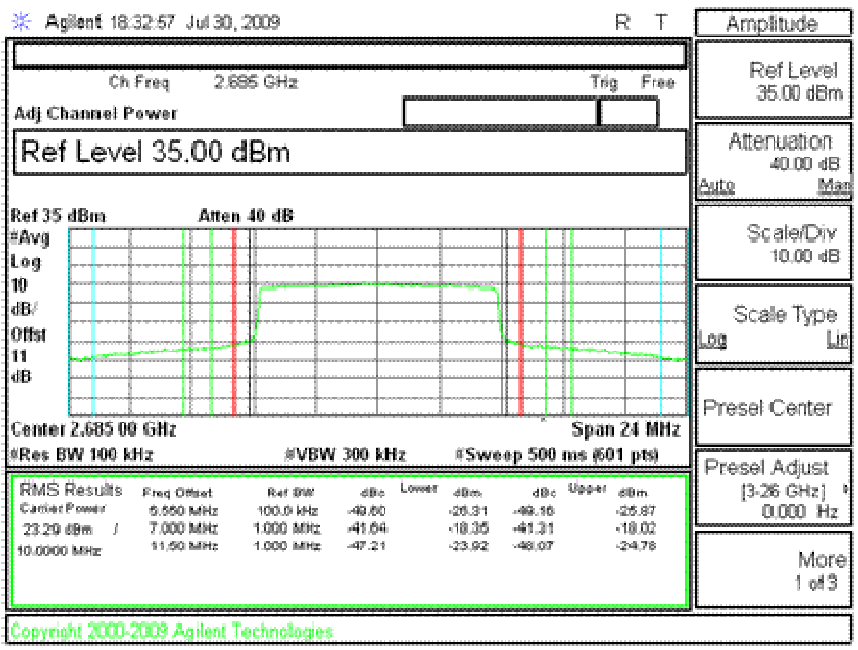
10 MHz_QPSK Mid CH

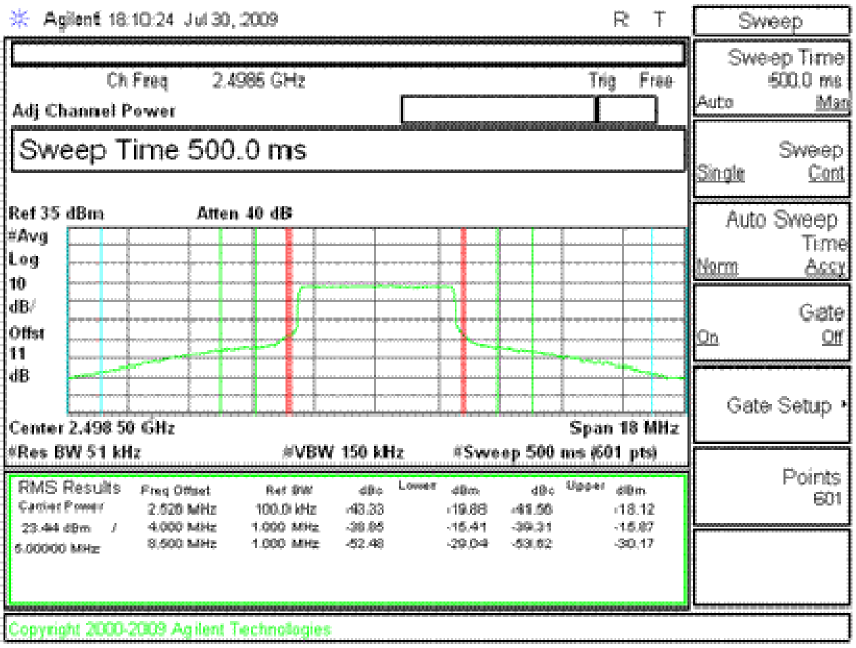


10 MHz_QPSK High CH

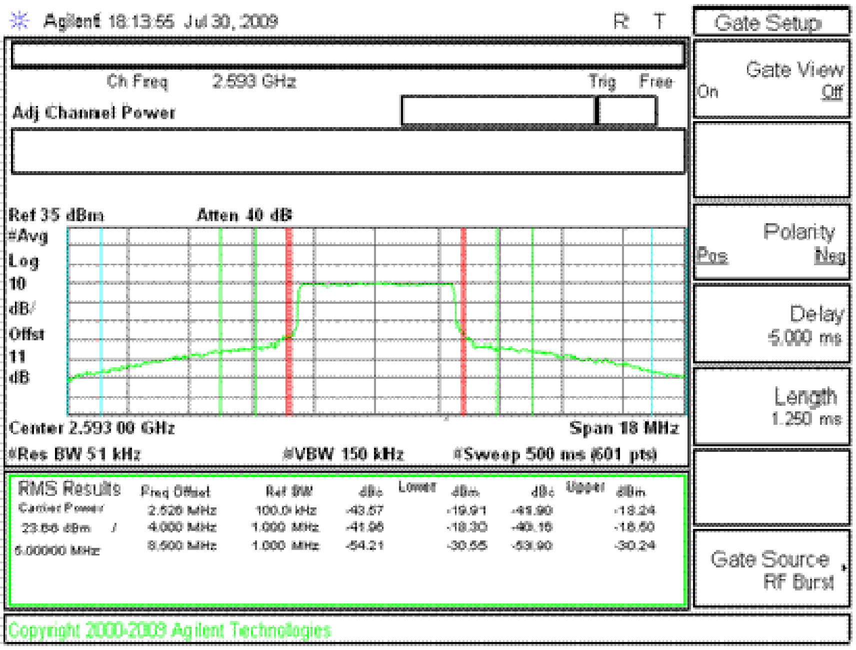


Power Plots 5 MHz

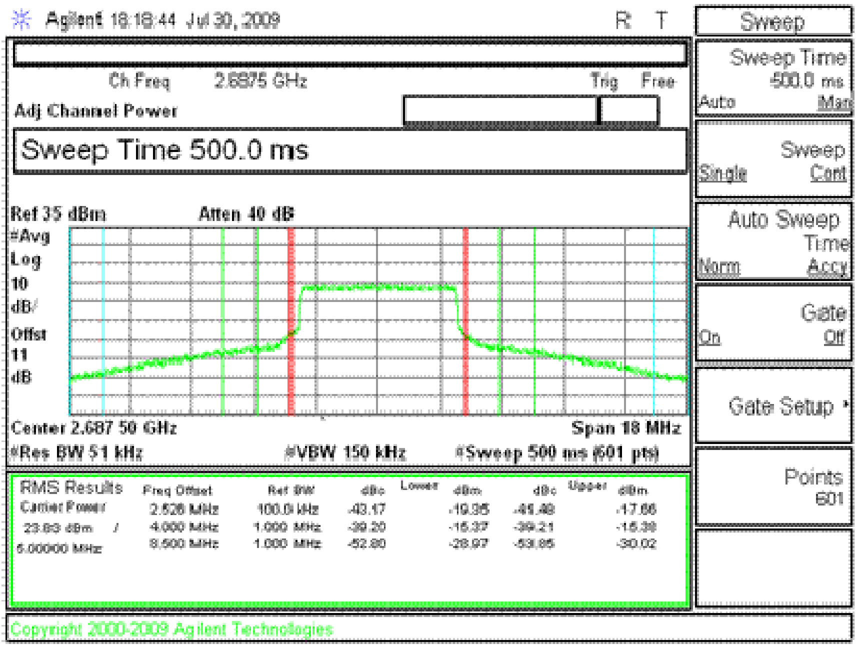
5 MHz_16QAM Low CH



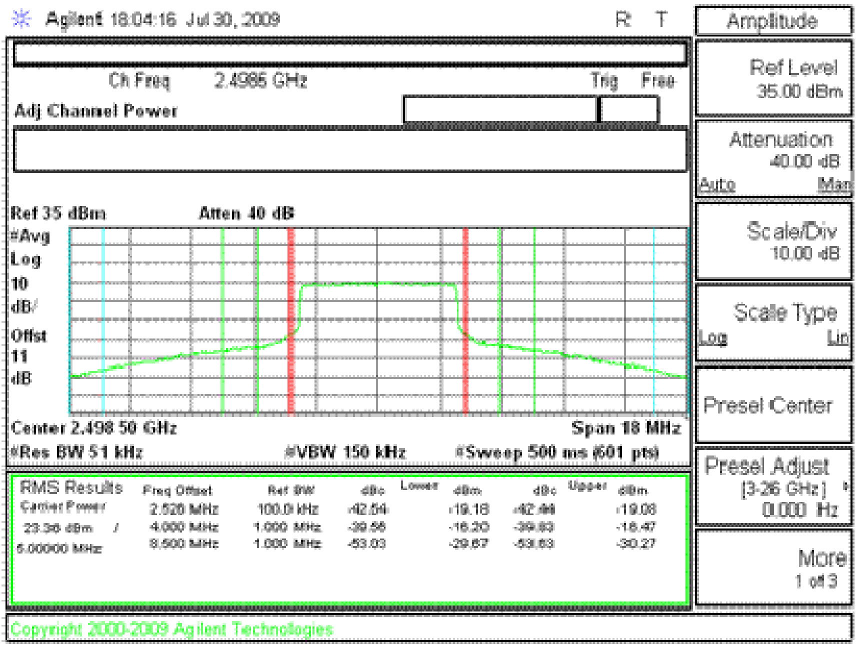
5 MHz_16QAM Mid CH



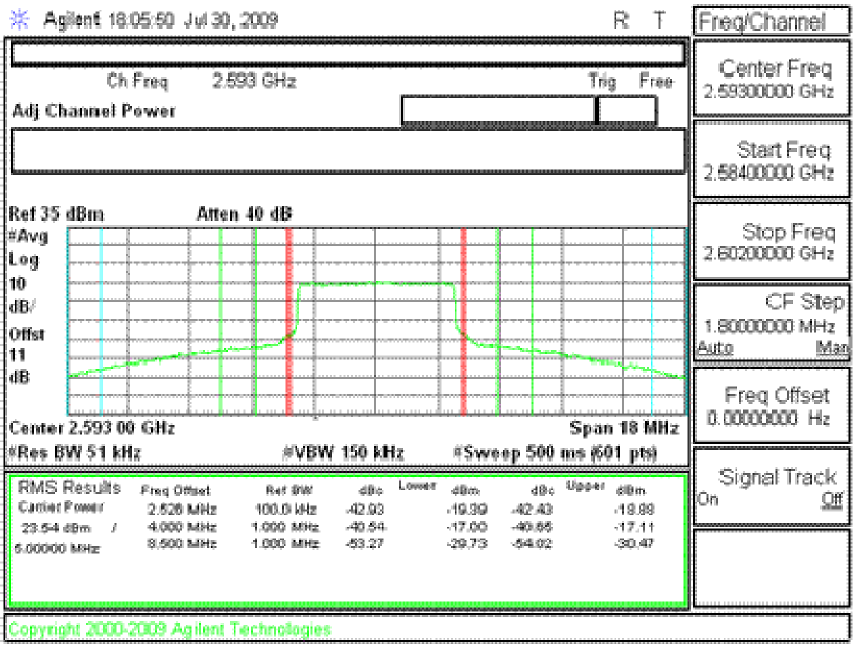
5 MHz_16QAM High CH



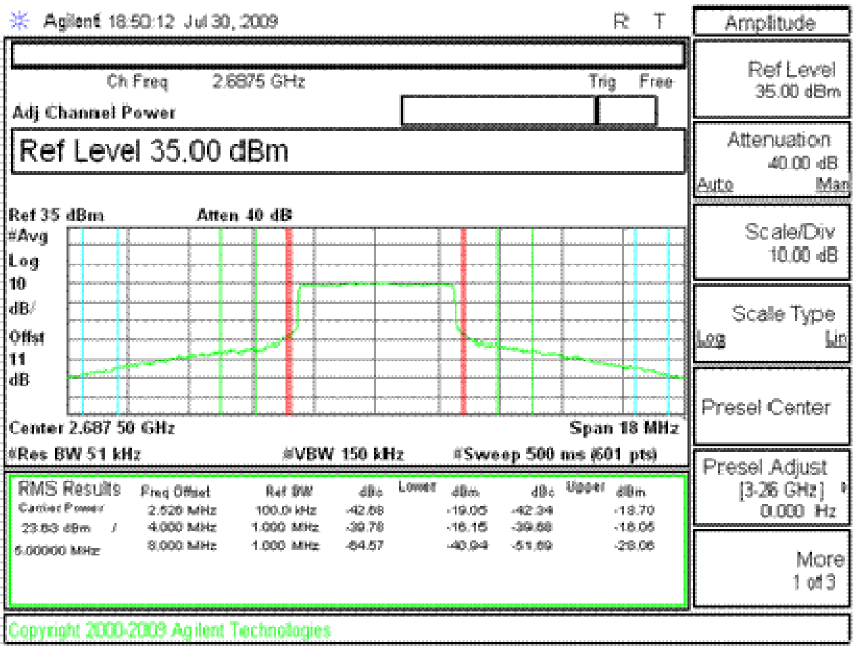
5 MHz_QPSK Low CH



5 MHz_QPSK Mid CH



5 MHz_QPSK High CH



14.1. PEAK TO AVERAGE RATIO

Peak and Average Output power measurements were made with Power Meter. Power meter in the Pulse mode measuring only during the ON time of the burst.

10 MHz

Mode	Test Vector file name	Ch. No	f (MHz)	Conducted Power (dBm)		Peak-to-average ratio (PAR)
				Peak	Average	
16QAM	DQ4_12_UQ16_12_10M	368	2593	30.777	23.266	7.511
QPSK	DQ64_UQ4_12_21S_10M	368	2593	30.841	22.787	8.054

5 MHz

Mode	Test Vector file name	Ch. No	f (MHz)	Conducted Power (dBm)		Peak-to-average ratio (PAR)
				Peak	Average	
16QAM	DQ4_12_UQ16_34_5M	378	2593	30.823	23.649	7.174
QPSK	DQ64_56_UQ4_12_5M	378	2593	30.823	22.83	7.993

Peak to Average Ratio Plots ON time of Burst

10MHz_16QAM

10MHz_QPSK

Peak to Average Ratio Plots On time of Burst

5MHz_16QAM

5MHz_QPSK

PAR ratio including OFF time

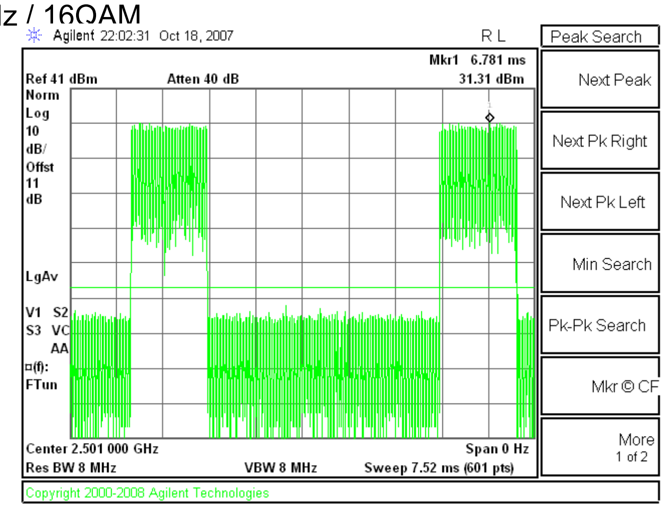
10 MHz

Mode	Test Vector file name	Ch. No	f (MHz)	Peak-to-average ratio (PAR)
16QAM	DQ4_12_UQ16_12_10M	368	2593	13.615
QPSK	DQ64_UQ4_12_21S_10M	368	2593	11.75

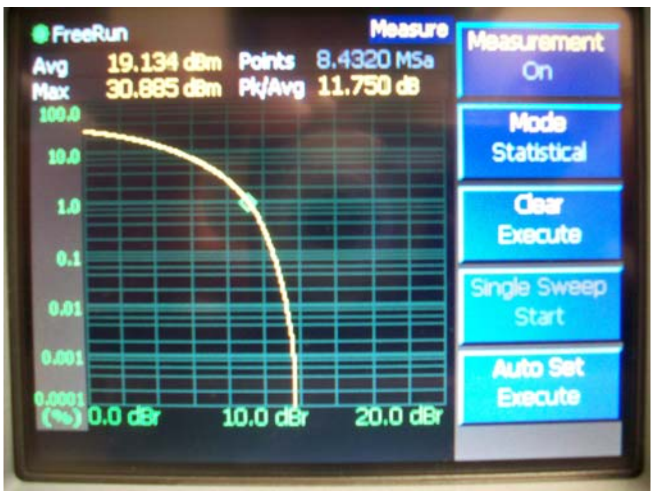
5 MHz

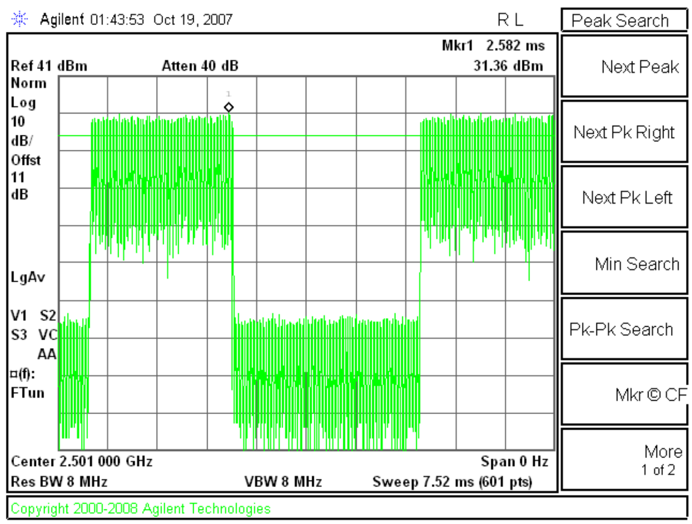
Mode	Test Vector file name	Ch. No	f (MHz)	Peak-to-average ratio (PAR)
16QAM	DQ4_12_UQ16_34_5M	378	2593	11.958
QPSK	DQ64_56_UQ4_12_5M	378	2593	12.115

10 MHz / 16QAM

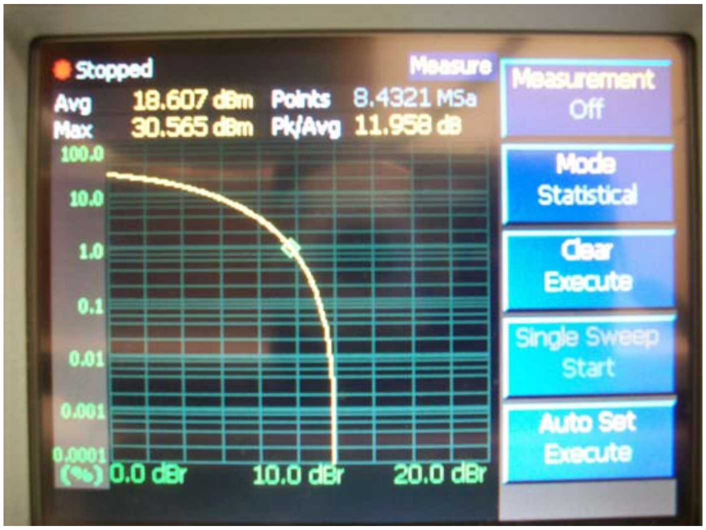


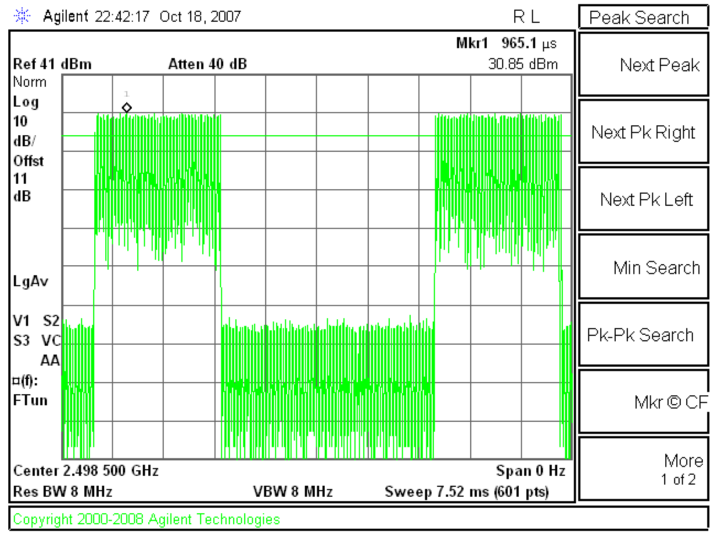
10 MHz/ QPSK



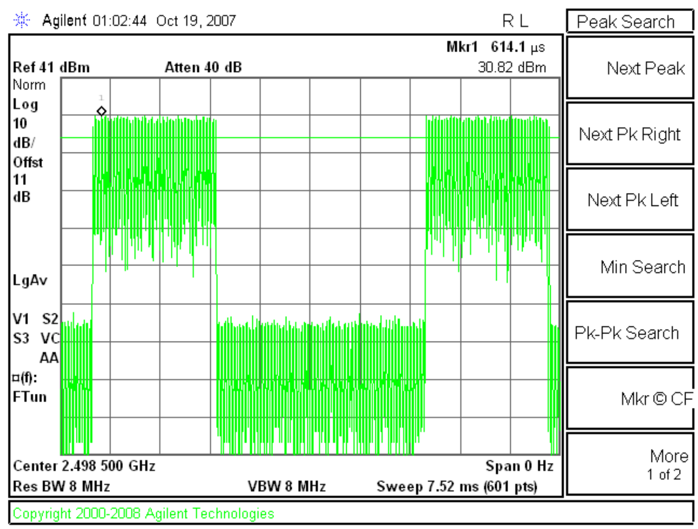


5 MHz / 16QAM





5 MHz/ QPSK



15. SUMMARY OF TEST RESULTS

The SAR measured at the middle channel for this configuration is at least 3 dB lower (0.8 mW/g) than SAR limit (1.6 mW/g), thus testing at low & high channel is optional.

15.1. 10 MHz CHANNEL BANDWIDTH

Mode	Test vector file name	f (MHz)	1g_SAR (mW/g)	Duty Cycle Scale Up Factor to DL:UL of 29:18	Scaled 1g_SAR (mW/g)	Limit (mW/g)
16QAM	DQ4_12_UQ16_12_10M	2593	0.007	1.39	0.009	1.6
QPSK	DQ64_UQ4_12_21S_10M	2593	0.011	0.76	0.008	

15.2. 5 MHz CHANNEL BANDWIDTH

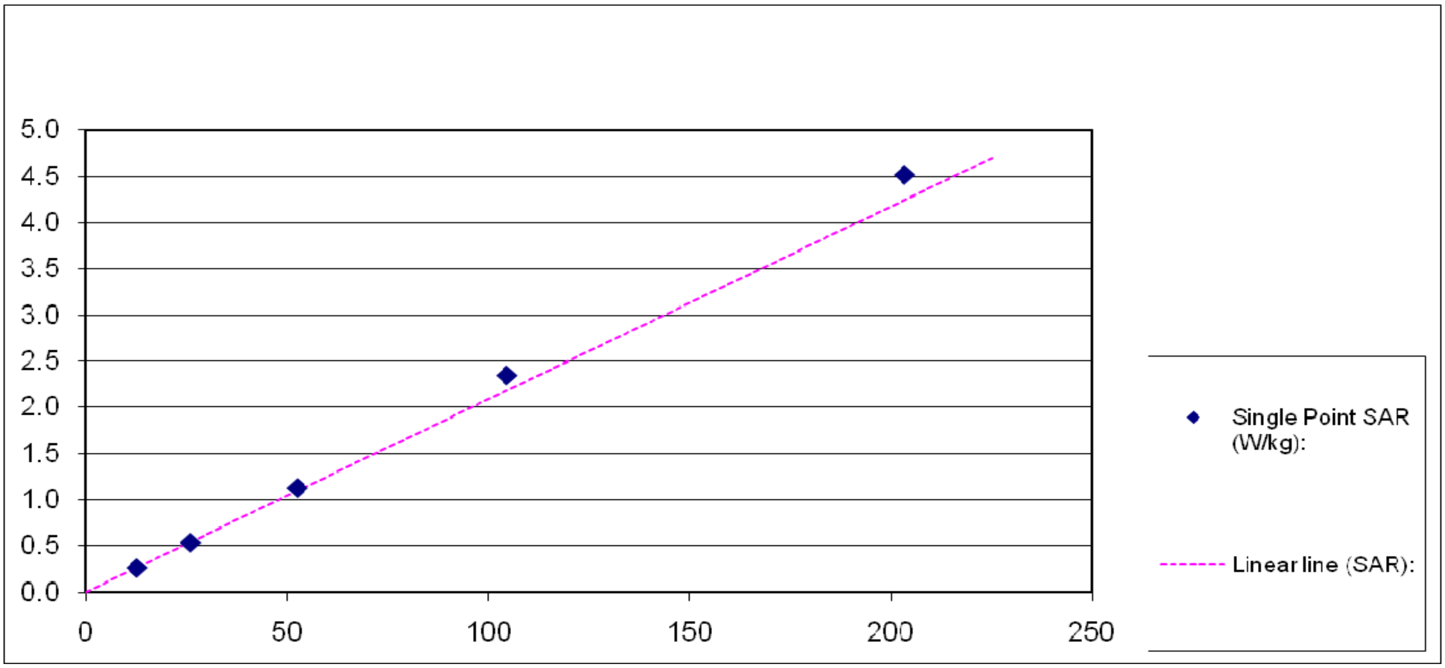
Mode	Test vector file name	f (MHz)	1g_SAR (mW/g)	Duty Cycle Scale Up Factor to DL:UL of 29:18	Scaled 1g_SAR (mW/g)	Limit (mW/g)
16QAM	DQ4_12_UQ16_34_5M	2593	0.013	0.92	0.012	1.6
QPSK	DQ64_56_UQ4_12_5M	2593	0.012	0.94	0.012	

16. PAR and SAR Error Consideration

In order to estimate the measurement error due to PAR issues, the configuration with the highest SAR in each channel bandwidth and frequency band is measured at various power levels, from approximately 12.5 mW at approx. 3 dB steps, until the maximum power is reached. During the tests, the edge of LCD panel is positioned at 0 cm separation distance to flat phantom (for purpose of evaluation but not consider as normal operation).

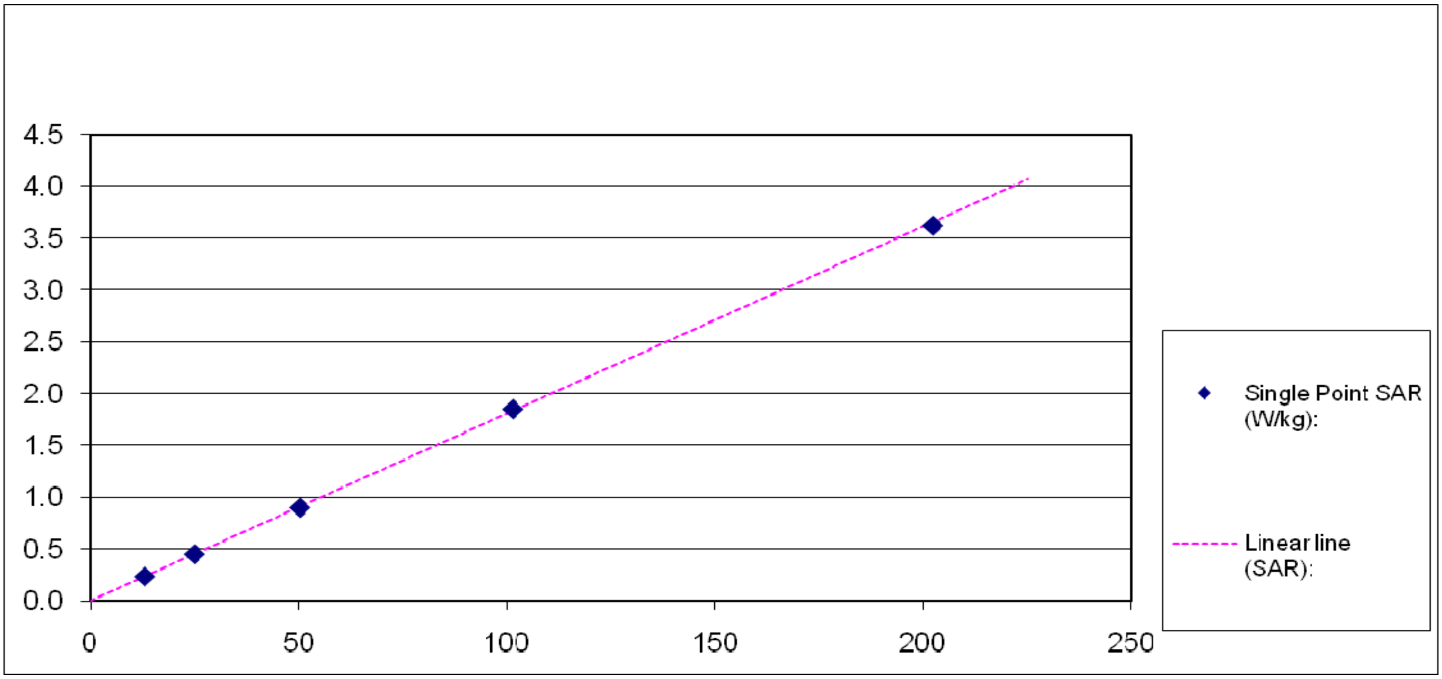
10 MHz/QPSK

Average Power (mW):	12.43	25.75	52.34	104.36	203.20	225.00
Single Point SAR (W/kg):	0.260	0.537	1.130	2.350	4.520	
Linear line (SAR):	0.260	0.539	1.095	2.183	4.250	4.706
Estimation (%):	0.000	-0.300	3.215	7.654	6.344	



5 MHz/ 16QAM

Average Power (mW):	12.95	24.88	50.23	101.45	202.40	225
Single Point SAR (W/kg):	0.234	0.449	0.898	1.850	3.620	
Linear line (SAR):	0.234	0.450	0.908	1.833	3.657	4.066
Estimation (%):	0.000	-0.127	-1.061	0.919	-1.019	



16QAM 10 MHz Ch. BW SAR Plot & Data

Date/Time: 7/27/2009 9:42:37 AM

Test Laboratory: Compliance Certification Services

Laptop mode 10M

DUT: Lenovo; Type: U150; Serial: N/A

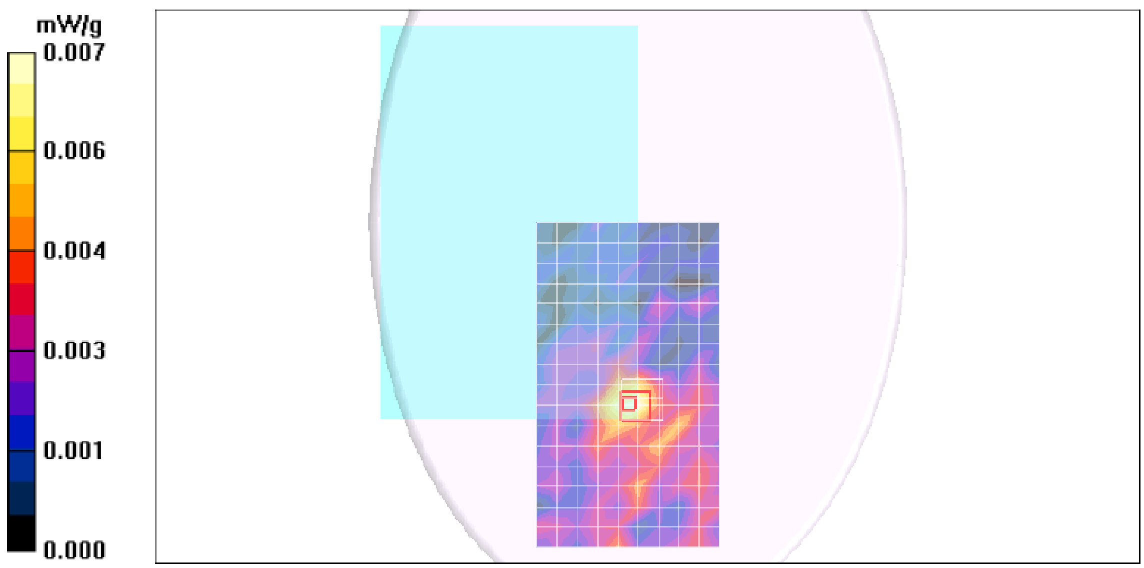
Communication System: WIMAX 2.6G 10M; Frequency: 2593 MHz;Duty Cycle: 1:4.05
Medium parameters used (interpolated): f = 2593 MHz; σ = 2.14 mho/m; ε_r = 52.8; ρ = 1000 kg/m^3
Phantom section: Flat Section

Room Ambient Temperature: 24.0 deg. C; Liquid Temperature: 23.0 deg. C

DASY4 Configuration:
- Area Scan setting - Find Secondary Maximum Within: 2.0 dB and with a peak SAR value greater than 0.0012W/kg
- Probe: EX3DV4 - SN3686; ConvF(6.4, 6.4, 6.4); Calibrated: 3/23/2009
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn427; Calibrated: 10/20/2008
- Phantom: Flat Phantom ELI4.0; Type: QDOVA001BA; Serial: SN:XXXX
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

16QAM 10M - Mid-ch/Area Scan (10x17x1): Measurement grid: dx=15mm, dy=15mm
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 0.007 mW/g

16QAM 10M - Mid-ch/Zoom Scan (7x7x9)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=3mm
Peak SAR (extrapolated) = 0.021 W/kg
SAR(1 g) = 0.00682 mW/g; SAR(10 g) = 0.00306 mW/g
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 0.009 mW/g



QPSK 10 MHz Ch. BW SAR Plot & Data

Date/Time: 7/27/2009 10:20:56 AM

Test Laboratory: Compliance Certification Services

Laptop mode 10M

DUT: Lenovo; Type: U150; Serial: N/A

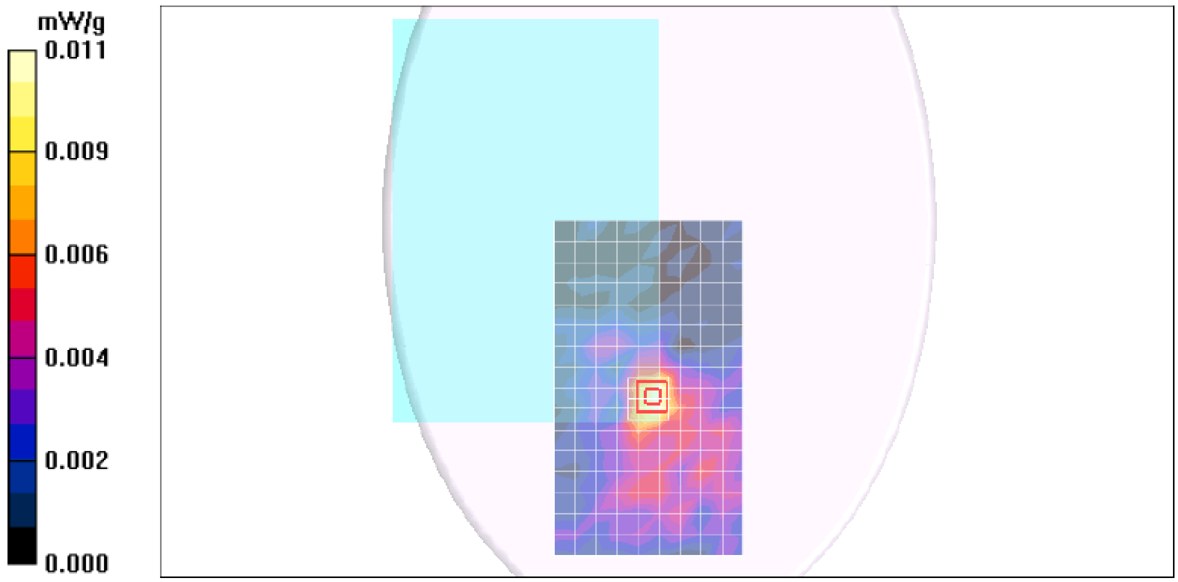
Communication System: WIMAX 2.6G 10M; Frequency: 2593 MHz;Duty Cycle: 1:2.32
Medium parameters used (interpolated): f = 2593 MHz; σ = 2.14 mho/m; ε_r = 52.8; ρ = 1000 kg/m^3
Phantom section: Flat Section

Room Ambient Temperature: 24.0 deg. C; Liquid Temperature: 23.0 deg. C

DASY4 Configuration:
- Area Scan setting - Find Secondary Maximum Within: 2.0 dB and with a peak SAR value greater than 0.0012W/kg
- Probe: EX3DV4 - SN3686; ConvF(6.4, 6.4, 6.4); Calibrated: 3/23/2009
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn427; Calibrated: 10/20/2008
- Phantom: Flat Phantom ELI4.0; Type: QDOVA001BA; Serial: SN:XXXX
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

QPSK 10M - Mid-ch/Area Scan (10x17x1): Measurement grid: dx=15mm, dy=15mm
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 0.011 mW/g

QPSK 10M - Mid-ch/Zoom Scan (7x7x9)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=3mm
Peak SAR (extrapolated) = 0.021 W/kg
SAR(1 g) = 0.011 mW/g; SAR(10 g) = 0.00543 mW/g
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 0.014 mW/g



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16QAM 5 MHz Ch. BW SAR Plot & Data

Date/Time: 7/27/2009 11:02:34 AM

Test Laboratory: Compliance Certification Services

Laptop mode 5M

DUT: Lenovo; Type: U150; Serial: N/A

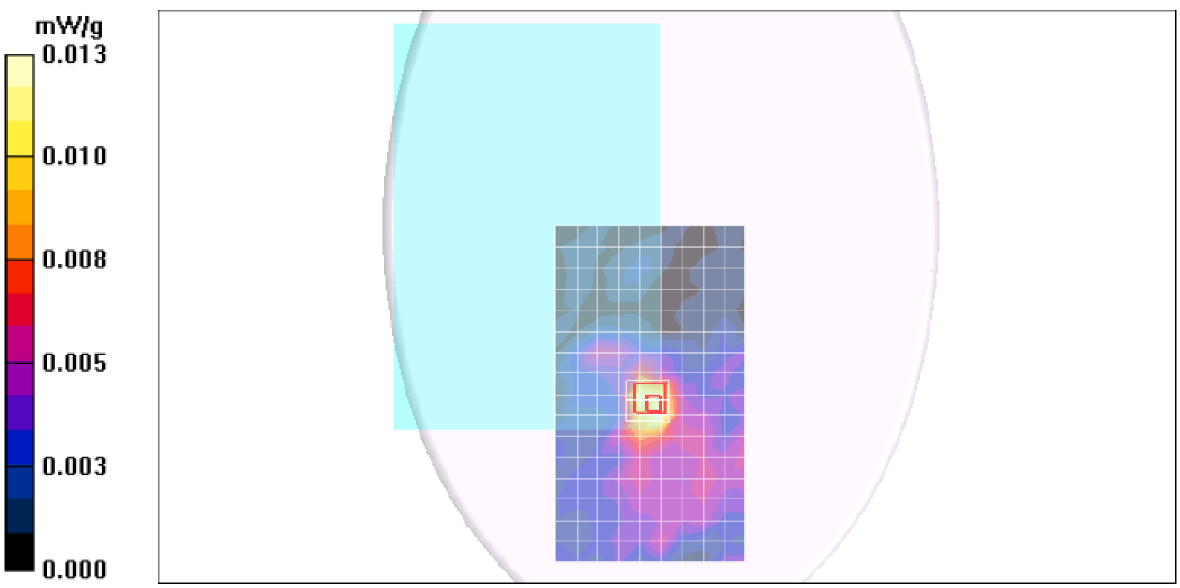
Communication System: WIMAX 2.6G 5M; Frequency: 2593 MHz;Duty Cycle: 1:2.7
Medium parameters used (interpolated): f = 2593 MHz; σ = 2.14 mho/m; ε_r = 52.8; ρ = 1000 kg/m^3
Phantom section: Flat Section

Room Ambient Temperature: 24.0 deg. C; Liquid Temperature: 23.0 deg. C

DASY4 Configuration:
- Area Scan setting - Find Secondary Maximum Within: 2.0 dB and with a peak SAR value greater than 0.0012W/kg
- Probe: EX3DV4 - SN3686; ConvF(6.4, 6.4, 6.4); Calibrated: 3/23/2009
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn427; Calibrated: 10/20/2008
- Phantom: Flat Phantom ELI4.0; Type: QDOVA001BA; Serial: SN:XXXX
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

16QAM 5M - Mid-ch/Area Scan (10x17x1): Measurement grid: dx=15mm, dy=15mm
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 0.013 mW/g

16QAM 5M - Mid-ch/Zoom Scan (7x7x9)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=3mm
Peak SAR (extrapolated) = 0.046 W/kg
SAR(1 g) = 0.013 mW/g; SAR(10 g) = 0.00524 mW/g
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 0.048 mW/g



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QPSK 5 MHz Ch. BW SAR Plot & Data

Date/Time: 7/27/2009 11:58:15 AM

Test Laboratory: Compliance Certification Services

Laptop mode 5M

DUT: Lenovo; Type: U150; Serial: N/A

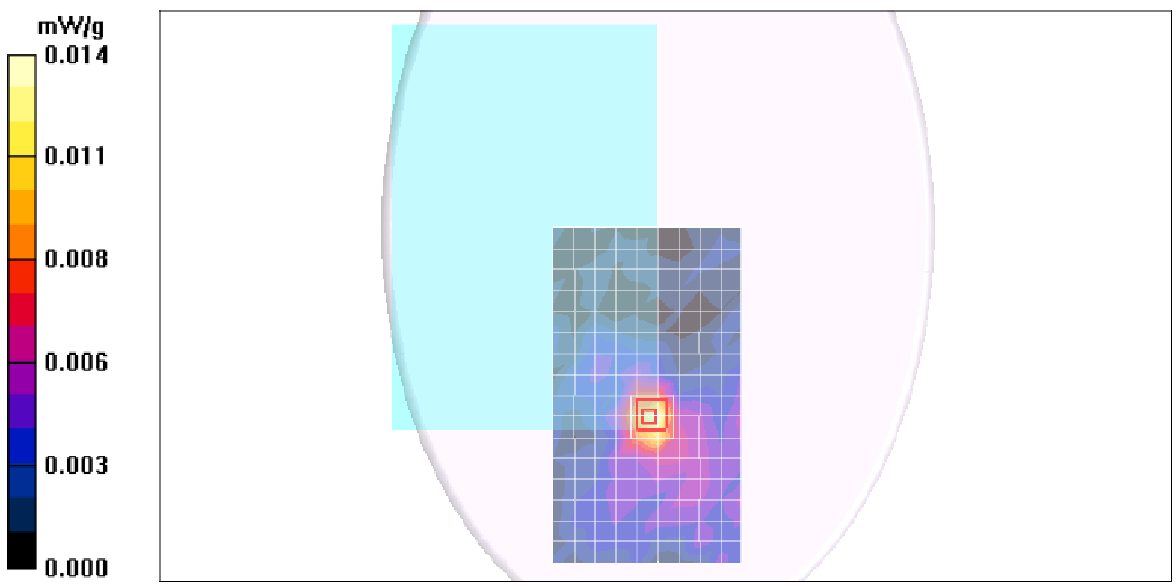
Communication System: WIMAX 2.6G 5M; Frequency: 2593 MHz;Duty Cycle: 1:2.7
Medium parameters used (interpolated): f = 2593 MHz; σ = 2.14 mho/m; ε_r = 52.8; ρ = 1000 kg/m^3
Phantom section: Flat Section

Room Ambient Temperature: 24.0 deg. C; Liquid Temperature: 23.0 deg. C

DASY4 Configuration:
- Area Scan setting - Find Secondary Maximum Within: 2.0 dB and with a peak SAR value greater than 0.0012W/kg
- Probe: EX3DV4 - SN3686; ConvF(6.4, 6.4, 6.4); Calibrated: 3/23/2009
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn427; Calibrated: 10/20/2008
- Phantom: Flat Phantom ELI4.0; Type: QDOVA001BA; Serial: SN:XXXX
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

QPSK 5M - Mid-ch/Area Scan (10x17x1): Measurement grid: dx=15mm, dy=15mm
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 0.014 mW/g

QPSK 5M - Mid-ch/Zoom Scan (7x7x9)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=3mm
Peak SAR (extrapolated) = 0.022 W/kg
SAR(1 g) = 0.012 mW/g; SAR(10 g) = 0.00704 mW/g
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 0.016 mW/g



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17. ATTACHMENTS

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2	Certificate of E-Field Probe - EX3DV4 SN3686	10
3	Certificate of System Validation Dipole - D2600V2 - SN:1006	6