SAR TEST REPORT

FCC ID : VYO-USBW25200

REPORT NO.: SA981118L05

MODEL NO.: USBw25200

RECEIVED: Dec. 5, 2009

TESTED: Dec. 09 ~ Jan. 12, 2010

ISSUED: Jan. 21, 2010

APPLICANT: Motorola, Inc.

ADDRESS: 1475 W. SHURE DRIVE, ARLINGTON HEIGHTS, IL 60004 UNITED STATES

ISSUED BY: Bureau Veritas Consumer Products Services (H.K.) Ltd., Taoyuan Branch

LAB ADDRESS: No. 47, 14th Ling, Chia Pau Tsuen, Lin Kou Hsiang, Taipei Hsien 244, Taiwan, R.O.C.

TEST LOCATION: No. 19, Hwa Ya 2nd Rd, Wen Hwa Tsuen, Kwei Shan Hsiang, Taoyuan Hsien 333, Taiwan, R.O.C.

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1. CERTIFICATION

PRODUCT: WiMAX USB Dongle
MODEL: USBw25200
BRAND: Motorola
APPLICANT: Motorola, Inc.
TESTED: Dec. 09 ~ Jan. 12, 2010
TEST SAMPLE: ENGINEERING SAMPLE
STANDARDS: **FCC Part 2 (Section 2.1093)**
FCC OET Bulletin 65, Supplement C (01-01)
RSS-102

The above equipment (model: USBw25200) has been tested by **Bureau Veritas Consumer Products Services (H.K.) Ltd., Taoyuan Branch,** and found compliance with the requirement of the above standards. The test record, data evaluation & Equipment Under Test (EUT) configurations represented herein are true and accurate accounts of the measurements of the sample's EMC characteristics under the conditions specified in this report.

PREPARED BY : Andrea Hsia / Specialist , **DATE:** Jan. 21, 2010

TECHNICAL ACCEPTANCE Responsible for RF : James Fan / Senior Engineer , **DATE:** Jan. 21, 2010

APPROVED BY : Gary Chang / Assistant Manager , **DATE:** Jan. 21, 2010

2. GENERAL INFORMATION

2.1 GENERAL DESCRIPTION OF EUT

PRODUCT	WiMAX USB Dongle
MODEL NO.	USBw25200
FCC ID	VYO-USBW25200
POWER SUPPLY	5.0Vdc
MODULATION TYPE	QPSK, 16QAM, 64QAM (refer to NOTE for more details)
CODING RATE	1/2, 2/3, 3/4, 5/6 (refer to NOTE for more details)
MODULATION TECHNOLOGY	OFDMA
DUPLEX METHOD	TDD
FREQUENCY RANGE	2498.5MHz ~ 2687.5MHz
CHANNEL BANDWIDTH	5MHz, 10MHz
CONDUCTED OUTPUT POWER	Refer to Note 4
UL ZONE TYPE	PUSC
AVERAGE SAR (1g)	1.53W/kg
ANTENNA TYPE	Printed antenna with 3dBi gain
DATA CABLE	NA
I/O PORTS	Refer to user's manual
ACCESSORY DEVICES	NA

NOTE:

1. For the EUT modulation type and coding rate.

Up Link		Down Link	
Modulation	**Coding rate**	**Modulation**	**Coding rate**
QPSK	1/2	QPSK	1/2
	3/4		3/4
16QAM	1/2	16QAM	1/2
	3/4		3/4
		64QAM	1/2
			2/3
			3/4
			5/6

2. The EUT can supports different UL / DL ratio, max transmit ratio is up to 18(UL): 29 (DL).
3. The EUT provides one completed transmitter and two receivers.

4. The above EUT information was declared by manufacturer and for more detailed features description, please refers to the manufacturer's specifications or User's Manual.
5. Per KDB 615223 "FCC WiMAX SAR Guidance", below are required "Device and System Operating Parameters" specified in Table 1 and Table 2

Table 1 : 802.16e/WiMAX Device and System Operating Parameters

Description	Parameter		Comment
FCC ID	VYO-USBW25200		Identify all related FCC ID
Radio Service	Part 27 subpart M		Rule parts
Transmit Frequency Range (MHz)	2496MHz-2690MHz		System parameter
System/Channel Bandwidth (MHz)	5MHz	10MHz	System parameter
System Profile	Revision 1.7.0		Defined by WiMAX Forum
Modulation Schemes	QPSK,16QAM for uplink		Identify all applicable UL modulations
Sampling Factor	28/25		System parameter
Sampling Frequency (MHz)	5.6MHz	11.2MHz	(Fs)
Sample Time (ns)	178.581ns	89.3ns	(1/Fs)
FFT Size (NFFT)	512	1024	(NFFT)
Sub-Carrier Spacing (kHz)	10.9375kHz		(Δf)
Useful Symbol time (μs)	91.43us		(Tb=1/Δf)
Guard Time (μs)	11.43us		(Ts=Tb+Tg)
OFDMA Symbol Time(μs)	102.86μs		(Ts=Tb+Tg)
Frame Size (ms)	5ms		System parameter
TTG + RTG (μs or number of symbols)	165.7143us		Idle time, system parameter
Number of DL OFDMA Symbols per Frame	29		Identify the allowed & maximum symbols, including both traffic & control symbols
Number of UL OFDMA Symbols per Frame	18		
DL:UL Symbol Ratio	29:18		For determining UL duty factor
Power Class (dBm)	Power Class 2, 23±1dBm		Identify power class and tolerance
Wave1 / Wave2	Wave2, 2 antenna with receive MRC DL MIMO matrix A and B.		Describe antenna diversity info and MIMO requirements separately
UL Zone Types (FUSC, PUSC, OFUSC, OPUSC, AMC, TUSC1, TUSC2)	Segmented PUSC Unsegmented PUSC		Describe separately the symbol and sub-carrier/sub-channel structures applicable to each zone type
Maximum Number of UL Sub-Carriers	409	841	Identify the allowed and tested/to be tested parameters; include separate
UL Burst Maximum Average Power	5MHz :23.13dBm	10MHz:23.09dBm	
Number and type of UL Control Symbols	3 PUSC symbols (used for ranging, CQICH and ACK/NACK)		
UL Control Symbol Maximum Average Power	**60.47mW**	**29.1mW**	
UL Burst Peak-to-Average Power Ratio (PAR)	A Anritus wideband power meter was used to measure this item. Average, peak and PAR are measured simultaneously and presented in the measurement plots. PAR ratio is 6.73-8.33 dB. For detail please refer to Appendix C.		Identify the expected range and measured/tested PAR; explain separately the methods used / to be used to address SAR probe calibration and measurement error issues

Frame Averaged UL Transmission Duty Factor	Duty cycle was measured by a spectrum analyzer and 2 plots are taken for this item. Plot 1 is for complete frame length ,plot 2 is for UL burst length. Measured Duty cycle is 31.2 % and the Theoretical Duty cycle is 15x102.857us / 5000us =30.857%. cf = 1/(0.30857)=3.24 . As instructed by the commission, the theoretical conversion factor cf=3.24 was used during the SAR evaluation. Please refer to Appendix D and following pages for detail.	Show calculations separately and explain how the applicable cf factor (conversion factor) used or to be use in the SAR measurements is derived and how the control symbols are accounted for

Table 2 : Information on Test Equipment and Measurement Results

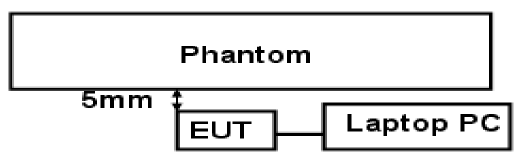
Test software

The Beceem test tool is used on the laptop.
Beceem test tool is used to instruct the USB dongle to go to full power. Under normal operating conditions the BS would be responsible for controlling the MS Tx power. When working with a BS, the MS cannot Tx at a power greater than the max power requested by Beceem test tool.

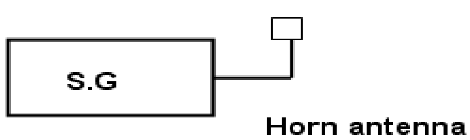
Note: Beceem test tool is a specific tool provided by client. This tool can control EUT to transmit at specific channel, maximum output power, and channel bandwidth.

Signal Generator, Communication test set ,protocol simulator

The test set-up is shown in the following picture. The USB Adapter (EUT) is plugged into the notebook computer and configured exactly as it would be in the field on a normal network.



Linking up through air interface



Output power of S.G is - 20dBm
Horn antenna has 10.6dBi gain at 2.5GHz
Distance between horn antenna and EUT is 4m

On the network side, there is a vector signal generator as below:

Agilent E4438C ESG with below options:
N7613A: Signal Studio for 802.16-2004 WiMAX
N7615B: Signal studio for 802.16 WiMAX

Software is loaded into the E4438C ESG that produces an output signal that looks like a 29:18 WiMAX frame, the EUT detects the “network” and begins to transmit based on the commands from the ESG signal and the measurements are then taken on the EUT.

SAR Test Signal Characteristics and Structure

The USBw25200device is 2.5 GHz WiMAX transceiver in a USB dongle configuration using Beceem chipset which supports 1xTx and 2xRx for this device. Its uplink is capable of both 10 MHz and 5 MHz bandwidths.

PUSC zone type:
For the 10 MHz bandwidth, it has 35 sub-channels structured from 1024 subcarriers; 184 are used as spare/safeguard subcarriers, leaving 840 available for transmission. From this, 560 subcarriers for data transmission with 280 subcarriers intended for pilot use. For the 5 MHz bandwidth, it contains 17 sub-channels using 512 subcarriers; 104 subcarriers as spare/safeguard subcarriers, 272 for data transmission, and 136 for pilot.

The up-link sub-frame is triggered by an Allocation Start Time contained in the information of UL-MAP. This information specifies the starting times of the Uplink and Downlink frames. In any UL sub-frame, the duty factor and bandwidth information is used to ensure optimal system operation. In the real usage, the data burst power will be adjusted according to the signal strength of the communication. In this way, by using the test mode arrangement we are transmitting at a worst case RF level.

The signal generator produces a downlink DL burst every 5 milliseconds which simulates the transmission of a base-station operating under normal mode. This DL burst instructs the mobile station MS to transmit for 15 symbols in the UL data zone. This UL transmission is repeated every 5 milliseconds. The TX power of the mobile station is set to maximum power. The ESG and MS use same frequency. The ESG power is much less than the MS Tx power (Approximately 50dB less than the MS power) and so does not affect the SAR readings. Since both the signal generator (BS simulator) and MS are working in TDD mode, co-operation under same frequency is not an issue.

The ESG is loaded with a BS (Base Station) downlink signal which contains the 29:18 information. The mobile station (MS) (DUT) synchronizes to the signal from the ESG in frequency and time and then demodulates two maps contained in the ESG DL frame. The first map, called the DL map, specifies the number of DL symbols (29). The second map, called the UL map, specifies the number of UL symbols (18). The UL map also tells the MS to transmit a burst which occupies all data symbols and all sub-channels. No control channel transmissions are requested by the ESG. Measurements were taken in this configuration with the MS transmitting using the 29:18 ratio, but since there was no energy in the control symbols, the effective power is only across 15 data symbols.

As mentioned above the DL:UL frame is specified in the DL and UL maps respectively. There is no ranging present when there is data traffic. The other types of control traffic are HARQ ACK/NACK, CQICH (CINR reporting) and bandwidth BW requests. BW requests are piggy-backed onto the data symbols when traffic is present. The control traffic that is relevant to the SAR calculation is CQICH and HARQ ACK/NACK. The maximum power for this control traffic is 29.10mW(5/35 of 203.70mW) for 10MHz and 60.47mW(5/17 of 205.59 mW) for 5MHz.

In the test mode the UL operates in PUSC with all data sub-channels (All 35 sub-channels for 10MHz) occupied with data. During normal operation the MS will transmit on all sub-channels when maximum UL throughput is required. It is possible for the mobile-station to transmit with fewer sub-channels. The sub-channels consist of tones that are distributed over the entire signal BW and a jump every three symbols so that the spectral density and hence SAR for the fractional sub-channel case will be similar to the full sub-channel case that is tested. (Note: In the WiMAX standard a sub-channel consists of tones that are spread across the occupied bandwidth. After every three symbols, the tones that make up the sub-channel switch to a new set of frequencies spread across the band. This “jumping” is called sub-channel rotation and helps to give the sub-channel frequency diversity.)

Scaling factor calculation

The testing was done at 29:18 ratio as this is the max achievable ratio for the product (Please refer to manufacture declaration latter). The 29 indicates the number of downlink (from the base station) symbols and the 18 indicates the number of uplink (transmitted from the MS) symbols. Inside the uplink, 15 of the symbols are used for data, and three of the symbols are used for sending control information to the network. During the testing, the control symbols contained no information, so did not contribute to the total energy transmitted. To compensate for the maximum energy which may presented in the 3 control symbols, following scheme is used for the up scaling:

Max output power of 5MHz is 23.13dBm =205.59mW (Reference power table of P9)

The maximum power in 5M control traffic is 60.47mW (5/17 of 205.59 mW)

Scaling factor for 5MHz bandwidth =

= (3*60.47+15*205.59) / (15 * max measured power of the channel tested)
=3265.26 / (15 * max measured power of the channel tested)

Max output power of 10MHz is 23.09dBm =203.70mW (Reference power table of P9)

The maximum power in 10M control traffic is 29.10mW (5/35 of 203.70mW)

Scaling factor for 10MHz bandwidth =

= (3*29.1+15*203.7) / (15 * max measured power of the channel tested)
=3142.865 / (15 * max measured power of the channel tested)

Output Power Measurement

A Anritus wideband power meter was used for measuring this item. The power indicated below was taken during the burst-on period only by means of triggering and gating function. **For detail measurement records please refer to Appendix C.**

The measured conducted output powers and PAR are listed below.

The max average power for 5M BW is : 23.13 dBm (205.59 mW)
The max average power for 10M BW is : 23.09 dBm (203.7 mW)
The PAR range is from 6.73 to 8.33 dB

FOR PUSC ZONE TYPE

Measured Average and Peak power

Bandwidth		5MHz						
TX Antenna		Ant 1				Ant 2		
Modulation	Frequency(MHz)	AV	PK	PAR		AV	PK	PAR
QPSK 1/2	2498.5	**23.13**	30.25	7.12		23.1	30.26	7.16
	2587	22.71	30.03	7.32		22.81	30.17	7.36
	2687.5	21.72	29.51	7.79		21.76	29.91	8.15
QPSK 3/4	2498.5	23.13	29.86	6.73		23.11	30.22	7.11
	2587	22.77	29.79	7.02		22.81	30.22	7.41
	2687.5	21.74	30.07	8.33		21.78	29.91	8.13
16QAM 1/2	2498.5	23.02	30.25	7.23		23.04	30.22	7.18
	2587	22.86	29.66	6.8		22.76	30.27	7.51
	2687.5	21.76	29.37	7.61		21.81	29.87	8.06
16QAM 3/4	2498.5	23.04	30.32	7.28		23.05	30.25	7.2
	2587	22.81	30.01	7.2		22.71	30.24	7.53
	2687.5	21.79	29.21	7.42		21.71	29.98	8.27

Bandwidth		10MHz						
TX Antenna		Ant 1				Ant 2		
Modulation	Frequency(MHz)	AV	PK	PAR		AV	PK	PAR
QPSK 1/2	2501	23.08	30.18	7.1		23.07	30.28	7.21
	2587	22.77	29.76	6.99		22.75	30.1	7.35
	2685	21.81	29.62	7.81		21.78	29.97	8.19
QPSK 3/4	2501	**23.09**	30.39	7.3		23.05	29.88	6.83
	2587	22.74	30.07	7.33		22.82	29.99	7.17
	2685	21.82	29.92	8.1		21.86	29.85	7.99
16QAM 1/2	2501	23.05	29.88	6.83		23.08	30.09	7.01
	2587	22.71	30.14	7.43		22.75	30.1	7.35
	2685	21.8	29.92	8.12		21.74	29.92	8.18
16QAM 3/4	2501	23.06	29.99	6.93		23.05	30.31	7.26
	2587	22.76	30.07	7.31		22.74	30.05	7.31
	2685	21.73	29.82	8.09		21.76	29.78	8.02

Scaling Factor deriving

Bandwidth	5MHz	10MHz
Max power	23.13dBm=205.59mW	23.09dBm=203.7mW
Max Power of 3 control symbols	60.47mW	29.1mW

For PUSC 5MHz

Scaling factor
= (3*60.47+15*205.59) / (15 * max measured power of the channel tested)
=3265.26 / (15 * max measured power of the channel tested)
For example: S.F for Ant 1 QPSK 1/2 first channel
=3265.26 / (15 *205.59)= 1.059 23.13dBm=205.59mw

Ant 1

Modulation	Power tested	S.F
QPSK 1/2	23.13	1.059
	22.71	1.166
	21.72	1.465
QPSK 3/4	23.13	1.059
	22.77	1.150
	21.74	1.458
16QAM 1/2	23.02	1.086
	22.86	1.127
	21.76	1.452
16QAM 1/2	23.04	1.081
	22.81	1.140
	21.79	1.442

Ant 2

Power tested	S.F
23.1	1.066
22.81	1.140
21.76	1.452
23.11	1.064
22.81	1.140
21.78	1.445
23.04	1.081
22.76	1.153
21.81	1.435
23.05	1.079
22.71	1.166
21.71	1.468

For PUSC 10MHz

Scaling factor
= (3*29.1+15*203.7) / (15 * max measured power of the channel tested)
=3142.865 / (15 * max measured power of the channel tested)

Ant 1

Modulation	Power tested	S.F
QPSK 1/2	23.08	1.031
	22.77	1.107
	21.81	1.381
QPSK 3/4	23.09	1.029
	22.74	1.115
	21.82	1.378
16QAM 1/2	23.05	1.038
	22.71	1.123
	21.8	1.384
16QAM 1/2	23.06	1.036
	22.76	1.110
	21.73	1.407

Ant 2

Power tested	S.F
23.07	1.033
22.75	1.112
21.78	1.391
23.05	1.038
22.82	1.095
21.86	1.365
23.08	1.031
22.75	1.112
21.74	1.404
23.05	1.038
22.74	1.115
21.76	1.397

Time domain plots for 5MHz bandwidth -QPSK 1/2 modulation

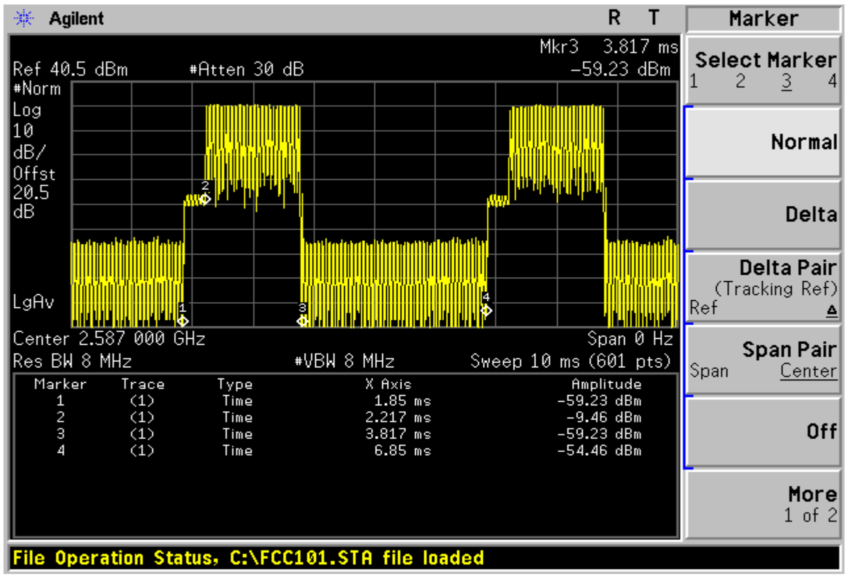
TEST CHANNEL	MODULATION	ZONE TYPE
MIDDLE	QPSK 1/2	PUSC

2 plots are recorded for duty cycle.

Plot 1 is for measuring the frame length of the test signal.

Frame length = Mark 4 – Mark 1=6.85ms -1.85ms = 5ms

Plot 1

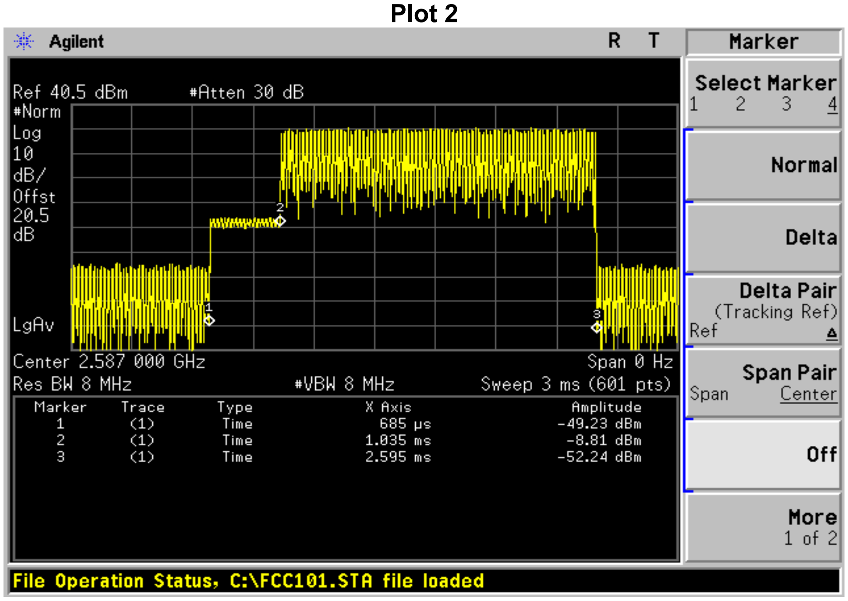


Plot 2 is for measuring the UL burst-on time of the test signal.

Mark 2 – Mark1 = First 3 symbols UL time

Mark 3 – Mark 2 =15 symbols UL time

Plot 2



Duty cycle = 15 symbols UL time / frame length *100 %
=2.595ms-1.035ms)/ 5ms x 100% = 31.2 %

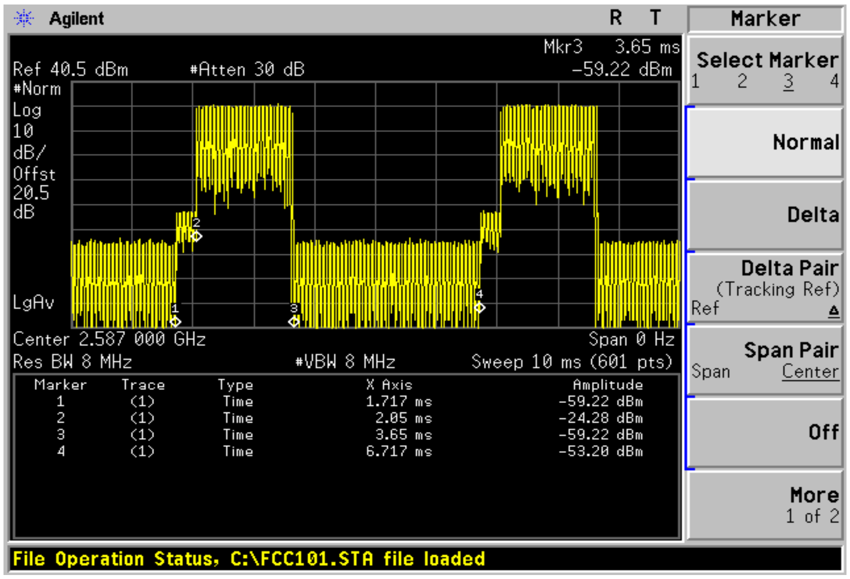
Time domain plots for 5MHz bandwidth -16QAM 1/2 modulation

TEST CHANNEL	MODULATION	ZONE TYPE
MIDDLE	16QAM 1/2	PUSC

2 plots are recorded for duty cycle.

Plot 1 is for measuring the frame length of the test signal.
Burst length = Mark 4 – Mark 1=6.717ms – 1.717ms = 5 ms

Plot 1

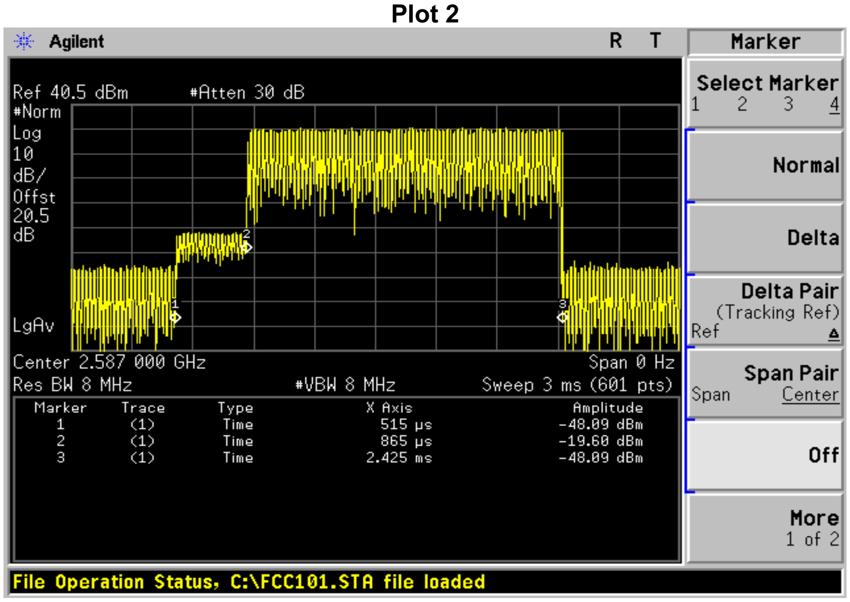


Plot 2 is for measuring the UL burst-on time of the test signal.

Mark 2 – Mark1 = First 3 symbols UL time

Mark 3 – Mark 2 =15 symbols UL time

Plot 2



Duty cycle = 15 symbols UL time / frame length *100 %
=(2.425ms -0.865ms)/ 5ms x 100%
= 31.2 %

Time domain plots for 10MHz bandwidth -QPSK 1/2 modulation

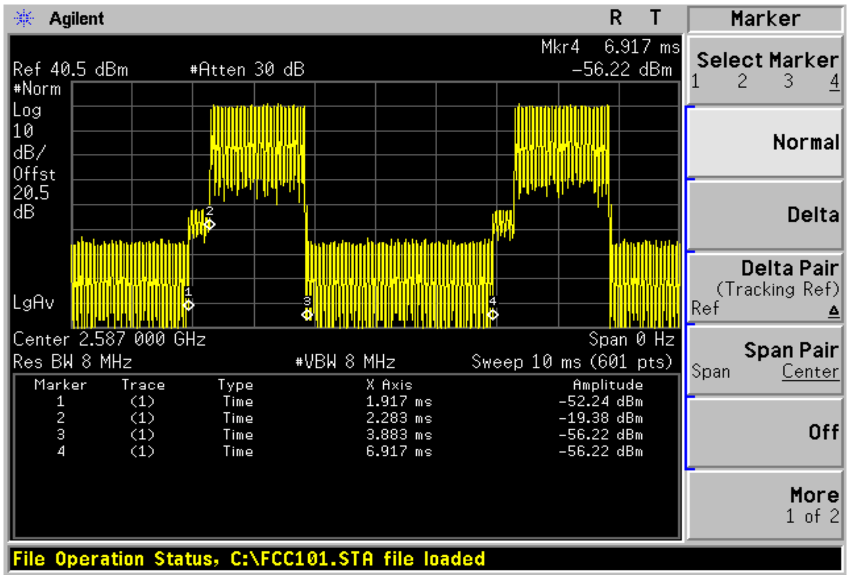
TEST CHANNEL	MODULATION	ZONE TYPE
MIDDLE	QPSK 1/2	PUSC

2 plots are recorded for duty cycle.

Plot 1 is for measuring the frame length of the test signal.

Burst length = Mark 4 – Mark 1=6.617ms – 1.917ms = 5ms

Plot 1

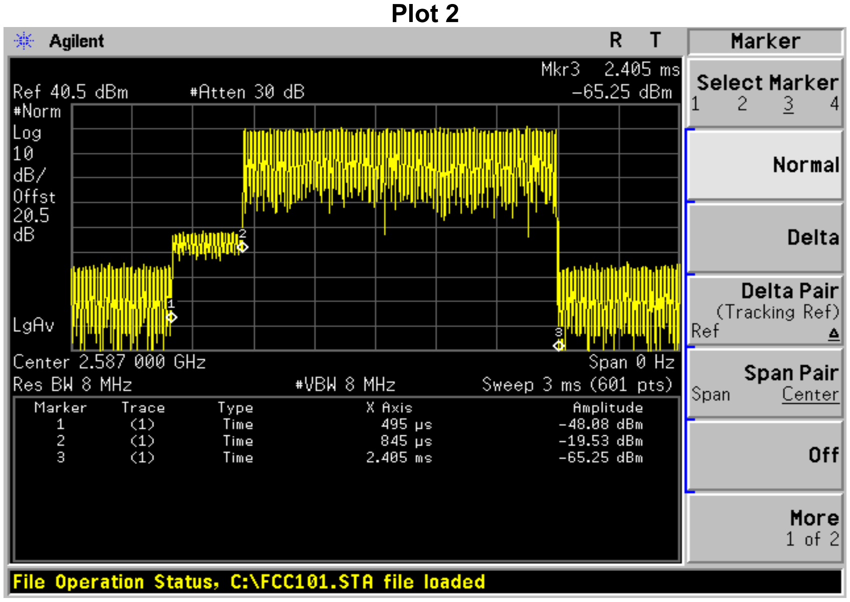


Plot 2 is for measuring the UL burst-on time of the test signal..

Mark 2 – Mark1 = First 3 symbols UL time

Mark 3 – Mark 2 =15 symbols UL time

Plot 2



Duty cycle = 15 symbols UL time / frame length *100 %
= (2.405ms-0.845ms)/ 5ms x 100% = 31.2 %

Time domain plots for 10MHz bandwidth -16WAM 1/2 modulation

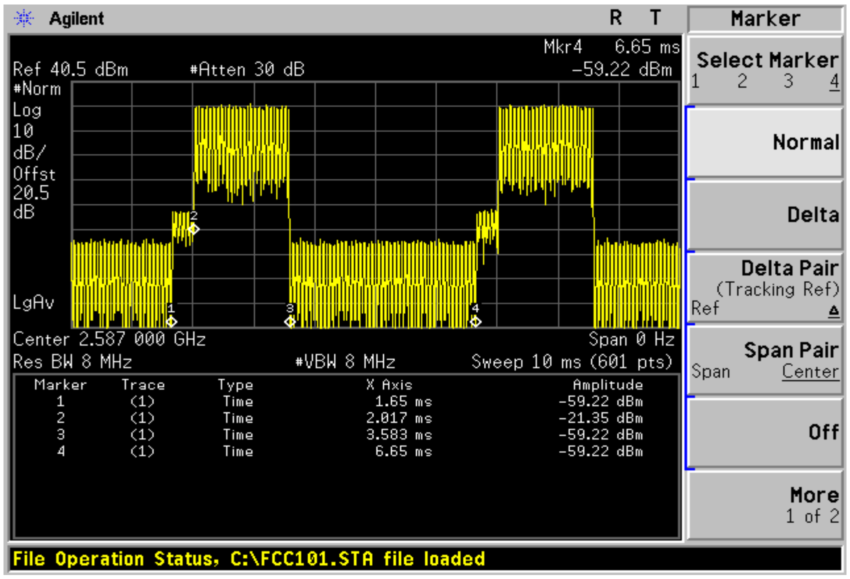
TEST CHANNEL	MODULATION	ZONE TYPE
MIDDLE	16QAM 1/2	PUSC

2 plots are recorded for duty cycle.

Plot 1 is for measuring the frame length of the test signal.

Burst length = Mark 4 – Mark 1=6.65ms- 1.65 ms = 5ms

Plot 1

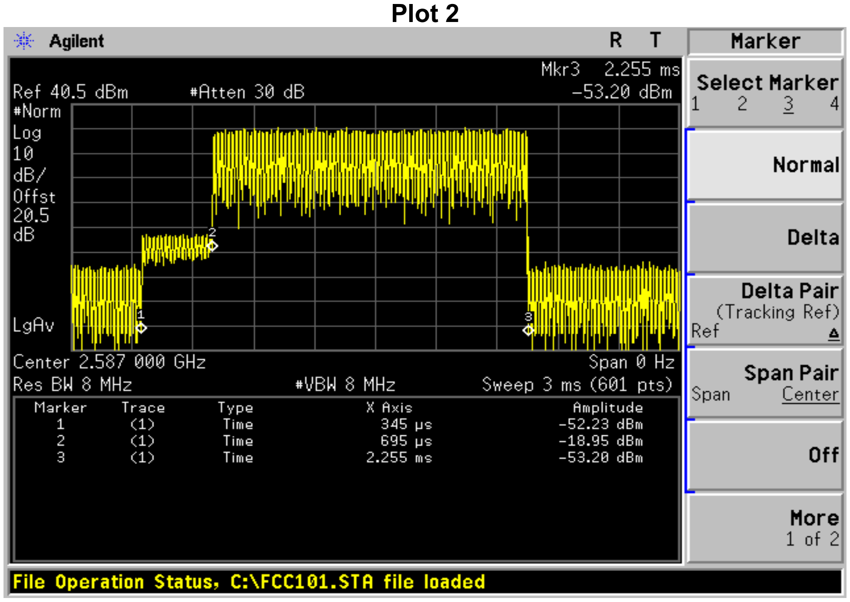


Plot 2 is for measuring the UL burst-on time of the test signal.

Mark 2 – Mark1 = First 3 symbols UL time

Mark 3 – Mark 2 =15 symbols UL time

Plot 2



Duty cycle =15 symbols UL time / frame length *100 %

=(2.255ms -0.695ms)/ 5ms x 100%

= 31.2 %

SAR Measurement Results Summary

In lab PBA # 228372, we have requested the test reduction for conducting SAR evaluation on the worst diversity antenna only. However, we feel this may cause extra concern during the FCC/TCB review later. To avoid this uncertainty, We had decided to conduct full SAR test on both diversity antennas in this application. All test results are tabulated in following tables.

SAR value For PUSC / ANT 1

5M BW QPSK 1/2

Bandwidth		5MHz		Modulation		QPSK 1/2		Zone type		PUSC	
SAR (W/ kg)		Horizontal-A		Horizontal-B		Vertical-C		Vertical-D		Tail	
Channel	Freq(MHz)	Meas.	Scaled	Meas.	Scaled	Meas.	Scaled	Meas.	Scaled	Meas.	Scaled
Low	2498.50	0.677	0.717	0.381	0.403	0.753	0.797			0.478	0.506
Middle	2587.00	0.904	1.054	0.453	0.528	0.851	0.992	0.3	0.350	0.649	0.757
High	2687.50	0.856	1.254	0.406	0.595	0.792	1.160			0.603	0.883

10M BW QPSK 1/2

Bandwidth		10MHz		Modulation		QPSK 1/2		Zone type		PUSC	
SAR (W/ kg)		Horizontal-A		Horizontal-B		Vertical-C		Vertical-D		Tail	
Channel	Freq(MHz)	Meas.	Scaled	Meas.	Scaled	Meas.	Scaled	Meas.	Scaled	Meas.	Scaled
Low	2501	0.747	0.770	0.377	0.389	0.668	0.689			0.461	0.475
Middle	2587	0.912	1.010	0.463	0.513	0.796	0.881	0.302	0.334	0.665	0.736
High	2685	0.903	1.247	0.473	0.653	0.767	1.059			0.608	0.840

SAR value For PUSC / ANT 2

5M BW QPSK 1/2

Bandwidth		5MHz		Modulation		QPSK 1/2		Zone type		PUSC	
SAR (W/ kg)		Horizontal-A		Horizontal-B		Vertical-C		Vertical-D		Tail	
Channel	Freq(MHz)	Meas.	Scaled	Meas.	Scaled	Meas.	Scaled	Meas.	Scaled	Meas.	Scaled
Low	2498.50	0.807	0.860	0.417	0.445			0.635	0.677	0.518	0.552
Middle	2587.00	**1.08**	1.231	0.485	0.553	0.362	0.413	0.986	1.124	0.766	0.873
High	2687.50	1.05	**1.525**	0.423	0.614			0.941	1.366	0.718	1.043

Note: To confirm that the QPSK 1/2 is indeed the worst modulation, all other 3 modulations are tested at the highest raw 1g SAR configuration (1.08 w/kg) found above and result tabulated below.

Bandwidth 5MHz; Zone type PUSC							
Modulation		QPSK 3/4		16QAM 1/2		16QAM 3/4	
SAR (W/ kg)		Horizontal-A		Horizontal-A		Horizontal-A	
Channel	Freq(MHz)	Meas.	Scaled	Meas.	Scaled	Meas.	Scaled
Middle	2587.00	1.04	1.186	1.05	1.211	1.01	1.178

Sample calculation for the worst case SAR

S.F for Ant 2 QPSK 1/2 = 1.452 form page 10 Ant 2 table

Raw measured SAR = 1.05

Final rescaled SAR = 1.05*1.452= 1.525

10M BW QPSK 1/2

Bandwidth		10MHz		Modulation		QPSK 1/2		Zone type		PUSC	
SAR (W/ kg)		Horizontal-A		Horizontal-B		Vertical-C		Vertical-D		Tail	
Channel	Freq(MHz)	Meas.	Scaled	Meas.	Scaled	Meas.	Scaled	Meas.	Scaled	Meas.	Scaled
Low	2501	0.892	0.921	0.382	0.395			0.631	0.652	0.528	0.545
Middle	2587	**1.07**	1.190	0.493	0.548	0.287	0.319	0.967	1.075	0.764	0.850
High	2685	1.02	1.419	0.517	0.719			0.92	1.280	0.707	0.983

Note: To confirm that the QPSK 1/2 is indeed the worst modulation, all other 3 modulations are tested at the highest raw 1g SAR configuration (1.07 w/kg) found above and result tabulated below.

Bandwidth		10MHz		Zone type		PUSC	
Modulation		QPSK 3/4		16QAM 1/2		16QAM 3/4	
SAR (W/ kg)		Horizontal-A		Horizontal-A		Horizontal-A	
Channel	Freq(MHz)	Meas.	Scaled	Meas.	Scaled	Meas.	Scaled
Middle	2587.00	1.03	1.128	1.04	1.156	1.01	1.126

linearity response & scan resolution Check

Linearity response check:

Test setup is as below

Distance between phantom and the front of EUT is 5mm . Control EUT to transmit at various average power level and do single point peak SAR measurement at specified power level. The reported power is RMS average measured during burst-on period by trigger and gating.

Test condition

Zone type	PUSC	PUSC
Modulation	5M QPSK1/2	10M QPSK1/2
Waveform	29U18	29U18
Test configuration	Horizontal-A	Horizontal-A
Separation distance	5mm	5mm
Frequency	2587 MHz	2587 MHz

Note: this is the same setup which produce the highest raw 1g SAR for 5M and 10M QPSK configuration.

Test instrument for output power

DESCRIPTION & MANUFACTURER	MODEL NO.	SERIAL NO.	DATE OF CALIBRATION	DUE DATE OF CALIBRATION
High Speed Peak Power Meter	ML2495A	0824012	Aug. 10, 2009	Aug. 09, 2010
Power Sensor	MA2411B	0738138	Aug. 10, 2009	Aug. 09, 2010

NOTE:
The calibration interval of the above test instruments is 12 months and the calibrations are traceable to NML/ROC and NIST/USA.

Reference line is based on measured SAR value of 12.5 and 25mW.

For 10MHz QPSK 1/2

WiMAX Peak RMS output power (mW) , X axis 12.5 25
Measured SAR (mW /g), Y axis0.157 0.312

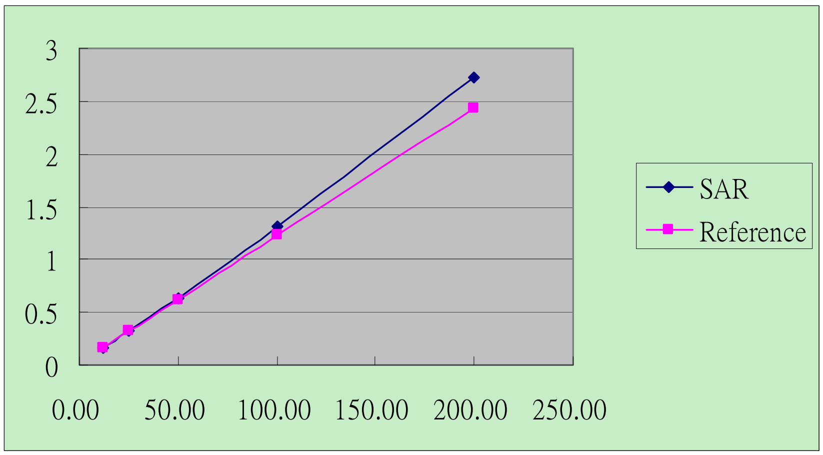
Calculation method is as below:
1. Get the slope of the 2 point. (12.5, 0.157) , (25 , 0.312)
Slope=M= (0.312-0.157)/(25-12.5)=0.0124
2. Fit the linear equation
Linear equation , Y=M * X+ A
A=Y-M*X=0.312-0.0124*25=0.002
Therefore, Y=M * X + 0.002
Y is the reference SAR value
EX :
If we want to get the reference SAR value of 50mW, only change the “X” of linear equation then the calculated value is the reference SAR value

Y=0.0124*50+0.002=0.622

SAR value for various output power

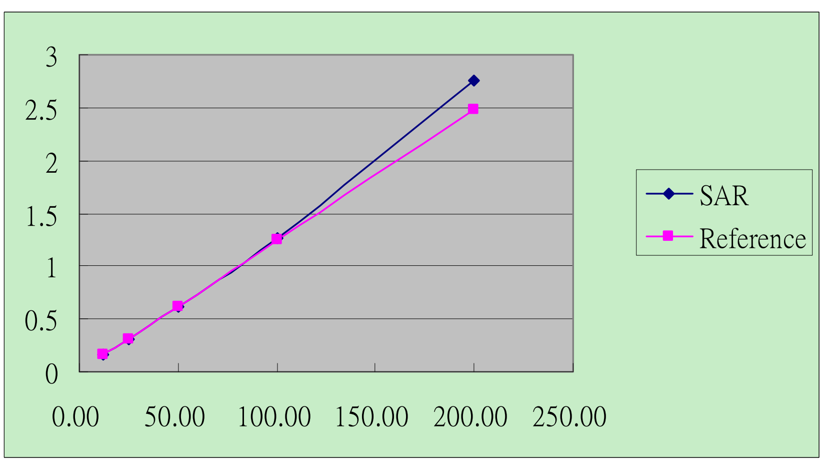
5M QPSK 1/2/ PUSC:

WiMAX Peak RMS output power (mW)	12.5	25	50	100	200
Measured SAR (mW /g)	0.17	0.321	0.634	1.32	2.72
Value from 12.5-25mw reference line	0.17	0.321	0.623	1.227	2.435
Difference	0	0	0.011	0.093	0.285
Percentage of Difference %	0.00	0.00	1.77	7.58	11.70



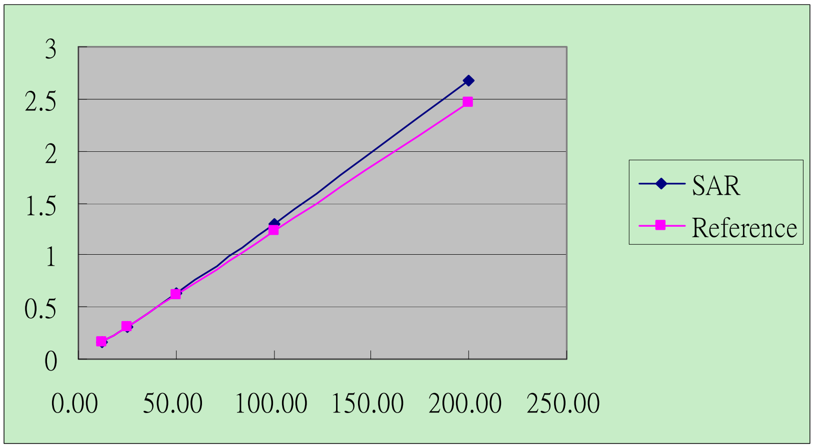
10MHz QPSK 1/2 / PUSC :

WiMAX Peak RMS output power (mW)	12.5	25	50	100	200
Measured SAR (mW /g)	0.157	0.312	0.624	1.270	2.760
Value from 12.5-25mw reference line	0.157	0.312	0.622	1.242	2.482
Difference	0	0	0.002	0.028	0.278
Percentage of Difference %	0.00	0.00	0.32	2.25	11.20



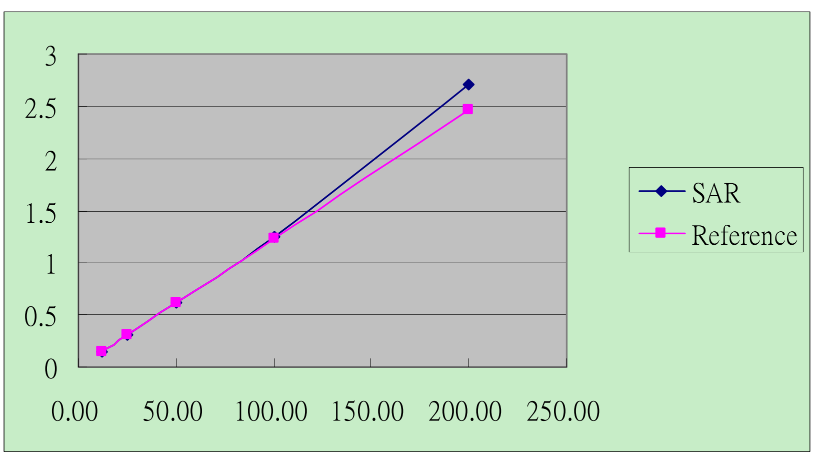
5M 16QAM 1/2/ PUSC:

WiMAX Peak RMS output power (mW)	12.5	25	50	100	200
Measured SAR (mW /g)	0.162	0.315	0.63	1.29	2.68
Value from 12.5-25mw reference line	0.162	0.315	0.621	1.233	2.457
Difference	0	0	0.009	0.057	0.223
Percentage of Difference %	0.00	0.00	1.45	4.62	9.08



10MHz 16QAM 1/2 / PUSC :

WiMAX Peak RMS output power (mW)	12.5	25	50	100	200
Measured SAR (mW /g)	0.148	0.301	0.612	1.25	2.71
Value from 12.5-25mw reference line	0.148	0.301	0.607	1.219	2.443
Difference	0	0	0.005	0.031	0.267
Percentage of Difference %	0.00	0.00	0.82	2.54	10.93



Conclusion:

From the above evaluation, it suggests that the SAR result is about 9.08% to 11.7% over estimated depends on the BW and modulation type. Accordingly we believe that the final SAR result is conservative.

Compare with different scan grid size

With EUT hold on the highest raw 1g SAR configuration (5MHz bandwidth / Mid. channel/ Horizontal-A configuration position which has highest measured SAR number) with no any change in position or setting. Two 1g SAR evaluations were performed with different scanning grid size as listed below for assessing the impact on SAR reading.

Test data as below:

Middle channel of 5MHz at Horizontal-A position		
AREA SCAN Grid Size (mm)	**ZOOM SCAN Grid Size (mm)**	**SAR VALUE (W/kg)**
15	5	1.07
5	2.5	1.08

Conclusion: No significant change detected, so 5mm scan resolution was used for speeding up the SAR measurement.

2.2 GENERAL DESCRIPTION OF APPLIED STANDARDS

According to the specifications of the manufacturer, this product must comply with the requirements of the following standards:

FCC Part 2 (2.1093)

FCC OET Bulletin 65, Supplement C (01- 01)

RSS-102

IEEE 1528-2003

All test items have been performed and recorded as per the above standards.

2.3 GENERAL INOFRMATION OF THE SAR SYSTEM

DASY4 **(software 4.7 Build 80)** consists of high precision robot, probe alignment sensor, phantom, robot controller, controlled measurement server and near-field probe. The robot includes six axes that can move to the precision position of the DASY4 software defined. The DASY4 software can define the area that is detected by the probe. The robot is connected to controlled box. Controlled measurement server is connected to the controlled robot box. The DAE includes amplifier, signal multiplexing, AD converter, offset measurement and surface detection. It is connected to the Electro-optical coupler (ECO). The ECO performs the conversion form the optical into digital electric signal of the DAE and transfers data to the PC.

EX3DV3 ISOTROPIC E-FIELD PROBE

CONSTRUCTION	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
FREQUENCY	10 MHz to > 6 GHz Linearity: ± 0.2 dB (30 MHz to 6 GHz)
DIRECTIVITY	± 0.3 dB in HSL (rotation around probe axis) ± 0.5 dB in tissue material (rotation normal to probe axis)
DYNAMIC RANGE	10 μW/g to > 100 mW/g Linearity: ± 0.2 dB (noise: typically < 1 μW/g)
DIMENSIONS	Overall length: 330 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Typical distance from probe tip to dipole centers: 1 mm
APPLICATION	High precision dosimetric measurements in any exposure scenario (e.g., very strong gradient fields). Only probe which enables compliance testing for frequencies up to 6 GHz with precision of better 30%.

NOTE

1. The Probe parameters have been calibrated by the SPEAG. Please reference “APPENDIX D” for the Calibration Certification Report.
2. For frequencies above 800MHz, calibration in a rectangular wave-guide is used, because wave-guide size is manageable.
3. For frequencies below 800MHz, temperature transfer calibration is used because the wave-guide size becomes relatively large.

TWIN SAM V4.0

CONSTRUCTION	The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528-2003, EN 62209-1 and IEC 62209. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points with the robot.
SHELL THICKNESS	2 ± 0.2mm
FILLING VOLUME	Approx. 25liters
DIMENSIONS	Height: 810mm; Length: 1000mm; Width: 500mm

SYSTEM VALIDATION KITS:

CONSTRUCTION	Symmetrical dipole with l/4 balun enables measurement of feedpoint impedance with NWA matched for use near flat phantoms filled with brain simulating solutions. Includes distance holder and tripod adaptor
CALIBRATION	Calibrated SAR value for specified position and input power at the flat phantom in brain simulating solutions
FREQUENCY	2600MHz
RETURN LOSS	> 20dB at specified validation position
POWER CAPABILITY	> 100W (f < 1GHz); > 40W (f > 1GHz)
OPTIONS	Dipoles for other frequencies or solutions and other calibration conditions upon request

DEVICE HOLDER FOR SAM TWIN PHANTOM

CONSTRUCTION

The device holder for the mobile phone device is designed to cope with different positions given in the standard. It has two scales for the device rotation (with respect to the body axis) and the device inclination (with respect to the line between the ear reference points). The rotation centers for both scales is the ear reference point (ERP). Thus the device needs no repositioning when changing the angles. The holder has been made out of low-loss POM material having the following dielectric parameters: relative permittivity ε =3 and loss tangent δ =0.02. The amount of dielectric material has been reduced in the closest vicinity of the device, since measurements have suggested that the influence of the clamp on the test results could thus be lowered. The device holder for the portable device makes up of the polyethylene foam. The dielectric parameters of material close to the dielectric parameters of the air.

DATA ACQUISITION ELECTRONICS

CONSTRUCTION

The data acquisition electronics (DAE3) consists of a highly sensitive electrometer grade preamplifier with auto-zeroing, a channel and gain-switching multiplex, a fast 16 bit AD converter and a command decoder and control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information as well as an optical uplink for commands and the clock. The mechanical probe is mounting device includes two different sensor systems for frontal and sideways probe contacts. They are used for mechanical surface detection and probe collision detection. The input impedance of the DAE3 box is 200MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.

2.4 GENERAL DESCRIPTION OF THE SPATIAL PEAK SAR EVALUATION

The DASY4 post-processing software (SEMCAD) automatically executes the following procedures to calculate the field units from the micro-volt 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

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:

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

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	(DASY parameter)
dcp_i	=diode compression point	(DASY parameter)

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

$$\text{E-fieldprobes: } E_i = \sqrt{\frac{V_1}{Norm_i \cdot ConvF}}$$

$$\text{H-fieldprobes: } H_i = \sqrt{V_i} \cdot \frac{a_{i0} + a_{i1} f + a_{i2} f^2}{f}$$

V_i	=compensated signal of channel I	(i = x, y, z)
$Norm_i$	=sensor sensitivity of channel i µV/(V/m)2 for E-field Probes	(i = x, y, z)
ConvF	= sensitivity enhancement in solution	
a_{ij}	= sensor sensitivity factors for H-field probes	
F	= carrier frequency [GHz]	
E_i	= electric field strength of channel i in V/m	
H_i	= 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.

$$SAR = E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1'000}$$

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/cm3

Note that the density is set to 1, to account for actual head tissue density rather than the density of the tissue simulating liquid. 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:

1. The extraction of the measured data (grid and values) from the Zoom Scan
2. The calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters)
3. The generation of a high-resolution mesh within the measured volume
4. The interpolation of all measured values from the measurement grid to the high-resolution grid

5. The extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface
6. The calculation of the averaged SAR within masses of 1g and 10g.

The probe is calibrated at the center of the dipole sensors that is located 1 to 2.7mm away from the probe tip. During measurements, the probe stops shortly above the phantom surface, depending on the probe and the surface detecting system. Both distances are included as parameters in the probe configuration file. The software always knows exactly how far away the measured point is from the surface. As the probe cannot directly measure at the surface, the values between the deepest measured point and the surface must be extrapolated. The angle between the probe axis and the surface normal line is less than 30 degree.

The maximum search is automatically performed after each area scan measurement. It is based on splines in two or three dimensions. The procedure can find the maximum for most SAR distributions even with relatively large grid spacing. After the area scanning measurement, the probe is automatically moved to a position at the interpolated maximum. The following scan can directly use this position for reference, e.g., for a finer resolution grid or the cube evaluations. The 1g and 10g peak evaluations are only available for the predefined cube 7 x 7 x 7 scans. The routines are verified and optimized for the grid dimensions used in these cube measurements. The measured volume of 30 x 30 x 30mm contains about 30g of tissue. The first procedure is an extrapolation (incl. boundary correction) to get the points between the lowest measured plane and the surface. The next step uses 3D interpolation to get all points within the measured volume in a 1mm grid (42875 points). In the last step, a 1g cube is placed numerically into the volume and its averaged SAR is calculated. This cube is the moved around until the highest averaged SAR is found. If the highest SAR is found at the edge of the measured volume, the system will issue a warning: higher SAR values might be found outside of the measured volume. In that case the cube measurement can be repeated, using the new interpolated maximum as the center.

3. DESCRIPTION OF SUPPORT UNITS

The EUT has been tested as an independent unit together with other necessary accessories or support units. The following support units or accessories were used to form a representative test configuration during the tests.

NO.	PRODUCT	BRAND	MODEL NO.	SERIAL NO.	FCC ID
1	NOTEBOOK	DELL	PP18L	29144041120	CXSMM01BRD02D 330
	SIGNAL GENERATOR	AGILENT	E4438C	MY45092849	NA

NO.	SIGNAL CABLE DESCRIPTION OF THE ABOVE SUPPORT UNITS
1	NA
2	NA

NOTE: All power cords of the above support units are non shielded (1.8m).

4. DESCRIPTION OF TEST MODES AND CONFIGURATIONS

4.1. WORST CASE MODE FINDING PROCEDURE

Per lab KDB tracking No: 228372, following procedure was proposed to and agreed by the commission.

Step1: Find the worst antenna

EUT is a WiMAX USB dongle which supports 1 TX / 2 RX and TX diversity function.
Due to the TX diversity function, both antennas need to be investigated to determine which one will produce the higher SAR level.

Use test software to transmit max available power level to Antenna 1 and Antenna2 to do 1g SAR evaluation for finding the worst antenna. Test condition and measured results are listed below.

TEST CONFIGURATION		Horizontal-A	
UL ZONE TYPE		PUSC	
MODULATION TYPE		QPSK 1/2	
SAR VALUE (W/kg)			
BANDWIDTH(MHz)	FREQUENCY(MHz)	ANT 1	ANT 2
5	2498.5	0.677	**0.807**
10	2501	0.747	**0.892**

According to above table, Antenna 2 produce higher SAR value.
Therefore, Antenna 2 was picked for final test.

Step 2: Find the worst channel

This step is to assess which channel produce higher SAR value.

Use test software to transmit highest available power for the antenna and do 1g SAR evaluation for low , middle and high channel to find the worst channel. Test condition and measured results listed below:

TEST POSITION		Horizontal-A
UL ZONE TYPE		PUSC
MODULATION TYPE		QPSK 1/2
TX ANTENNA		ANT 2
BANDWIDTH(MHz)	FREQUENCY(MHz)	SAR VALUE (W/kg)
5	2498.5	0.807
	2587	**1.080**
	2687.5	1.050
10	2501	0.892
	2587	**1.070**
	2685	1.020

According to above table, worst channel is middle channel.
Therefore, middle channel will be used to confirm the worst modulation type..

Step 3: Find the worst modulation

The EUT supports 4 UL modulation type as below :

QPSK 1/2
QPSK 3/4
16QAM 1/2
16QAM 3/4

The measurement result reveal that QPSK is the worst case modulation as show below:

TEST CONDITION		Horizontal-A	
TX ANTENNA		ANT 2	
TEST FREQUENCY (MHz)		2587	
SAR VALUE (W/kg)			
CHANNEL BANDWIDTH		5MHz	10MHz
UL ZONE TYPE		PUSC	PUSC
MODULATION TYPE	QPSK 1/2	**1.080**	**1.070**
	QPSK 3/4	1.040	1.030
	16QAM 1/2	1.050	1.040
	16QAM 3/4	1.010	1.010

Accordingly, QPSK 1/2 modulation type is picked for the final test.

Step 4: Check SAR value of other TX antenna and zone type

In lab PBA # 228372, we have requested the test reduction for conducting the SAR evaluation on worst diversity antenna only. However, we feel this may cause extra concern during the FCC/TCB review later. We actually conducted full SAR test on both diversity antennas in this report.

FINAL TEST MODES

Following step 1 to 4 , final test modes are found and show as below

Test modes for ANT 1 and ANT 2

UL ZONE TYPE		PUSC	
BANDWIDTH	TEST POSTITION	MODULATION	TESTED CHANNEL
5MHz/10MHz	Horizontal-A	QPSK1/2	L, M, H
	Horizontal-B		L, M, H
	Vertical-C		L, M, H
	Vertical-D		L, M, H
	Tail		L, M, H

The EUT will be tested under conditions shown in above table.
As concluded above, QPSK 1/2 is the worst modulation, and will be used as default worst case modulation for majority of the test.

Applicable test reduction conditions.

Per KDB447498 1(e)(ii), test of other 2 channels is optional, if 1g SAR for the highest output channel is less than 0.4 W/kg (WiMAX operation bandwidth is greater than 100M and less than 200M)

As proposed and accepted in the KDB tracking No: 228372, We test other modulation types only if raw SAR value is higher than 1.2 W/ kg

4.2. FINAL TEST MODE LIST

PUSC TYPE					
TEST MODE	BANDWIDTH(MHz)	MODULATION TYPE	ASSESSMENT POSTITION	TESTED CHANNEL	ANTENNA
1	5	QPSK1/2	Horizontal-A	L, M, H	2
2		QPSK3/4		M	2
3		16QAM1/2		M	2
4		16QAM3/4		M	2
5		QPSK1/2		L, M, H	1
6	10	QPSK1/2		L, M, H	2
7		QPSK3/4		M	2
8		16QAM1/2		M	2
9		16QAM 3/4		M	2
10		QPSK1/2		L, M, H	1
11	5	QPSK1/2	Horizontal-B	L, M, H	2
12				L, M, H	1
13	10			L, M, H	2
14				L, M, H	1
15	5		Vertical-C	M	2
16				L, M, H	1
17	10			M	2
18				L, M, H	1
19	5		Vertical-D	L, M, H	2
20				M	1
21	10			L, M, H	2
22				M	1
23	5		Tail	L, M, H	2
24				L, M, H	1
25	10			L, M, H	2
26				L, M, H	1

4.3. TEST SETUP AND TEST SIGNAL DETAIL

Please refer to p6 Table 2 of this report for detail.

5. TEST RESULTS

5.1 TEST PROCEDURES

Use the software to control the EUT channel and transmission power. 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 spline interpolation algorithm that has been implemented in the software of DASY4 SAR measurement system manufactured and calibrated by SPEAG. According to the IEEE 1528 standards, the recommended procedure for assessing the peak spatial-average SAR value consists of the following steps:

- Power reference measurement
- Verification of the power reference measurement
- Area scan
- Zoom scan
- Power reference measurement

The area scan was performed for the highest spatial SAR location. The zoom scan with 30mm x 30mm x 30mm volume was performed for SAR value averaged over 1g and 10g spatial volumes.

In the zoom scan, the distance between the measurement point at the probe sensor location (geometric center behind the probe tip) and the phantom surface is 3mm and maintained at a constant distance of ±0.5mm during a zoom scan to determine peak SAR locations. The distance is 3mm between the first measurement point and the bottom surface of the phantom. The secondary measurement point to the bottom surface of the phantom is with 8mm separation distance. The cube size is 7 x 7 x 7 points consists of 343 points and the grid space is 5mm.

The measurement time is 0.5s at each point of the zoom scan. The probe boundary effect compensation shall be applied during the SAR test. Because of the tip of the probe to the Phantom surface separated distances are longer than half a tip probe diameter.

In the area scan, the separation distance is 3mm between the each measurement point and the phantom surface. The scan size shall be included the transmission portion of the EUT. The measurement time is the same as the zoom scan. At last the reference power drift shall be less than ±5%.

5.2 MEASURED SAR RESULTS

PUSC ZONE TYPE					
ENVIRONMENTAL CONDITION	Air Temperature：22.6°C, Liquid Temperature：21.3°C Humidity：61%RH				
TESTED BY	Sam Onn		**DATE**	Dec. 09, 2009	
FREQ. (MHz)	**MODULATION Type**	**CONDUCTED POWER (dB m)** **BEGIN TEST**	**POWER DRIFT (dB)**	**DEVICE TEST MODE**	**MEASURED 1g SAR (W/kg)**
2498.50 (Low)	**5M QPSK 1/2**	23.10	-0.102	1	0.807
2587.00 (Mid.)	**5M QPSK 1/2**	22.81	-0.151	1	**1.080**
2687.50 (High)	**5M QPSK 1/2**	21.76	-0.112	1	1.050
2587.00 (Mid.)	**5M QPSK 3/4**	22.81	-0.135	2	1.040
2587.00 (Mid.)	**5M 16QAM 1/2**	22.76	-0.116	3	1.050
2587.00 (Mid.)	**5M 16QAM 3/4**	22.71	-0.057	4	1.010
2498.50 (Low)	**5M QPSK 1/2**	23.13	-0.153	5	0.677
2587.00 (Mid.)	**5M QPSK 1/2**	22.71	-0.054	5	0.904
2687.50 (High)	**5M QPSK 1/2**	21.72	-0.084	5	0.856

NOTE:

1. Test configuration of each mode is described in section 4.3.
2. In this testing, the limit for General Population Spatial Peak averaged over 1g, **1.6 W/kg**, is applied.
3. Please see the Appendix A for the data.
4. The variation of the EUT conducted power measured before and after SAR testing should not over 5%.

PUSC ZONE TYPE					
ENVIRONMENTAL CONDITION	Air Temperature：22.6℃, Liquid Temperature：21.3℃ Humidity：61%RH				
TESTED BY	Sam Onn		**DATE**	Dec. 09, 2009	

FREQ. (MHz)	MODULATION Type	CONDUCTED POWER (dB m) BEGIN TEST	POWER DRIFT (dB)	DEVICE TEST MODE	MEASURED 1g SAR (W/kg)
2501.00 (Low)	**10M QPSK 1/2**	23.07	-0.071	6	0.892
2587.00 (Mid.)	**10M QPSK 1/2**	22.75	-0.001	6	1.070
2685.00 (High)	**10M QPSK 1/2**	21.78	-0.116	6	1.020
2587.00 (Mid.)	**10M QPSK 3/4**	22.82	-0.074	7	1.030
2587.00 (Mid.)	**10M 16QAM 1/2**	22.75	-0.150	8	1.040
2587.00 (Mid.)	**10M 16QAM 3/4**	22.74	-0.180	9	1.010
2501.00 (Low)	**10M QPSK 1/2**	23.08	-0.062	10	0.747
2587.00 (Mid.)	**10M QPSK 1/2**	22.77	-0.077	10	0.912
2685.00 (High)	**10M QPSK 1/2**	21.81	-0.047	10	0.903

NOTE:

1. Test configuration of each mode is described in section 4.3.
2. In this testing, the limit for General Population Spatial Peak averaged over 1g, **1.6 W/kg**, is applied.
3. Please see the Appendix A for the data.
4. The variation of the EUT conducted power measured before and after SAR testing should not over 5%.

PUSC ZONE TYPE					
ENVIRONMENTAL CONDITION	Air Temperature：22.6°C, Liquid Temperature：21.3°C Humidity：61%RH				
TESTED BY	Sam Onn		**DATE**	Dec. 09, 2009	
FREQ. (MHz)	**MODULATION Type**	**CONDUCTED POWER (dB m)** **BEGIN TEST**	**POWER DRIFT (dB)**	**DEVICE TEST MODE**	**MEASURED 1g SAR (W/kg)**
2498.50 (Low)	**5M QPSK 1/2**	23.10	0.08	11	0.417
2587.00 (Mid.)	**5M QPSK 1/2**	22.81	-0.118	11	0.485
2687.50 (High)	**5M QPSK 1/2**	21.76	-0.164	11	0.423
2498.50 (Low)	**5M QPSK 1/2**	23.13	-0.069	12	0.381
2587.00 (Mid.)	**5M QPSK 1/2**	22.71	-0.016	12	0.453
2687.50 (High)	**5M QPSK 1/2**	21.72	-0.065	12	0.406
2501.00 (Low)	**10M QPSK 1/2**	23.07	-0.074	13	0.382
2587.00 (Mid.)	**10M QPSK 1/2**	22.75	-0.128	13	0.493
2685.00 (High)	**10M QPSK 1/2**	21.78	-0.152	13	0.517
2501.00 (Low)	**10M QPSK 1/2**	23.08	-0.063	14	0.377
2587.00 (Mid.)	**10M QPSK 1/2**	22.77	-0.092	14	0.463
2685.00 (High)	**10M QPSK 1/2**	21.81	-0.137	14	0.473

NOTE:

1. Test configuration of each mode is described in section 4.3.
2. In this testing, the limit for General Population Spatial Peak averaged over 1g, **1.6 W/kg**, is applied.
3. Please see the Appendix A for the data.
4. The variation of the EUT conducted power measured before and after SAR testing should not over 5%.

PUSC ZONE TYPE					
ENVIRONMENTAL CONDITION	Air Temperature：22.6°C, Liquid Temperature：21.3°C Humidity：61%RH				
TESTED BY	Sam Onn		DATE	Dec. 09, 2009	
FREQ. (MHz)	MODULATION Type	CONDUCTED POWER (dB m)	POWER DRIFT (dB)	DEVICE TEST MODE	MEASURED 1g SAR (W/kg)
		BEGIN TEST			
2587.00 (Mid.)	5M QPSK 1/2	22.81	-0.071	15	0.362
2498.50 (Low)	5M QPSK 1/2	23.13	-0.109	16	0.753
2587.00 (Mid.)	5M QPSK 1/2	22.71	-0.079	16	0.851
2687.50 (High)	5M QPSK 1/2	21.72	-0.112	16	0.792
2587.00 (Mid.)	10M QPSK 1/2	22.75	-0.053	17	0.287
2501.00 (Low)	10M QPSK 1/2	23.08	-0.103	18	0.668
2587.00 (Mid.)	10M QPSK 1/2	22.77	-0.138	18	0.796
2685.00 (High)	10M QPSK 1/2	21.81	-0.032	18	0.767

NOTE:

1. Test configuration of each mode is described in section 4.3.
2. In this testing, the limit for General Population Spatial Peak averaged over 1g, **1.6 W/kg**, is applied.
3. Please see the Appendix A for the data.
4. The variation of the EUT conducted power measured before and after SAR testing should not over 5%.

PUSC ZONE TYPE					
ENVIRONMENTAL CONDITION	Air Temperature：22.6°C, Liquid Temperature：21.3°C Humidity：61%RH				
TESTED BY	Sam Onn		**DATE**	Dec. 09, 2009	

FREQ. (MHz)	MODULATION Type	CONDUCTED POWER (dB m)	POWER DRIFT (dB)	DEVICE TEST MODE	MEASURED 1g SAR (W/kg)
		BEGIN TEST			
2498.50 (Low)	**5M QPSK 1/2**	23.10	-0.161	19	0.635
2587.00 (Mid.)	**5M QPSK 1/2**	22.81	-0.004	19	0.986
2687.50 (High)	**5M QPSK 1/2**	21.76	-0.135	19	0.941
2587.00 (Mid.)	**5M QPSK 1/2**	22.71	-0.065	20	0.300
2501.00 (Low)	**10M QPSK 1/2**	23.07	-0.143	21	0.631
2587.00 (Mid.)	**10M QPSK 1/2**	22.75	-0.184	21	0.967
2685.00 (High)	**10M QPSK 1/2**	21.78	-0.149	21	0.920
2587.00 (Mid.)	**10M QPSK 1/2**	22.77	-0.077	22	0.302

NOTE:

1. Test configuration of each mode is described in section 4.3.
2. In this testing, the limit for General Population Spatial Peak averaged over 1g, **1.6 W/kg**, is applied.
3. Please see the Appendix A for the data.
4. The variation of the EUT conducted power measured before and after SAR testing should not over 5%.

PUSC ZONE TYPE					
ENVIRONMENTAL CONDITION	Air Temperature：22.6°C, Liquid Temperature：21.3°C Humidity：61%RH				
TESTED BY	Sam Onn		DATE	Dec. 09, 2009	

FREQ. (MHz)	MODULATION Type	CONDUCTED POWER (dB m) BEGIN TEST	POWER DRIFT (dB)	DEVICE TEST MODE	MEASURED 1g SAR (W/kg)
2498.50 (Low)	5M QPSK 1/2	23.10	-0.149	23	0.518
2587.00 (Mid.)	5M QPSK 1/2	22.81	-0.06	23	0.766
2687.50 (High)	5M QPSK 1/2	21.76	-0.165	23	0.718
2498.50 (Low)	5M QPSK 1/2	23.13	-0.194	24	0.478
2587.00 (Mid.)	5M QPSK 1/2	22.71	0.067	24	0.649
2687.50 (High)	5M QPSK 1/2	21.72	-0.073	24	0.603
2501.00 (Low)	10M QPSK 1/2	23.07	-0.137	25	0.528
2587.00 (Mid.)	10M QPSK 1/2	22.75	-0.065	25	0.764
2685.00 (High)	10M QPSK 1/2	21.78	-0.111	25	0.707
2501.00 (Low)	10M QPSK 1/2	23.08	-0.142	26	0.461
2587.00 (Mid.)	10M QPSK 1/2	22.77	-0.033	26	0.665
2685.00 (High)	10M QPSK 1/2	21.81	-0.111	26	0.608

NOTE:

1. Test configuration of each mode is described in section 4.3.
2. In this testing, the limit for General Population Spatial Peak averaged over 1g, **1.6 W/kg**, is applied.
3. Please see the Appendix A for the data.
4. The variation of the EUT conducted power measured before and after SAR testing should not over 5%.

Final SAR value after Scaled up with 3 CONTROL SYMBOLS

PUSC ZONE TYPE							
Freq. (MHz)	MODULATION	TEST MODE	MEASURED 1g SAR (W/kg)	SCALING FACTOR	SCALED UP SAR	ANTENNA	DEVICE TEST POSITION
2498.50	5M QPSK1/2	1	0.807	1.066	0.860	2	Horizontal-A
2587.00	5M QPSK1/2		1.080	1.140	1.231		
2687.50	5M QPSK1/2		**1.050**	**1.452**	**1.525**		
2587.00	5M QPSK3/4	2	1.040	1.140	1.186		
2587.00	5M 16QAM1/2	3	1.050	1.153	1.211		
2587.00	5M 16QAM3/4	4	1.010	1.166	1.178		
2498.50	5M QPSK1/2	5	0.677	1.059	0.717	1	
2587.00	5M QPSK1/2		0.904	1.166	1.054		
2687.50	5M QPSK1/2		0.856	1.465	1.254		
2501.00	10M QPSK1/2	6	0.892	1.033	0.921	2	
2587.00	10M QPSK1/2		1.070	1.112	1.190		
2685.00	10M QPSK1/2		1.020	1.391	1.419		
2587.00	10M QPSK3/4	7	1.030	1.095	1.128		
2587.00	10M 16QAM1/2	8	1.040	1.112	1.156		
2587.00	10M 16QAM3/4	9	1.010	1.115	1.126		
2501.00	10M QPSK1/2	10	0.747	1.031	0.770	1	
2587.00	10M QPSK1/2		0.912	1.107	1.010		
2685.00	10M QPSK1/2		0.903	1.381	1.247		
2498.50	5M QPSK1/2	11	0.417	1.066	0.445	2	Horizontal-B
2587.00	5M QPSK1/2		0.485	1.140	0.553		
2687.50	5M QPSK1/2		0.423	1.452	0.614		
2498.50	5M QPSK1/2	12	0.381	1.059	0.403	1	
2587.00	5M QPSK1/2		0.453	1.166	0.528		
2687.50	5M QPSK1/2		0.406	1.465	0.595		
2501.00	10M QPSK1/2	13	0.382	1.033	0.395	2	
2587.00	10M QPSK1/2		0.493	1.112	0.548		
2685.00	10M QPSK1/2		0.517	1.391	0.719		
2501.00	10M QPSK1/2	14	0.377	1.031	0.389	1	
2587.00	10M QPSK1/2		0.463	1.107	0.513		
2685.00	10M QPSK1/2		0.473	1.381	0.653		
2587.00	5M QPSK1/2	15	0.362	1.140	0.413	2	Vertical-C
2498.50	5M QPSK1/2	16	0.753	1.059	0.797	1	
2587.00	5M QPSK1/2		0.851	1.166	0.992		
2687.50	5M QPSK1/2		0.792	1.465	1.160		
2587.00	10M QPSK1/2	17	0.287	1.112	0.319	2	
2501.00	10M QPSK1/2	18	0.668	1.031	0.689	1	
2587.00	10M QPSK1/2		0.796	1.107	0.881		
2685.00	10M QPSK1/2		0.767	1.381	1.059		

PUSC ZONE TYPE							
Freq. (MHz)	MODULATION	TEST MODE	MEASURED 1g SAR (W/kg)	SCALING FACTOR	SCALED UP SAR	ANTENNA	DEVICE TEST POSITION
2498.50	5M QPSK1/2	19	0.635	1.066	0.677	2	Vertical-D
2587.00	5M QPSK1/2		0.986	1.140	1.124		
2687.50	5M QPSK1/2		0.941	1.452	1.366		
2587.00	5M QPSK1/2	20	0.300	1.166	0.350	1	
2501.00	10M QPSK1/2	21	0.631	1.033	0.652	2	
2587.00	10M QPSK1/2		0.967	1.112	1.075		
2685.00	10M QPSK1/2		0.920	1.391	1.280		
2587.00	10M QPSK1/2	22	0.302	1.107	0.334	1	
2498.50	5M QPSK1/2	23	0.518	1.066	0.552	2	Tail
2587.00	5M QPSK1/2		0.766	1.140	0.873		
2687.50	5M QPSK1/2		0.718	1.452	1.043		
2498.50	5M QPSK1/2	24	0.478	1.059	0.506	1	
2587.00	5M QPSK1/2		0.649	1.166	0.757		
2687.50	5M QPSK1/2		0.603	1.465	0.883		
2501.00	10M QPSK1/2	25	0.528	1.033	0.545	2	
2587.00	10M QPSK1/2		0.764	1.112	0.850		
2685.00	10M QPSK1/2		0.707	1.391	0.983		
2501.00	10M QPSK1/2	26	0.461	1.031	0.475	1	
2587.00	10M QPSK1/2		0.665	1.107	0.736		
2685.00	10M QPSK1/2		0.608	1.381	0.840		

5.3 SAR LIMITS

HUMAN EXPOSURE	SAR (W/kg)	
	(GENERAL POPULATION / UNCONTROLLED EXPOSURE ENVIRONMENT)	(OCCUPATIONAL / CONTROLLED EXPOSURE ENVIRONMENT)
Spatial Average (whole body)	0.08	0.4
Spatial Peak (averaged over 1 g)	**1.6**	8.0
Spatial Peak (hands / wrists / feet / ankles averaged over 10 g)	4.0	20.0

NOTE:

1. This limits accord to 47 CFR 2.1093 – Safety Limit.
2. The EUT property been complied with the partial body exposure limit under the general population environment.

5.4 RECIPES FOR TISSUE SIMULATING LIQUIDS

For the measurement of the field distribution inside the SAM phantom, the phantom must be filled with 25 litters of tissue simulation liquid.

THE RECIPES FOR 2600MHz SIMULATING LIQUID TABLE

Ingredient	Muscle Simulating Liquid 2600MHz (MSL-2600)
Water	69.83%
DGMBE	30.17%
Salt	NA
Dielectric Parameters at 22℃	f= 2600MHz ε= 52.5 ± 5% σ= 2.16 ± 5% S/m

Testing the liquids using the Agilent Network Analyzer E8358A and Agilent Dielectric Probe Kit 85070D.The testing procedure is as following

1. Turn Network Analyzer on and allow at least 30min. warm up.
2. Mount dielectric probe kit so that interconnecting cable to Network Analyzer will not be moved during measurements or calibration.
3. Pour de-ionized water and measure water temperature (±1°).
4. Set water temperature in Agilent-Software (Calibration Setup).
5. Perform calibration.
6. Validate calibration with dielectric material of known properties (e.g. polished ceramic slab with >8mm thickness ε'=10.0, ε''=0.0). If measured parameters do not fit within tolerance, repeat calibration (±0.2 for ε': ±0.1 for ε'').
7. Conductivity can be calculated from ε'' by $\sigma = \omega\, \varepsilon_0\, \varepsilon'' = \varepsilon''\, f\, [GHz] / 18$.
8. Measure liquid shortly after calibration. Repeat calibration every hour.
9. Stir the liquid to be measured. Take a sample (~ 50ml) with a syringe from the center of the liquid container.
10. Pour the liquid into a small glass flask. Hold the syringe at the bottom of the flask to avoid air bubbles.
11. Put the dielectric probe in the glass flask. Check that there are no air bubbles in front of the opening in the dielectric probe kit.
12. Perform measurements.
13. Adjust medium parameters in DASY4 for the frequencies necessary for the measurements (‘Setup Config’, select medium (e.g. Brain 900MHz) and press ‘Option’-button.
14. Select the current medium for the frequency of the validation (e.g. Setup Medium Brain 900MHz).

FOR WIMAX BAND SIMULATING LIQUID

LIQUID TYPE		MSL-2600		
SIMULATING LIQUID TEMP.		21.3		
TEST DATE		Dec. 09, 2009		
TESTED BY		Sam Onn		
FREQ. (MHz)	LIQUID PARAMETER	STANDARD VALUE	MEASUREMENT VALUE	ERROR PERCENTAGE
2498.5	Permitivity (ε)	52.60	54.00	2.66
2501.0		52.60	53.70	2.09
2587.0		52.50	53.70	2.29
2600.0		52.50	53.70	2.29
2685.0		52.40	53.30	1.72
2687.5		52.40	53.30	1.72
2498.5	Conductivity (σ) S/m	2.02	2.08	2.97
2501.0		2.02	2.08	2.97
2587.0		2.14	2.19	2.34
2600.0		2.16	2.20	1.85
2685.0		2.28	2.24	-1.75
2687.5		2.29	2.24	-2.18
Dielectric Parameters Required at 22℃		f= 2600MHz ε= 52.5 ± 5% σ= 2.16 ± 5% S/m		

LIQUID TYPE		MSL-2600		
SIMULATING LIQUID TEMP.		21.2		
TEST DATE		Jan. 12, 2010		
TESTED BY		Sam Onn		
FREQ. (MHz)	LIQUID PARAMETER	STANDARD VALUE	MEASUREMENT VALUE	ERROR PERCENTAGE
2587.0	Permitivity (ε)	52.5	54.1	3.05
2600.0		52.5	54.1	3.05
2587.0	Conductivity (σ)S/m	2.14	2.16	0.93
2600.0		2.16	2.17	0.46

5.5 TEST EQUIPMENT FOR TISSUE PROPERTY

ITEM	NAME	BRAND	TYPE	SERIES NO.	DATE OF CALIBRATION	DUE DATE OF CALIBRATION
1	Network Analyzer	Agilent	E5071C	MY46104190	Apr. 10. 2009	Apr. 09. 2010
2	Dielectric Probe	Agilent	85070D	US01440176	NA	NA

NOTE:

1. Before starting, all test equipment shall be warmed up for 30min.
2. The tolerance (k=1) specified by Agilent for general dielectric measurements, deriving from inaccuracies in the calibration data, analyzer drift, and random errors, are usually ±2.5% and ±5% for measured permittivity and conductivity, respectively. However, the tolerances for the conductivity is smaller for material with large loss tangents, i.e., less than ±2.5% (k=1). It can be substantially smaller if more accurate methods are applied.

6. SYSTEM VALIDATION

The system validation was performed in the flat phantom with equipment listed in the following table. Since the SAR value is calculated from the measured electric field, dielectric constant and conductivity of the body tissue and the SAR is proportional to the square of the electric field. So, the SAR value will be also proportional to the RF power input to the system validation dipole under the same test environment. In our system validation test, 250mW RF input power was used.

6.1 TEST EQUIPMENT

ITEM	NAME	BRAND	TYPE	SERIES NO.	DATE OF CALIBRATION	DUE DATE OF CALIBRATION
1	SAM Phantom	S & P	QD000 P40 CA	TP-1150	NA	NA
2	Signal Generator	Agilent	E8257C	MY43320668	Dec. 31, 2008	Dec. 30, 2009
			E8257C	MY43321031	Jul. 14,2009	Jul. 13,2010
3			E4438C	MY47271120	Jul. 28, 2009	Jul. 27, 2010
4		Anritsu	68247B	984703	May. 21 , 2009	May. 20 , 2010
5	E-Field Probe	S & P	EX3DV3	3504	Jan. 21, 2009	Jan. 20, 2010
6	DAE	S & P	DAE	579	Jul. 17, 2009	Jul. 16, 2010
7	Robot Positioner	Staubli Unimation	NA	NA	NA	NA
8	Validation Dipole	S & P	D2600V2	1020	Jan. 14, 2009	Jan. 13, 2010
9	Validation Dipole	S & P	D2600V2	1003	Feb.17,2009	Feb.16,2010

NOTE: Before starting the measurement, all test equipment shall be warmed up for 30min.

6.2 TEST PROCEDURE

Before the system performance check, we need only to tell the system which components (probe, medium, and device) are used for the system performance check; the system will take care of all parameters. The dipole must be placed beneath the flat section of the SAM Twin Phantom with the correct distance holder in place. The distance holder should touch the phantom surface with a light pressure at the reference marking (little cross) and be oriented parallel to the long side of the phantom. Accurate positioning is not necessary, since the system will search for the peak SAR location, except that the dipole arms should be parallel to the surface. The device holder for mobile phones can be left in place but should be rotated away from the dipole.

1. 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 DASY system below ±0.02dB.

2. The ”Surface Check” job tests the optical surface detection system of the DASY 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.

3. 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. If a finer graphic is desired, the grid spacing can be reduced. Grid spacing and orientation have no influence on the SAR result.

4. 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).

About the validation dipole positioning uncertainty, the constant and low loss dielectric spacer is used to establish the correct distance between the top surface of the dipole and the bottom surface of the phantom, the error component introduced by the uncertainty of the distance between the liquid (i.e., phantom shell) and the validation dipole in the DASY4 system is less than ±0.1mm.

$$SAR_{tolerance}[\%] = 100 \times \left(\frac{(a+d)^2}{a^2} - 1\right)$$

As the closest distance is 10mm, the resulting tolerance $SAR_{tolerance}[\%]$ is <2%.

6.3 VALIDATION RESULTS

SYSTEM VALIDATION TEST OF SIMULATING LIQUID					
FREQUENCY (MHz)	**REQUIRED SAR (mW/g)**	**MEASURED SAR (mW/g)**	**DEVIATION (%)**	**SEPARATION DISTANCE**	**TESTED DATE**
MSL2600	14.20 (1g)	13.80	-2.82	10mm	Dec. 09, 2009
MSL2600	14.70 (1g)	13.90	-5.44	10mm	Jan. 17, 2010
TESTED BY	Sam Onn				

NOTE: Please see Appendix for the photo of system validation test.

6.4 SYSTEM VALIDATION UNCERTAINTIES

In the table below, the system validation uncertainty with respect to the analytically assessed SAR value of a dipole source as given in the IEEE 1528 standard is given. This uncertainty is smaller than the expected uncertainty for mobile phone measurements due to the simplified setup and the symmetric field distribution.

Error Description	Tolerance (±%)	Probability Distribution	Divisor	(C_i) (1g)	(C_i) (10g)	Standard Uncertainty (±%) (1g)	Standard Uncertainty (±%) (10g)	(v_i)
Measurement System								
Probe Calibration	5.50	Normal	1	1	1	5.50	5.50	∞
Axial Isotropy	4.70	Rectangular	$\sqrt{3}$	0.7	0.7	1.90	1.90	∞
Hemispherical Isotropy	9.60	Rectangular	$\sqrt{3}$	0.7	0.7	3.88	3.88	∞
Boundary effects	1.00	Rectangular	$\sqrt{3}$	1	1	0.58	0.58	∞
Linearity	4.70	Rectangular	$\sqrt{3}$	1	1	2.71	2.71	∞
System Detection Limits	1.00	Rectangular	$\sqrt{3}$	1	1	0.58	0.58	∞
Readout Electronics	0.30	Normal	1	1	1	0.30	0.30	∞
Response Time	0.80	Rectangular	$\sqrt{3}$	1	1	0.46	0.46	∞
Integration Time	0.625	Rectangular	$\sqrt{3}$	1	1	0.36	0.36	∞
RF Ambient Noise	3.00	Rectangular	$\sqrt{3}$	1	1	1.73	1.73	∞
RF Ambient Reflections	3.00	Rectangular	$\sqrt{3}$	1	1	1.73	1.73	∞
Probe Positioner	0.40	Rectangular	$\sqrt{3}$	1	1	0.23	0.23	∞
Probe Positioning	2.90	Rectangular	$\sqrt{3}$	1	1	1.67	1.67	∞
Max. SAR Eval.	1.00	Rectangular	$\sqrt{3}$	1	1	0.58	0.58	∞
Dipole Related								
Dipole Axis to Liquid Distance	2.00	Rectangular	$\sqrt{3}$	1	1	1.15	1.15	145
Input Power Drift	5.00	Rectangular	$\sqrt{3}$	1	1	2.89	2.89	∞
Phantom and Tissue parameters								
Phantom Uncertainty	4.00	Rectangular	$\sqrt{3}$	1	1	2.31	2.31	∞
Liquid Conductivity (target)	5.00	Rectangular	$\sqrt{3}$	0.64	0.43	1.85	1.24	∞
Liquid Conductivity (measurement)	3.59	Normal	1	0.64	0.43	2.30	1.54	∞
Liquid Permittivity (target)	5.00	Rectangular	$\sqrt{3}$	0.6	0.49	1.73	1.41	∞
Liquid Permittivity (measurement)	3.50	Normal	1	0.6	0.49	2.10	1.72	∞
Combined Standard Uncertainty						**9.88**	**9.51**	
Coverage Factor for 95%						**Kp=2**		
Expanded Uncertainty (K=2)						**19.77**	**19.02**	

NOTE: About the system validation uncertainty assessment, please reference the section 7.

7. MEASUREMENT SAR PROCEDURE UNCERTAINTIES

The assessment of spatial peak SAR of the hand handheld devices is according to IEEE 1528 / EN 62209-1. All testing shall comply with following requirements.

- The system is used by an experienced engineer who follows the manual and the guidelines taught during the training provided by SPEAG.
- The probe has been calibrated within the required period and the uncertainty for the relevant frequency bands does not exceed 4.8% (k=1).
- The validation dipole has been calibrated within the required period and the system performance check has been successful.
- The DAE unit has been calibrated within the required period.
- The minimum distance between the probe sensor and inner phantom shell is follow the FCC SAR measurement guidance.
- The operational mode of the DUT is WiMAX and the measurement/integration time per point is >500 ms.
- The dielectric parameters of the liquid have been assessed using Agilent 85070D dielectric probe kit.
- The dielectric parameters are within 5% of the target values.
- The DUT has been positioned as described in section 3.

7.1. PROBE CALIBRATION UNCERTAINTY

SPEAG conducts the probe calibration in compliance with international and national standards (e.g. IEEE 1528, EN 62209-1, IEC 62209, etc.) under ISO17025. The uncertainties are stated on the calibration certificate. For the most relevant frequency bands, these values do not exceed 4.8% (k=1). If evaluations of other bands are performed for which the uncertainty exceeds these values, the uncertainty tables given in the summary have to be revised accordingly.

7.2. ISOTROPY UNCERTAINTY

The axial isotropy tolerance accounts for probe rotation around its axis while the hemispherical isotropy error includes all probe orientations and field polarizations. These parameters are assessed by SPEAG during initial calibration. In 2001, SPEAG further tightened its quality controls and warrants that the maximal deviation from axial isotropy is ±0.20dB, while the maximum deviation of hemispherical isotropy is ±0.40dB, corresponding to ±4.7% and ±9.6%, respectively. A weighting factor of cp equal to 0.5 can be applied, since the axis of the probe deviates less than 30 degrees from the normal surface orientation.

7.3. BOUNDARY EFFECT UNCERTAINTY

The effect can be estimated according to the following error approximation formula

$$SAR_{tolerance}[\%] = SAR_{be}[\%] \times \frac{(d_{be} + d_{step})^2}{2d_{step}} \frac{e^{-\frac{d_{be}}{\delta/2}}}{\delta/2}$$

$$d_{be} + d_{step} < 10mm$$

The parameter d_{be} is the distance in mm between the surface and the closest measurement point used in the averaging process; d_{step} is the separation distance in mm between the first and second measurement points; δ is the minimum penetration depth in mm within the head tissue equivalent liquids (i.e., δ= 13.95mm at 3GHz); SAR_{be} is the deviation between the measured SAR value at the distance d_{be} from the boundary and the wave-guide analytical value SAR_{ref}.DASY4 applies a boundary effect compensation algorithm according to IEEE 1528, which is possible since the axis of the probe never deviates more than 30 degrees from the normal surface orientation. SAR_{be}[%] is assessed during the calibration process and SPEAG warrants that the uncertainty at distances larger than 4mm is always less than 1%.In summary, the worst case boundary effect SAR tolerance[%] for scanning distances larger than 4mm is < ± 0.8%.

7.4. PROBE LINEARITY UNCERTAINTY

Field probe linearity uncertainty includes errors from the assessment and compensation of the diode compression effects for CW and pulsed signals with known duty cycles. This error is assessed using the procedure described in IEEE 1528 / EN 62209-1. For SPEAG field probes, the measured difference between CW and pulsed signals, with pulse frequencies between 10Hz and 1kHz and duty cycles between 1 and 100, is < ±0.20dB (< ±4.7%).

7.5. READOUT ELECTRONICS UNCERTAINTY

All uncertainties related to the probe readout electronics (DAE unit), including the gain and linearity of the instrumentation amplifier, its loading effect on the probe, and accuracy of the signal conversion algorithm, have been assessed accordingly to IEEE 1528 / EN 62209-1.The combination (root-sum-square RSS method) of these components results in an overall maximum error of ±1.0%.

7.6. RESPONSE TIME UNCERTAINTY

The time response of the field probes is assessed by exposing the probe to a well-controlled electric field producing SAR larger than 2.0W/kg at the tissue medium surface. The signal response time is evaluated as the time required by the system to reach 90% of the expected final value after an on/of switch of the power source. Analytically, it can be expressed as:

$$SAR_{tolerance}[\%] = 100 \times \left(\frac{T_m}{T_m + \tau e^{-T_m/\tau} - \tau} - 1\right)$$

where Tm is 500 ms, i.e., the time between measurement samples, and τ the time constant. The response time τ of SPEAG's probes is <5ms. In the current implementation, DASY4 waits longer than 100 ms after having reached the grid point before starting a measurement, i.e., the response time uncertainty is negligible.

7.7. INTEGRATION TIME UNCERTAINTY

If the device under test does not emit a CW signal, the integration time applied to measure the electric field at a specific point may introduce additional uncertainties due to the discretization and can be assessed as follows

$$SAR_{tolerance}[\%] = 100 \times \sum_{allsub-frames} \frac{t_{frame}}{t_{integration}} \frac{slot_{idle}}{slot_{total}}$$

Mobile WiMAX is fixed at 48 symbols per 5 ms frame. The EUT supports max UL symbol number is 18. Measurement/integration of SAR system is 0.5s = 500ms

Integration time uncertainty = 5/500*30/48*100% = 0.625 %

Probe Positioner Mechanical Tolerance

The mechanical tolerance of the field probe positioner can introduce probe positioning uncertainties. The resulting SAR uncertainty is assessed by comparing the SAR obtained according to the specifications of the probe positioner with respect to the actual position defined by the geometric enter of the probe sensors. The tolerance is determined as:

$$SAR_{tolerance}[\%] = 100 \times \frac{d_{ph}}{\delta/2}$$

The specified repeatability of the RX robot family used in DASY4 systems is ±25μm. The absolute accuracy for short distance movements is better than ±0.1mm, i.e., the $SAR_{tolerance}$[%] is better than 1.5% (rectangular).

7.8. PROBE POSITIONING

The probe positioning procedures affect the tolerance of the separation distance between the probe tip and the phantom surface as:

$$SAR_{tolerance}[\%] = 100 \times \frac{d_{ph}}{\delta/2}$$

where d_{ph} is the maximum deviation of the distance between the probe tip and the phantom surface. The optical surface detection has a precision of better than 0.2mm, resulting in an $SAR_{tolerance}$[%] of <2.9% (rectangular distribution). Since the mechanical detection provides better accuracy, 2.9% is a worst-case figure for DASY4 system.

7.9. PHANTOM UNCERTAINTY

The SAR measurement uncertainty due to SPEAG phantom shell production tolerances has been evaluated using

$$SAR_{tolerance}[\%] \cong 100 \times \frac{2d}{a}, \qquad d << a$$

For a maximum deviation d of the inner and outer shell of the phantom from that specified in the CAD file of ±0.2mm, and a 10mm spacing a between source and tissue liquid, the calculated phantom uncertainty is ±4.0%.

7.10. DASY4 UNCERTAINTY BUDGET

Error Description	Tolerance (±%)	Probability Distribution	Divisor	(C_i)		Standard Uncertainty (±%)		(v_i)
				(1g)	(10g)	(1g)	(10g)	
Measurement Equipment								
Probe Calibration	5.50	Normal	1	1	1	5.50	5.50	∞
Axial Isotropy	4.70	Rectangular	$\sqrt{3}$	0.7	0.7	1.90	1.90	∞
Hemispherical Isotropy	9.60	Rectangular	$\sqrt{3}$	0.7	0.7	3.88	3.88	∞
Boundary effects	1.00	Rectangular	$\sqrt{3}$	1	1	0.58	0.58	∞
Linearity	4.70	Rectangular	$\sqrt{3}$	1	1	2.71	2.71	∞
System Detection Limits	1.00	Rectangular	$\sqrt{3}$	1	1	0.58	0.58	∞
Readout Electronics	0.30	Normal	1	1	1	0.30	0.30	∞
Response Time	0.80	Rectangular	$\sqrt{3}$	1	1	0.46	0.46	∞
Integration Time	2.60	Rectangular	$\sqrt{3}$	1	1	1.50	1.50	∞
RF Ambient Noise	3.00	Rectangular	$\sqrt{3}$	1	1	1.73	1.73	∞
RF Ambient Reflections	3.00	Rectangular	$\sqrt{3}$	1	1	1.73	1.73	∞
Probe Positioner	0.40	Rectangular	$\sqrt{3}$	1	1	0.23	0.23	∞
Probe Positioning	2.90	Rectangular	$\sqrt{3}$	1	1	1.67	1.67	∞
Max. SAR Eval.	1.00	Rectangular	$\sqrt{3}$	1	1	0.58	0.58	∞
Test Sample Related								
Device Positioning	0.69	Normal	1	1	1	0.69	0.69	10
Device Holder	3.60	Normal	1	1	1	3.60	3.60	5
Power Drift	5.00	Rectangular	$\sqrt{3}$	1	1	2.89	2.89	∞
Phantom and Tissue parameters								
Phantom Uncertainty	4.00	Rectangular	$\sqrt{3}$	1	1	2.31	2.31	∞
Liquid Conductivity (target)	5.00	Rectangular	$\sqrt{3}$	0.64	0.43	1.85	1.24	∞
Liquid Conductivity (measurement)	3.59	Normal	1	0.64	0.43	2.30	1.54	∞
Liquid Permittivity (target)	5.00	Rectangular	$\sqrt{3}$	0.6	0.49	1.73	1.41	∞
Liquid Permittivity (measurement)	3.50	Normal	1	0.6	0.49	2.10	1.72	∞
Combined Standard Uncertainty						**10.58**	**10.23**	
Coverage Factor for 95%						**Kp=2**		
Expanded Uncertainty (K=2)						**21.16**	**20.46**	

TABLE 7.2

The table 7.2: Worst-Case uncertainty budget for DASY4 assessed according to IEEE 1528. The budget is valid for the frequency range 300MHz ~ 3GHz and represents a worst-case analysis. For specific tests and configurations, the uncertainty could be considerable smaller.

8. INFORMATION ON THE TESTING LABORATORIES

We, Bureau Veritas Consumer Products Services (H.K.) Ltd., Taoyuan Branch, were founded in 1988 to provide our best service in EMC, Radio, Telecom and Safety consultation. Our laboratories are accredited and approved by the following approval agencies according to ISO/IEC 17025.

USA	FCC, NVLAP
GERMANY	TUV Rheinland
JAPAN	VCCI
NORWAY	NEMKO
CANADA	INDUSTRY CANADA, CSA
R.O.C.	TAF, BSMI, NCC
NETHERLANDS	Telefication
SINGAPORE	GOST-ASIA (MOU)
RUSSIA	CERTIS (MOU)

Copies of accreditation certificates of our laboratories obtained from approval agencies can be downloaded from our web site: www.adt.com.tw/index.5/phtml. If you have any comments, please feel free to contact us at the following:

Linko EMC/RF Lab:
Tel: 886-2-26052180
Fax: 886-2-26051924

Hsin Chu EMC/RF Lab:
Tel: 886-3-5935343
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Hwa Ya EMC/RF/Safety/Telecom Lab:
Tel: 886-3-3183232
Fax: 886-3-3185050

Web Site: www.adt.com.tw

The address and road map of all our labs can be found in our web site also.

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