SAR TEST REPORT

Test item	:	WiMAX & WiFi Dual CPE
Model No.	:	IMW-C610W
Order No.	:	1006-00257
Date of receipt	:	2010-06-17
Test duration	:	2010-07-21
Date of issue	:	2010-07-29
Use of report	:	FCC Original Grant

Applicant : Infomark Co., Ltd

#801, KINS Tower, 25-1, jeongja-Dong, Bundang-Gu Seongnam-Si, Gyonggi-Do, Korea

Test laboratory : Digital EMC Co., Ltd.

683-3, Yubang-Dong, Cheoin-Gu, Yongin-Si, Kyunggi-Do, 449-080, Korea

Test specification	:	§2.1093, FCC/OET Bulletin 65 Supplement C[July 2001]
Test environment	:	See appended test report
Test result	:	☒ Pass ☐ Fail

Tested by:	Witnessed by:	Reviewed by:
Engineer S.K.Ryu	N/A	Technical Director Harvey Sung

CONTENTS

1. General Information

1.1 Equipment information

FCC Equipment Class	Licensed Non-Broadcast Station Transmitter(TNB)
Equipment type	WiMAX & WiFi Dual CPE
Equipment model name	IMW-C610W
Equipment add model name	N/A
Modulation Technology	QPSK, 16QAM
Duplex Method	TDD
Equipment serial no.	Identical prototype
TX Frequency Range	2499.00 ~2686.75 MHz (5MHz OBW) / 2508.50 ~2683.50 MHz (10MHz OBW)
RX Frequency Range	2499.00 ~2686.75 MHz (5MHz OBW) / 2508.50 ~2683.50 MHz (10MHz OBW)
Max. SAR Measurement	**0.919** mW/g Body SAR

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

2. INTROCUCTION/SAR DEFINITION

In 1974, the International Radiation Protection Association (IRPA) formed a working group on non-ionizing radiation (NIR), which examined the problems arising in the field of Protection against the various types of NIR. At the IRPA Congress in Paris in 1977, this working group because the International Non-Ionizing Radiation Committee (INIRC).

In cooperation with the Environmental Health Division of the World Health Organization (WHO), the IRPA/INIRC developed a number of health criteria documents on NIR as part of WHO'S Environmental Health Criteria Programme, sponsored by the United Nations Environment Programme (UNEP). Each document includes an overview of the physical characteristics, measurement and instrumentation, sources, and applications of NIR, a thorough review of the literature on biological effects, and an evaluation of the health risks of exposure to NIR. These health criteria have provided the scientific database for the subsequent development of exposure limits and codes of practice relating to NIR.

At the Eighth International Congress of the IRPA (Montreal, 18-22 May 1992), a new, independent scientific organization-the International Commission on Non-Ionizing Radiation Protection (ICNIRP)-was established as a successor to the IRPA/INIRC. The functions of the Commission are to investigate the hazards that may be association with the different forms of NIR, develop international guidelines on NIR exposure to static and extremely-low-frequency (ELF) electric and magnetic field have been reviewed by UNEP/WHO/IRPA (1984, 1987). Those publications and a number of others, including UNEP/WHO/IRPA (1993) and Allen et al. (1991), provided the scientific rationale for these guidelines.

A glossary of terms appears in the Appendix.

2.1 SAR Definition

Specific Absorption Rate (SAR) is defined as the time derivative (rate) of the incremental energy (dU) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dV) of a given density (ρ) It is also defined as the rate of RF energy absorption per unit mass at a point in an absorbing body (see Fig. 1.1)

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

Figure 1.1
SAR Mathematical Equation

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

SAR = E^2 / ρ

Where:

σ = conductivity of the tissue-simulant material (S/m)
ρ = mass density of the tissue-simulant material (kg/m3)
E = Total RMS electric field strength (V/m)

NOTE: The primary factors that control rate of energy absorption were found to be the wavelength of the incident field in relations to the dimensions and geometry of the irradiated organism, the orientation of the organism in relation to the polarity of field vectors, the presence of reflecting surfaces, and whether conductive contact is made by the organism with a ground plane.[6]

3. SAR MEASUREMENT SETUP

3.1 Robotic System

Measurements are performed using the DASY4 automated dosimetric assessment system. The DASY4 is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland and consists of high precision robotics system (Staubli), robot controller, Pentium III computer, near-field probe, probe alignment sensor, and the generic twin phantom containing the brain equivalent material. The robot is a six-axis industrial robot performing precise movements to position the probe to the location (points) of maximum electromagnetic field (EMF) (see Fig. 2.1).

3.2 System Hardware

A cell controller system contains the power supply, robot controller, teach pendant (Joystick), and a remote control used to drive the robot motors. The PC consists of the Micron Pentium IV 500 MHz computer with Windows NT system and SAR Measurement Software DASY4, A/D interface card, monitor, mouse, and keyboard. The Staubli Robot is connected to the cell controller to allow software manipulation of the robot. A data acquisition electronic (DAE) circuit that performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. is connected to the Electro-optical coupler (EOC). The EOC performs the conversion from the optical into digital electric signal of the DAE and transfers data to the PC plug-in card.

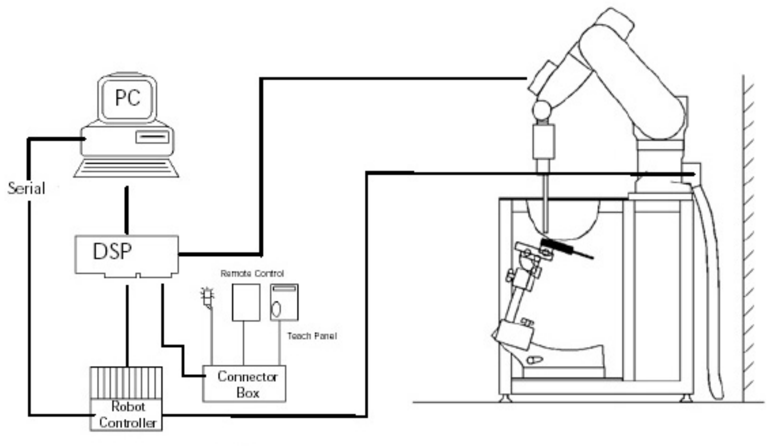


Figure 2.1 SAR Measurement System Setup

3.3 System Electronics

The DAE3 consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the PC-card is accomplished through an optical downlink for data and status information and an optical uplink for commands and clock lines. The mechanical probe mounting device includes two different sensor systems for frontal and sidewise probe contacts. They are also used for mechanical surface detection and probe collision detection. The robot uses its own controller with a built in VME-bus computer. The system is described in detail in [7].

3.4 Probe Measurement System

Figure 3.1 DAE System

The SAR measurements were conducted with the dosimetric probe EX3DV4, designed in the classical triangular configuration [7] (see Fig. 3.2) and optimized for dosimetric evaluation. The probe is constructed using the thick film technique; with printed resistive lines on ceramic substrates. The probe is equipped with an optical multifiber line ending at the front of the probe tip (see Fig. 3.3). It is connected to the EOC box on the robot arm and provides an automatic detection of the phantom surface. Half of the fibers are connected to a pulsed infrared transmitter, the other half to a synchronized receiver. As the probe approaches the surface, the reflection from the surface produces a coupling from the transmitting to the receiving fibers. This reflection increases first during the approach, reaches maximum and then decreases. If the probe is flatly touching the surface, the coupling is zero. The distance of the coupling maximum to the surface is independent of the surface reflectivity and largely independent of the surface to probe angle. The DASY4 software reads the reflection during a software approach and looks for the maximum using a 2nd order fitting (see Fig.3.1). The approach is stopped at reaching the maximum.

3.5 Probe Specifications

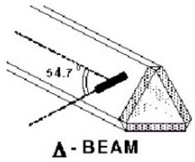


Figure 3.1 Triangular Probe Configuration

Calibration: In air from 10 MHz to 6.0 GHz
In brain and muscle simulating tissue at Frequencies of
835 MHz, 1750 MHz, 1900 MHz, 2450 MHz, 2600 MHz, 3500 MHz

Frequency: 10 MHz to 6 GHz

Linearity: ±0.2dB (30 MHz to 6 GHz)

Dynamic: 10 mW/kg to 100 W/kg

Range: Linearity: ±0.2 dB

Dimensions: Overall length: 330 mm

Tip length: 20 mm

Body diameter: 12 mm

Tip diameter: 2.5 mm

Distance from probe tip to sensor center: 1 mm

Application: SAR Dosimetry Testing
Compliance tests of mobile phones

Figure 3.2 Probe Thick-Film Technique

4. Probe Calibration Process

4.1 Dosimetric Assessment Procedure

Each probe is calibrated according to a dosimetric assessment procedure described in [8] with accuracy better than +/- 10%. The spherical isotropy was evaluated with the procedure described in [9] and found to be better than +/-0.25dB. The sensitivity parameters (NormX, NormY, NormZ), the diode compression parameter (DCP) and the conversion factor (ConvF) of the probe is tested.

4.2 Free Space Assessment

The free space E-field from amplified probe outputs is determined in a test chamber. This is performed in a TEM cell for frequencies below 1 GHz (see Fig. 4.1), and in a waveguide above 1GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity at the proper orientation with the field. The probe is then rotated 360 degrees.

4.3 Temperature Assessment *

E-field temperature correlation calibration is performed in a flat phantom filled with the appropriate simulated brain tissue. The measured free space E-field in the medium, correlates to temperature rise in a dielectric medium. For temperature correlation calibration a RF transparent thermistor based temperature probe is used in conjunction with the E-field probe (see Fig. 4.2).

$$\text{SAR} = C\frac{\Delta T}{\Delta t}$$

where:

Δt = exposure time (30 seconds),

C = heat capacity of tissue (brain or muscle),

ΔT = temperature increase due to RF exposure.

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

where:

σ = simulated tissue conductivity,

ρ = Tissue density (1.25 g/cm^3 for brain tissue)

SAR is proportional to ΔT / Δt , the initial rate of tissue heating, before thermal diffusion takes place. Now it's possible to quantify the electric field in the simulated tissue by equating the thermally derived SAR to the E- field;

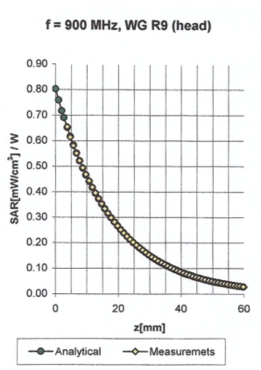


Figure 4.1 E-Field and Temperature Measurements at 900MHz[7]

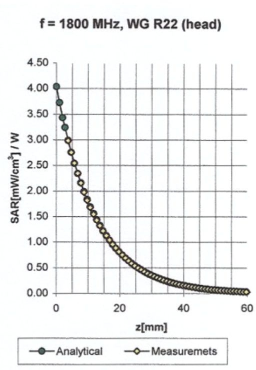


Figure 4.2 E-Field and Temperature Measurements at 1900MHz[7]

5. PHANTOM & EQUIVALENT TISSUES

5.1 SAM Phantom

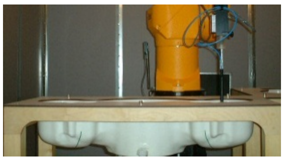


Figure 5.1 SAM Twin Phantom

The SAM Twin Phantom V4.0 is constructed of a fiberglass shell integrated in a wooden table. The shape of the shell is based on data from an anatomical study designed to determine the maximum exposure in at least 90% of all users [11][12]. 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 the 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 in the robot. (see Fig. 5.1)

5.2 Brain & Muscle Simulating Mixture Characterization

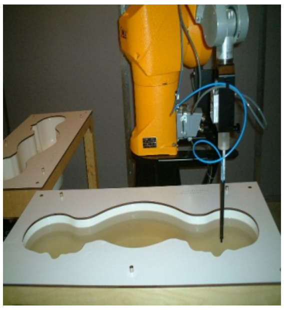


Figure 5.2 Simulated Tissue

The brain and muscle mixtures consist of a viscous gel using hydroxethyl cellullose (HEC) gelling agent and saline solution (see Table 6.1). Preservation with a bacteriacide is added and visual inspection is made to make sure air bubbles are not trapped during the mixing process. The mixture is calibrated to obtain proper dielectric constant (permittivity) and conductivity of the desired tissue. The head tissue dielectric parameters recommended by the IEEE SCC-34/SC-2 have been incorporated in the following table. Other head and body tissue parameters that have not be specified in P1528 are derived from the issue dielectric parameters computed from he 4-Cole-Cole equations The mixture characterizations used for the brain and muscle tissue simulating liquids are according to the data by C. Gabriel and G. Hartsgrove [13].(see Fig. 5.2)

Table 5.1 Composition of the Muscle Tissue Equivalent Matter

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

5.3 Device Holder for Transmitters

Figure 5.2 Mounting Device

In combination with the SAM Twin Phantom V4.0 the Mounting Device (see Fig. 5.2),enables the rotation of the mounted transmitter in spherical coordinates where by the rotation point is the ear opening. The devices can be easily, accurately, and repeatably be positioned according to the FCC specifications. The device holder can be locked at different phantom locations (left head, right head, flat phantom).

- Note: A simulating human hand is not used due to the complex anatomical and geometrical structure of the hand that may produce infinite number of configurations [12]. To produce the worst-case condition (the hand absorbs antenna output power), the hand is omitted during the tests.

6. TEST SYSTEM SPECIFICATIONS

6.1 Automated Test System Specifications

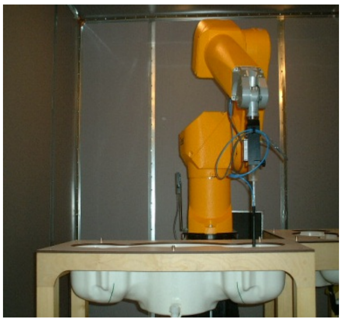


Figure 6.1 DASY4 Test System

Positioner

Robot: Stäubli Unimation Corp. Robot Model: RX60L
Repeatability: 0.02 mm
No. of axis: 6

Data Acquisition Electronic (DAE) System

Cell Controller

Processor: Pentium 4 CPU
Clock Speed: 3 GHz
Operating System: Window 2000
Data Card: DASY4 PC-Board

Data Converter

Features: Signal, multiplexer,A/D converter. & control logic
Software: DASY4
Connecting Lines : Optical downlink for data and status info
Optical uplink for commands and clock

PC Interface Card

Function: 24 bit (64 MHz) DSP for real time processing
Link to DAE 3
16 bit A/D converter for surface detection system
serial link to robot
direct emergency stop output for robot

E-Field Probes

Model: EX3DV4 S/N: 3643
Construction: Triangular core fiber optic detection system
Frequency: 10 MHz to 6 GHz
Linearity: ±0.2dB (30MHz to 6GHz)

Phantom

Phantom: SAM Twin Phantom (V4.0)
Shell Material: Vivac Composite
Thickness: 2.0 ± 0.2 mm

7. DOSIMETRIC ASSESSMENT & PHANTOM SPECS

7.1 Measurement Procedure

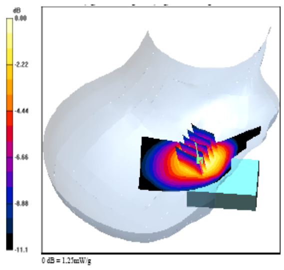


Figure 7.1 Sample Sar Area Scan

The evaluation was performed using the following procedure:

1. The SAR measurement was taken at a selected spatial reference point to monitor power variations during testing. This fixed location point was measured and used as a reference value.
2. The SAR distribution at the exposed side of the head was measured at a distance of 3.9mm from the Inner surface of the shell. The area covered the entire dimension o f the head and the horizontal grid spacing was 15 mm x 15 mm.
3. Based on the area scan data, the area of the maximum absorption was determined by spline interpolation. Around this point, a volume of 30 mm x 30 mm x 30 mm (fine resolution volume scan, zoom scan) was assessed by measuring 5 x 5 x 7 points. On this basis of this data set, the spatial peak SAR value was evaluated with the following procedure (see Fig. 7.1):
   a. The data at the surface was extrapolated, since the center of the dipoles is 2.7 mm away from the tip of the probe and the distance between the surface and the lowest measuring point is 1.2mm. The extrapolation was based on a least square algorithm [15]. A polynomial of the fourth order was calculated through the points in z-axes. This polynomial was then used to evaluate the points between the surface and the probe tip.
   b. The maximum interpolated value was searched with a straight-for war dalgorithm. Around this maximum the SAR values averaged over the spatial volumes (1g or 10g) were computed using the 3D-Spline interpolation algorithm. The 3D-spline is composed of three one-dimensional splines with the “Not a knot” condition (in x, y, and z directions) [15][16]. The volume was integrated with the trapezoidal algorithm. One thousand points (10 x 10 x 10) were interpolated to calculate the average.
   c. All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.
4. The SAR reference value, at the same location as procedure #1, was re-measured. If the value changed by more than 5 %, the evaluation is repeated.

7.2 Specific Anthropomorphic Mannequin (SAM) Specifications

The phantom for handset SAR assessment testing is a low-loss dielectric shell, with shape and dimensions derived from the anthropometric data of the 90th percentile adult male head dimensions as tabulated by the US Army. The SAM Twin Phantom shell is bisected along the mid-sagittal plane into right and left halves (see Fig. 7.2). The perimeter sidewalls of each phantom halves are extended to allow filling with liquid to a depth that is sufficient to minimized reflections from the upper surface. The liquid depth is maintained at a minimum depth of 15cm to minimize reflections from the upper surface.

Figure 7.2 SAM Twin Phantom shell

8. DEFINITION OF REFERENCE POINTS

8.1 EAR Reference Point

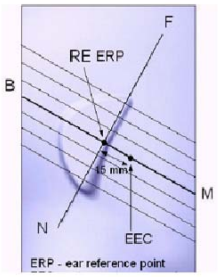


Figure 8.2 Close-up side view of ERPs

Figure 8.1 shows the front, back and side views of the SAM Twin Phantom. The point "M" is the reference point for the center of the mouth, "LE" is the left ear reference point(ERP), and "RE" is the right ERP. The ERPs are 15mm posterior to the entrance to the Ear canal (EEC) along the B-M line (Back-Mouth), as shown in Figure 9.2. The plane Passing, through the two ear canals and M is defined as the Reference Plane. The line N-F (Neck- Front) is perpendicular to the reference plane and passing through the RE (or LE) is called the Reference Pivoting Line (see Figure 8.2). Line B-M is perpendicular to the N-F line. Both N-F and B-M lines are marked on the external phantom shell to facilitate handset positioning [5]

Figure 8.1 Front, back and side view of SAM Twin Phantom

8.2 Handset Reference Points

Two imaginary lines on the handset were established: the vertical centerline and the horizontal line. The test device was placed in a normal operating position with the "test device reference point" located along the "vertical centerline" on the front of the device aligned to the "ear reference point" (See Fig. 8.3). The "test device reference point" was than located at the same level as the center of the ear reference point. The test device was positioned so that the "vertical centerline" was bisecting the front surface of the handset at it's top and bottom edges, positioning the "ear reference point" on the outer surface of the both the left and right head phantoms on the ear reference point.

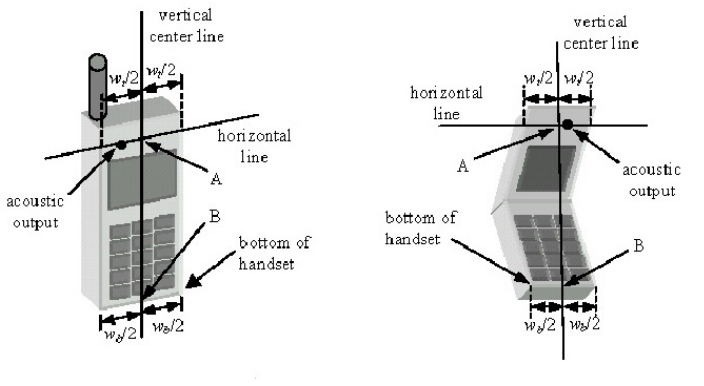


Figure 8.3 Handset Vertical Center & Horizontal Line Reference Points

9. DESCRIPTION OF SUPPORTED UNITS

The EUT has been tested with other necessary accessories or supported units. The following supported units or accessories were used to perform SAR tests for this device.

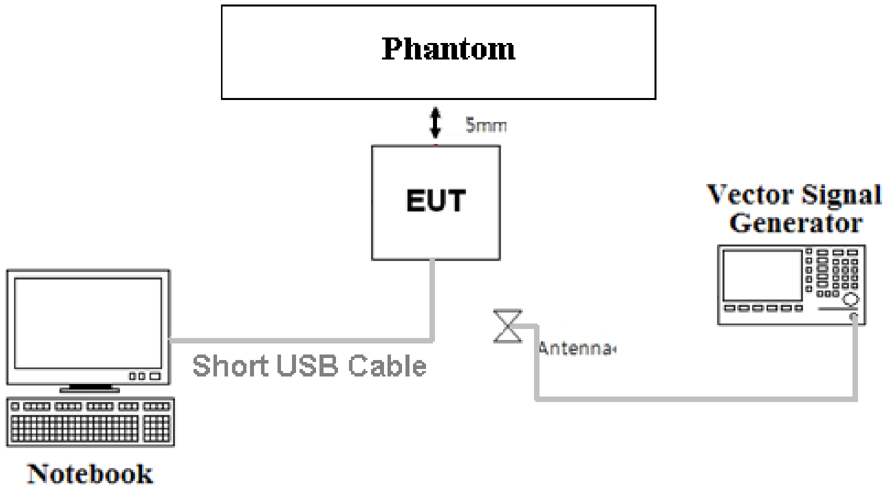
- Supported Units

NO.	PRODUCT	BRAND	MODEL NO.	SERIAL NO.	FCC ID
1	LAPTOP	TOSHIBA	PSME4K-014001	19101993W	CJ6UPA3613WL
2	Vector Signal Generator	Rohde Schwarz	SMJ100A	100148	N/A

10. TEST SETUP AND TEST SINGAL DETAIL

The test set-up is shown in the below picture. The WiMAX CPE Modem(EUT) to transmit rated output power under appropriate transmission mode and specific frequency.
The telnet program is used for verifying a connection status between notebook computer and EUT and to control maximum transmitting power, channel selection. BW(5MHz & 10MHz) AND TX/RX status of the DUT.

The EUT uses 29:18 WiMAX frame (Downlink : Uplink Symbols). Currently this is the maximum duty for WiMAX device. This WiMAX frame is selected using the specific wave form in the VSG(Vector Signal Generator).



The EUT is 2.5 GHz WiMAX transceiver using GCT chipset which supports antenna structure for 1 TX and 2 RX. Only one antenna is used for both transmitting and receiving while the other antenna is strictly used for RX diversity. The EUT has capable of both 10 MHz and 5 MHz uplink bandwidths. For the 10 MHz bandwidth of AMC zone format, it has 48 sub-channels structured from 1024 subcarriers; 160 are used as spare/safeguard subcarriers, leaving 864 available for transmission. From this, 768 subcarriers for data transmission with 96 subcarriers intended for pilot use.

For the 5 MHz bandwidth of AMC zone, it contains 24 sub-channels using 512 subcarriers; 80 subcarriers as spare/safeguard subcarriers, 384 for data transmission, and 48 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 ranging and bandwidth information is used to ensure optimal system operation. In normal transmission, the device will transmit control signaling at the first 3 uplink symbols and then use the rest of the uplink symbols for data traffic bursts in the uplink sub-frame.

Since the first 3 symbols are also used for ranging detection purposes and are shared among other devices , its transmitting power is much smaller than the data burst symbol power. During the SAR testing, the first 3 symbols are also kept in reduced power level and the data traffic bursts are always running at the maximum output power level. In the real usage, the data burst power will be adjusted according to the signal strength of the communication.

The VSG produces a downlink burst every 5 milliseconds which simulates the transmission of a BS operating under normal mode. This downlink burst instructs the MS to transmit for 15 symbols in the UL data zone. This UL transmission is repeated every 5 milliseconds. The transmitting power of the MS is set to maximum power.

10. TEST SETUP AND TEST SINGAL DETAIL (Continued)

The VSG and MS use same frequency. The VSG level is much less than the MS Tx power (Approximately 80dB less than the MS power) and so does not affect the SAR readings. Since both the VSG (Base station simulator) and MS are working in TDD mode, co-operation under same frequency is not an issue.

The VSG is loaded with a BS (Base Station) downlink signal which contains the 29:18 information. The mobile station synchronizes to the signal from the VSG in frequency and time and then demodulates two maps contained in the VSG 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 VSG. 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 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. Since the BW requests are shared across the Control Symbols (traffic versus non-traffic modes) and control symbols can be supported only in PUSC zone, the control traffic that is relevant to the SAR calculation is CQICH and HARQ ACK/NACK. So the conducted maximum power for this control traffic is 5/35 of 235.5 mW(23.72 dBm) for 10 MHz and 5/17 of 220.8 mW(23.44 dBm) for 5 MHz.

In the test mode in AMC zone format, the UL operates with all data sub-channels(48 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 MS to will transmit fewer sub-channels

For the signal from the VSG, it looks identical to the signal that would come from a BS in the field. The intent is to make the think it is in EUT a real network. The transmission from the EUT under test conditions is exactly the same as in the field in normal operation. The only difference is that normally in the field there will be information in some of the control symbols, whereas SAR tests were performed with not having the information in the some control symbols. So it is necessary to calculate a scaling factor that takes into consideration this fact.
You will see a calculation, scaling factor from the measurements (the measurements were taken under a channel configuration of 29:18, without control symbols) to a network configuration using 29:18. This is also calculated for 10MHz and 5MHz bandwidth channels.

The testing was done using a common 29:18 ratio as specified in the WiMAX specifications. 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. The correct duty factor should be (15*102.8571 uS)/5000 uS=30.86 %. Using this calculation method eliminates all the other transmit time, guard time, etc, and only uses the transmit time.

Regarding to why these numbers don't total to 48: Since AMC is dominant, this determines the allowed DL:UL ratios. In DL AMC, bursts require two symbols so DL symbol count must be an even number+1 symbol for the preamble. Hence the number of DL symbols must be an odd number. In the UL, AMC bursts require 3 symbols so UL must be a multiple of three symbols. In addition, the total number of symbols(DL+UL) is chosen to be 47 or less to allow for sufficient time to switch between DL and UL and vice versa.

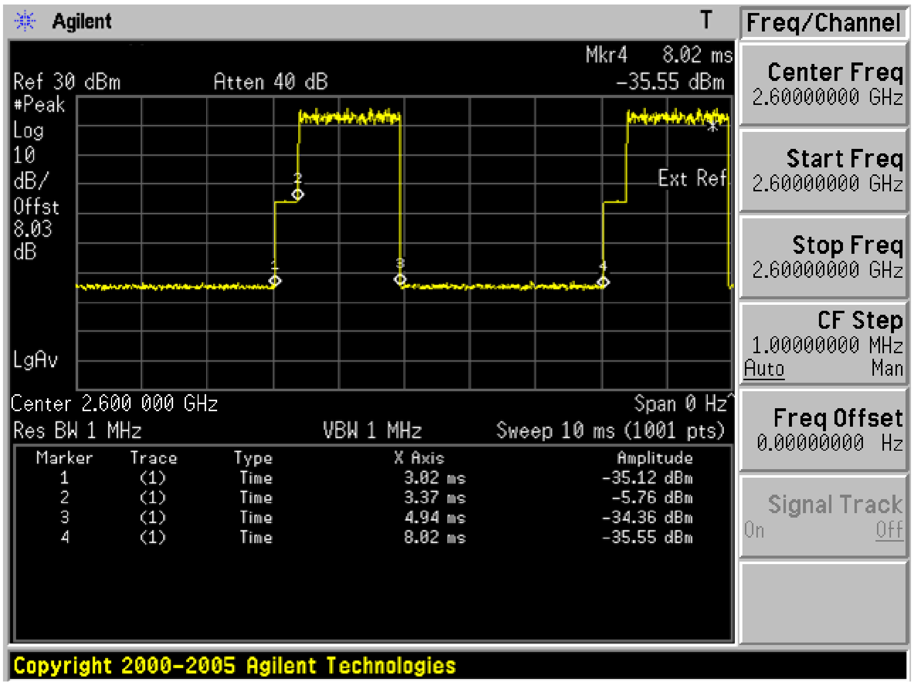
There is a quiet time between the DL and UL transmission and a quiet time between the UL and DL transmission. During these quiet intervals the Base Station is neither transmitting nor receiving. The unoccupied symbols become part of this quiet time.

Ranging is performed to make sure the MS transmits in the correct time window. Data transmission is disabled when the MS is ranging. This is done to prevent the MS from transmitting at the wrong time and interfering with other users. Hence the MS is not allowed to range and transmit data at the same time. So ranging was not considered in the scaling factor.

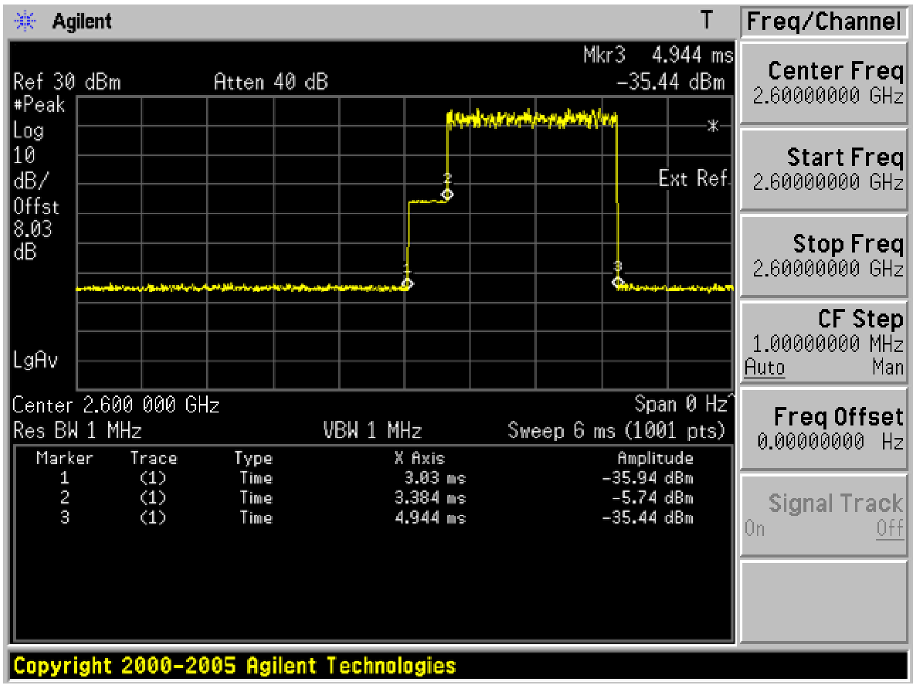
10. TEST SETUP AND TEST SINGAL DETAIL (Continued)

Actual Duty Cycle VS Theoretically Calculated Duty Cycle

AMC_QPSK 1/2(Plot 1)



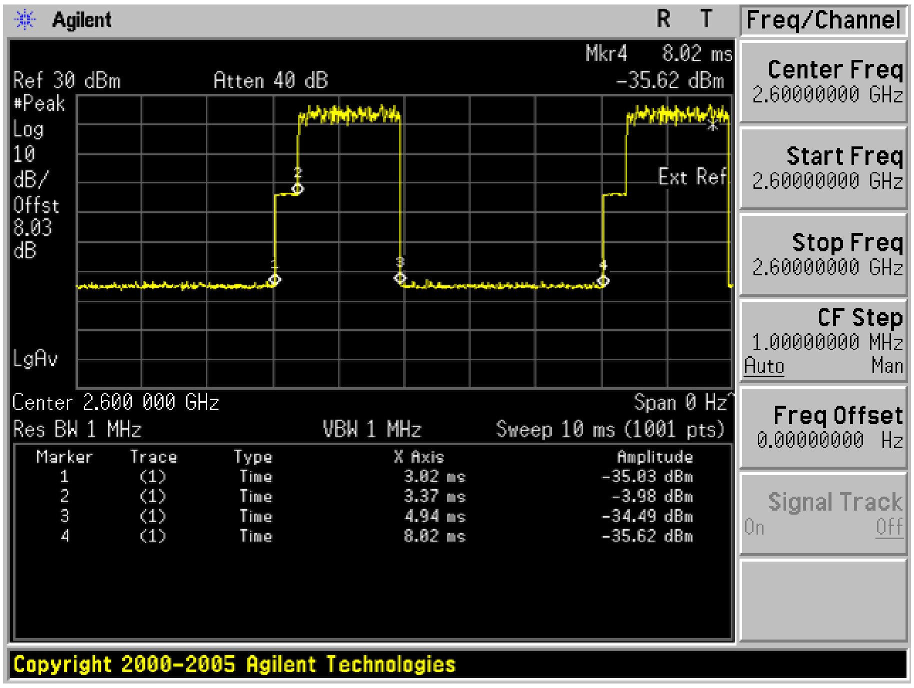
AMC_QPSK 1/2(Plot 2)



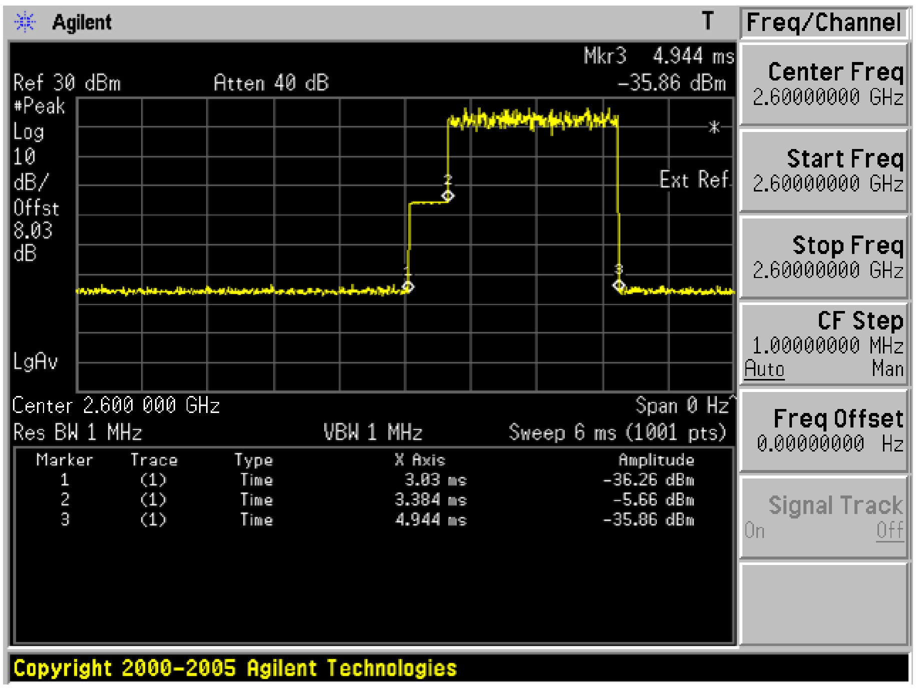
Burst length (Plot 1) = Mark 4 – Mark 1 = 8.02 ms – 3.02 ms = 5 ms
15 uplink symbol length (Plot 2) = Mark 3 – Mark 2= 4.944 ms – 3.384 ms = 1.56 ms
Duty cycle = 1.56 / 5 * 100 % = 31.2 %

10. TEST SETUP AND TEST SINGAL DETAIL (Continued)

AMC_16QAM 1/2(Plot 1)



AMC_16QAM 1/2(Plot 2)



Burst length (Plot 1) = Mark 4 – Mark 1 = 8.02 ms – 3.02 ms = 5 ms

15 uplink symbol length (Plot 2) = Mark 3 – Mark 2= 4.944 ms-3.384 ms = 1.56 ms

Duty cycle = 1.56 / 5 * 100 % = 31.2 %

The theoretically Calculated Duty Cycle = (15*102.8571 uS)/5000 uS=30.86 %.

This agrees with the actual duty cycles of this device.

11. SUMMARY OF TEST RESULTS

According to the supplied product information, basically the SAR test was performed at 29:18 (18 uplink symbols per frame with 15 data symbols) as the worst case. When performing the SAR tests using the VSG, it looks identical to the signal that would come from a BS in the field. The intent is to make the think it is in EUT a real network. The transmission from the EUT under test conditions is exactly the same as in the field in normal operation. The only difference is that normally in the field there will be information in some of the control symbols, whereas SAR tests were performed with not having in the some control symbols. Therefore it is necessary to calculate a scaling factor that takes into consideration this fact. The calculation of this scaling factor is described in the followings.

Scaling Factor for a 5MHz channel bandwidth

For the 29:18 frame the UL consists of 18 symbols.

The first three symbols are control channels (BS signaling) and the remaining 15 symbols are for data.
Since PUSC zone only support control signal, the first 3 symbols have a total of 17 slots in a 5 MHz channel bandwidth. The maximum number of control slots that an active can occupy in any frame is:

(A) 2 slots for CQICH report-maximum of 2 simultaneous CQICH reports are allowed by the Standard from any MS
(B) 3 slots for HARQ ACK/NAK (5 ACK/NAK bits corresponding to maximum of 5 DL HARQ bursts in previous DL frame allowed by the standard - each HARQ ACK/NAK bit is transmitted using 1/2 slot)

These 5 slots occupy 5/17 of the total number of available UL slots.
If the UL data burst is transmitted at full power (23.44 dBm in PUSC zone), then the control channels using 5/17th the total number of slots transmitting at the maximum power should use :

23.44 dBm – 10 log(17/5) =(23.44- 5.32) dBm=18.12 dBm= 64.86 mW.

BW requests from the MS to the BS are piggy-backed on the data symbols if the MS is transmitting in the frame.
For using a 5 MHz channel using the maximum 64.86 mw for each control symbol, and 220.8 mW on the data symbols, the math is as follow:

On the 29:18(15 data symbols are used)
Scaling Factor = (3*64.86+15*220.8)/(15*220.8)=1.06
So the worst case SAR value can be compensated as below.
0.593*1.06=0.629 mW/g

11. SUMMARY OF TEST RESULTS (Continued)

Scaling Factor for a 10 MHz channel bandwidth
For the 29:18 frame the UL consists of 18 symbols.

The first three symbols are control channels (BS signaling) and the remaining 15 symbols are for data.
Since PUSC zone only support control signal, the first 3 symbols have a total of 35 slots in a 10 MHz channel bandwidth. The maximum number of control slots that an active can occupy in any frame is:

(A) 2 slots for CQICH report - maximum of 2 simultaneous CQICH reports are allowed by the Standard from any MS
(B) 3 slots for HARQ ACK/NAK (5 ACK/NAK bits corresponding to maximum of 5 DL HARQ bursts in previous DL frame allowed by the standard - each HARQ ACK/NAK bit is transmitted using 1/2 slot)

These 5 slots occupy 5/35 of the total number of available UL slots.

If the UL data burst is transmitted at full power (23.72 dBm in PUSC), then the control channels using 5/35th the total number of slots transmitting at the maximum power should use 23.72 dBm-10log(35/5)=(23.72-8.45) dBm =15.27 dBm=33.65 mW.

BW requests from the MS to the BS are piggy-backed on the data symbols if the MS is transmitting in the frame.
For a 10 MHz channel using the maximum 33.65 mW for each control symbol, and 235.5 mW on the data symbols, the math is as follow:

On the 29:18 (15 data symbols are used)
Scaling Factor = (3*33.65+15*235.5)/(15*235.5)=1.03

So the worst case SAR data can be compensated as below
0.892*1.03=0.919 mW/g

Currently 29:18 (Downlink / Uplink Ratio) is the maximum duty for WIMAX device. Since US WiMAX operators in the BRS/EBS band have agreed to operate with 29 OFDMA symbols downstream and 18 symbols upstream. US operators are working through the Wireless Communications Association International (WCA) to finalize a US best practices document including this ratio. The proposal has been approval at the WCA working group level and is awaiting final approval by the Board of Directors.
Therefore other duty (downlink : uplink symbol ratio) is not considered for SAR test of this device.

13. ANSI / IEEE C95.1-1992 RF EXPOSURE LIMITS

13.1 Uncontrolled Environment

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

13.2 Controlled Environment

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

Table 13.1. SAR Human Exposure Specified in ANSI/IEEE C95.1-1992

	HUMAN EXPOSURE LIMITS	
	General Public Exposure (W/kg) or (mW/g)	Occupational Exposure (W/kg) or (mW/g)
Whole-Body average SAR (W/kg)	0.08	0.40
Localized SAR (head and trunk) (W/kg)	1.60	8.00
Localized SAR (limbs) (W/kg)	4.00	20.0

14. IEEE P1528 – MEASUREMENT UNCERTAINTIES

Error Description	Uncertaint value ±%	Probability Distribution	Divisor	(Ci) 1g	Standard (1g)	vi 2 or Veff
Measurement System						
Probe calibration	± 4.8	Normal	1	1	± 4.8 %	∞
Axial isotropy	± 4.7	Rectangular	√3	0.7	± 1.9 %	∞
Hemispherical isotropy	± 9.6	Rectangular	√3	0.7	± 3.9 %	∞
Boundary Effects	± 1.0	Rectangular	√3	1	± 0.6 %	∞
Probe Linearity	± 4.7	Rectangular	√3	1	± 2.7 %	∞
Detection limits	± 1.0	Rectangular	√3	1	± 0.6 %	∞
Readout Electronics	± 1.0	Normal	1	1	± 1.0 %	∞
Response time	± 0.8	Rectangular	√3	1	± 0.5 %	∞
Integration time	± 2.6	Rectangular	√3	1	± 1.5 %	∞
RF Ambient Conditions	± 3.0	Rectangular	√3	1	± 1.7 %	∞
Probe Positioner	± 0.4	Rectangular	√3	1	± 0.2 %	∞
Probe Positioning	± 2.9	Rectangular	√3	1	± 1.7 %	∞
Algorithms for Max. SAR Eval.	± 1.0	Rectangular	√3	1	± 0.6 %	∞
Test Sample Related						
Device Positioning	± 2.9	Normal	1	1	± 2.9 %	145
Device Holder	± 3.6	Normal	1	1	± 3.6 %	5
Power Drift	± 5.0	Rectangular	√3	1	± 2.9 %	∞
Physical Parameters						
Phantom Shell	± 4.0	Rectangular	√3	1	± 2.3 %	∞
Liquid conductivity (Target)	± 5.0	Rectangular	√3	0.64	± 1.8 %	∞
Liquid conductivity (Meas.)	± 2.5	Normal	1	0.64	± 1.6 %	∞
Liquid permittivity (Target)	± 5.0	Rectangular	√3	0.6	± 1.7 %	∞
Liquid permittivity (Meas.)	± 2.5	Normal	1	0.6	± 1.5 %	∞
Combined Standard Uncertainty					**± 10.3 %**	330
Expanded Uncertainty (k=2)					**± 20.6 %**	

The above measurement uncertainties are according to IEEE P1528 (2003)

15. SYSTEM VERIFICATION

15.1 Tissue Verification

Table 15.1 Simulated Tissue Verification [5]

MEASURED TISSUE PARAMETERS					
Date(s)	Target Frequency	Dielectric constant: ε		Conductivity: σ	
		Target	Measured	Target	Measured
July. 21, 2010	2499.0 MHz Muscle	52.6	53.6	2.02	2.17
	2508.5 MHz Muscle	52.6	53.6	2.02	2.17
	2600.0 MHz Muscle	52.5	53.6	2.16	2.16
	2683.5 MHz Muscle	52.4	53.5	2.28	2.15
	2686.75 MHz Muscle	52.4	53.5	2.29	2.14

15.2 Test System Validation

Prior to assessment, the system is verified to the ± 10 % of the specifications at 2600 MHz by using the system validation kit(s). (Graphic Plots Attached)

Table 1.2 System Validation [5]

SYSTEM DIPOLE VALIDATION TARGET & MEASURED (2600 MHz values are normalized to a forward power of 1/4 W)					
Date(s)	System Validation Kit:	Target Frequency	Targeted SAR_{1g} (mW/g)	Measured SAR_{1g} (mW/g)	Deviation (%)
July. 21, 2010	D-2600V2, S/N: 1016	2600 MHz Body	14.5	13.9	-4.14

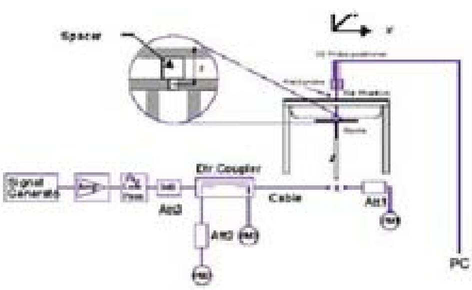


Figure 15.1 Dipole Validation Test Setup

16 DESCRIPTION OF TEST MODE AND SUMMARY OF RESULTS

16.1 DESCRIPTION OF TEST MODE

TEST MODE	COMMUNICATION	MODULATION TYPE & CODING RATE NOTE 1	Zone Format	ASSESSEMENT POSITION	TESTED CHANNEL
1	WiMAX-5 M,10 M	16QAM 1/2, QPSK 1/2	AMC	A	L,M,H
1	WiMAX-10 M	16QAM 1/2	PUSC	A	M
2	WiMAX-10 M	16QAM 1/2	AMC	B	M

Note 1 : 29 :18 frame structure is used for the SAR tests with rated maximum output power.

16.2 SUMMARY OF TEST RESULTS (Actual measured SAR)

- BANDWIDTH: 5 MHz

	MEASURED VALUE OF 1 g SAR (W/kg)									
TEST MODE	1		2		3		4		5	
MODULATION TYPE	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK
LOW CHANNEL	-	-	-	-	-	-	-	-	-	-
Middle CHANNEL	0.593	0.587	-	-	-	-	-	-	-	-
High CHANNEL	-	-	-	-	-	-	-	-	-	-

- BANDWIDTH: 10 MHz

	MEASURED VALUE OF 1 g SAR (W/kg)									
TEST MODE	1		2		3		4		5	
MODULATION TYPE	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK
LOW CHANNEL	0.353	-	-	-	-	-	-	-	-	-
Middle CHANNEL	0.644	0.537	0.412	-	-	-	-	-	-	-
HIGH CHANNEL	0.892	-	-	-	-	-	-	-	-	-
HIGH CHANNEL	0.815*NOTE									

*NOTE: The SAR test was repeated in the PUSC mode in the worst case channel of AMC Mode.

17. SCALING VALUE OF SAR

17.1 SUMMARY OF TEST RESULTS (Scaling SAR)

- BANDWIDTH: 5 MHz

	SCALED VALUE OF 1 g SAR (W/kg)									
TEST MODE	1		2		3		4		5	
MODULATION TYPE	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK
SCALING FACTOR	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06
LOW CHANNEL	-	-	-	-	-	-	-	-	-	-
Middle CHANNEL	0.629	0.622	-	-	-	-	-	-	-	-
High CHANNEL	-	-	-	-	-	-	-	-	-	-

- BANDWIDTH: 10 MHz

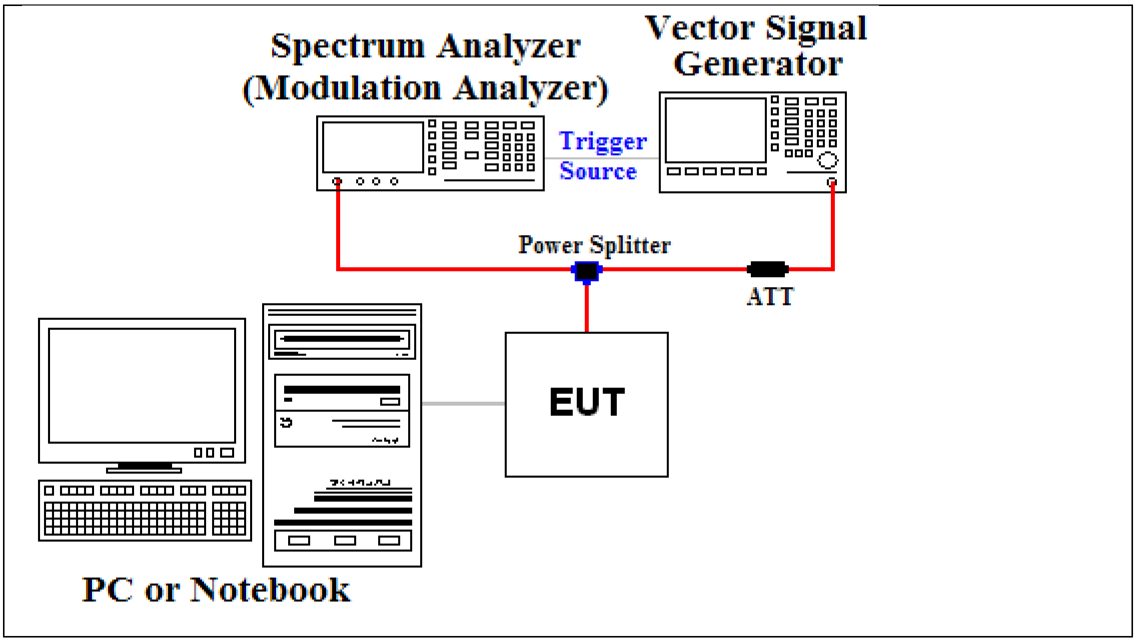
	MEASURED VALUE OF 1 g SAR (W/kg)									
TEST MODE	1		2		3		4		5	
MODULATION TYPE	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK
SCALING FACTOR	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
LOW CHANNEL	0.374	-	-	-	-	-	-	-	-	-
Middle CHANNEL	0.663	0.553	0.424	-	-	-	-	-	-	-
HIGH CHANNEL	0.919	-	-	-	-	-	-	-	-	-
HIGH CHANNEL	0.839	-	-	-	-	-	-	-	-	-

18. POWER TABLE

18.1 WiMAX Max. Power Output Table for IMW-C610W (W/ USB Cable)

Bandwidth	Zone Format	Frequency (MHz)	QPSK 1/2 (dBm)	QPSK 3/4 (dBm)	16QAM 1/2 (dBm)	16QAM 3/4 (dBm)
5MHz	PUSC	2499.00	23.35	23.44	23.37	23.10
		2600.00	23.13	23.11	23.02	23.06
		2686.75	22.95	23.06	22.93	22.92
	AMC	2499.00	23.90	23.89	**24.05**	23.73
		2600.00	23.80	23.67	23.90	23.70
		2686.75	23.88	23.80	23.73	23.65
10MHz	PUSC	2508.50	23.70	23.67	23.72	23.54
		2600.00	23.36	23.28	23.31	23.11
		2683.50	23.24	23.20	23.28	23.12
	AMC	2508.50	**24.20**	24.16	24.13	24.00
		2600.00	23.86	23.73	23.69	23.56
		2683.50	23.82	23.67	23.66	23.62

18.2. WiMAX Conducted Power Test Setup Diagram



18.3 W-LAN Max. Power Output Table for IMW-C610W (W/ USB Cable)

Test Mode	Frequency	Test Results	
		dBm	W
802.11b	Lowest	8.48	0.0070
	Middle	8.44	0.0070
	Highest	6.38	0.0043
802.11g	Lowest	8.49	0.0071
	Middle	8.39	0.0069
	Highest	7.65	0.0058

※ W-LAN SAR test is not required because output power is ≤ 60/f(GHz) mW.

19. SAR TEST DATA SUMMARY

Mixture Type : 2600 MHz Body

BANDWIDTH: 5 MHz

19.1 MEASUREMENT RESULTS						
FREQUENCY	**Begin Power (dBm)**	**Drift Power (dB)**	**Mode**	**Spacing**	**Device Test Position**	**SAR (W/kg)**
MHz						
2600	23.90	0.087	AMC_16QAM	10 mm [Phantom]	1	0.593
2600	23.80	0.130	AMC_QPSK	10 mm [Phantom]	1	0.587
ANSI / IEEE C95.1 1992 - SAFETY LIMIT **Spatial Peak** **Uncontrolled Exposure/General Population**						**Body** **1.6 W/kg** **(mW/g)** averaged over 1 gram

NOTE:

1. Test procedures used are according to FCC/OET Bulletin 65, Supplement C [July 2001] and KDB 615223 WiMax SAR Guidance.
2. All modes of operation were investigated, and worst-case results are reported.
3. Prior to testing the conducted output power was measured.
4. The EUT is tested 2nd hot-spot peak, if it is less than 2 dB below the highest peak.
5. Tissue parameters and temperatures are listed on the SAR plots.
6. Liquid tissue depth is 15.0 cm ± 0.1
7. Test configuration of each mode is described in section 12.2

19. SAR TEST DATA SUMMARY (Continued)

Mixture Type : 2600 MHz Body

BANDWIDTH: 10 MHz

19.2 MEASUREMENT RESULTS						
FREQUENCY MHz	**Begin Power (dBm)**	**Drift Power (dB)**	**Mode**	**Spacing**	**Device Test Position**	**SAR (W/kg)**
2508.5	24.13	-0.039	AMC_16QAM	10 mm [Phantom]	1	0.353
2600	23.69	-0.131	AMC_16QAM	10 mm [Phantom]	1	0.644
2683.5	**23.66**	**-0.063**	**AMC_16QAM**	**10 mm [Phantom]**	**1**	**0.892**
2600	23.69	-0.191	AMC_16QAM	10 mm [Phantom]	2	0.412
2600	23.86	0.135	AMC_QPSK	10 mm [Phantom]	1	0.537
2683.5	23.28	-0.048	PUSC_16QAM	10 mm [Phantom]	1	0.815**
ANSI / IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population						**Body 1.6 W/kg (mW/g)** averaged over 1 gram

NOTE:

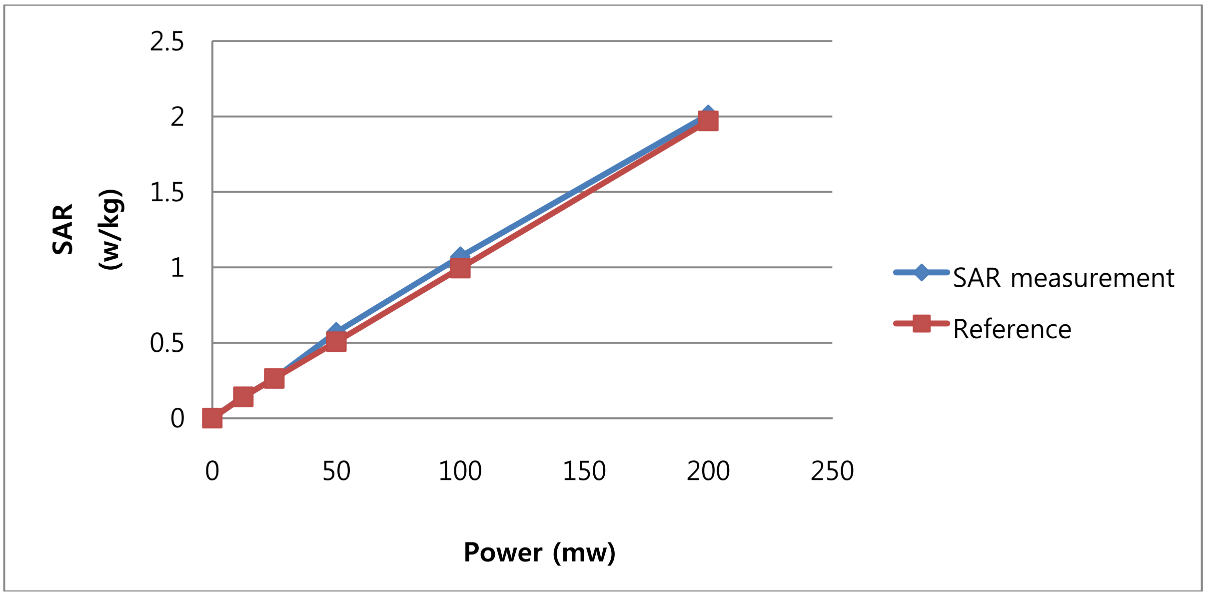
1. Test procedures used are according to FCC/OET Bulletin 65, Supplement C [July 2001] and KDB 615223 WiMax SAR Guidance.
2. All modes of operation were investigated, and worst-case results are reported.
3. Prior to testing the conducted output power was measured.
4. The EUT is tested 2nd hot-spot peak, if it is less than 2 dB below the highest peak.
5. Tissue parameters and temperatures are listed on the SAR plots.
6. Liquid tissue depth is 15.0 cm ± 0.1
7. Test configuration of each mode is described in section 12.2
8. ** The SAR tests was repeated in the PUSC mode in the worst case channel of AMC Mode.

20. Linearity response & Scan resolution check

20.1 Linearity response check:

Distance between phantom and the front of EUT is 10mm. 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.

Wimax Peak RMS output power (mW)	12.5	25	50	100	200
Measured SAR (mW / g)	0.141	0.263	0.569	1.07	2.01
Value from 12.5-25mw reference line	0.141	0.263	0.507	0.995	1.971
Difference	0	0	0.062	0.075	0.039
Percentage of Difference %	0	0	12.23	7.54	1.98



20.2 Compare with different scan grid size

With EUT hold on the highest raw 1g SAR configuration (10M bandwidth / high channel/ front 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.

High channel of 10MHz at Front position.		
Area scan grid size(mm)	Zoom scan grid size(mm)	SAR value (w/kg)
15	8	0.893
5	4	0.898

21. SAR TEST EQUOPMENT

Table 21.1 Test Equipment Calibration

EQUIPMENT SPECIFICATIONS			
Type	**Calibration Date**	**Next Calibration Date**	**Serial Number**
Robot	N/A	N/A	F02/5Q85A1/A/01
Robot Controller	N/A	N/A	F02/5Q85A1/C/01
Joystick	N/A	N/A	D221340031
Hicron Computer 1.1GHz Pentium Celeron ,Window 2000	N/A	N/A	N/A
Data Acquisition Electronics	November 19, 2009	November 19, 2010	520
Dosimetric E-Field Probe	January 26, 2010	January 26, 2011	3643
Dummy Probe	N/A	N/A	N/A
Sam Phantom	N/A	N/A	N/A
Probe Alignment Unit LB	N/A	N/A	321
SPEAG Validation Dipole D2600 MHz	May 27, 2010	May 27, 2012	1016
Head Equivalent Matter(2600 MHz)	January 2010	January 2011	N/A
Body Equivalent Matter(2600 MHz)	January 2010	January 2011	N/A
HP EPM-442A Power Meter	March 12, 2010	March 12, 2011	GB37170267
HP E4421A Signal Generator	July 01, 2010	July 01, 2011	US37230529
Attenuator (10dB)	January 11, 2010	January 11, 2011	BP4387
Attenuator (3dB)	July 01, 2010	July 01,2011	MY39260700
Low pass filter (1.5GHz)	January 01, 2010	January 01, 2011	N/A
Low pass filter (3.0GHz)	October 13, 2009	October 13, 2010	N/A
Dual Directional Coupler	January 11, 2010	January 11, 2011	50228
Amplifier	November 02, 2009	November 02, 2010	1020 D/C 0221
Network Analyzer	March 12, 2010	March 12, 2011	3410J01204
HP85070D Dielectric Probe Kit	N/A	N/A	LISO1440118
SEMITEC Engineering	N/A	N/A	Shield Room
Vector Signal Generator	February 02,2010	February 02,2011	255571

NOTE:
The E-field probe was calibrated by SPEAG, by temperature measurement procedure. Dipole Validation measurement is performed by Digital EMC. before each test. The brain simulating material is calibrated by Digital EMC using the dielectric probe system and network analyzer to determine the conductivity and permittivity (dielectric constant) of the brain-equivalent material.

22. CONCLUSION

Measurement Conclusion

The SAR measurement indicates that the EUT complies with the RF radiation exposure limits of the FCC. These measurements are taken to simulate the RF effects exposure under worst-case conditions. Precise laboratory measures were taken to assure repeatability of the tests. The tested device complies with the requirements in respect to all parameters subject to the test. The test results and statements relate only to the item(s) tested.
Please note that the absorption and distribution of electromagnetic energy in the body are very complex phenomena that depend on the mass, shape, and size of the body, the orientation of the body with respect to the field vectors, and the electrical properties of both the body and the environment. Other variables that may play a substantial role in possible biological effects are those that characterize the environment (e.g. ambient temperature, air velocity, relative humidity, and body insulation) and those that characterize the individual (e.g. age, gender, activity level, debilitation, or disease).
Because innumerable factors may interact to determine the specific biological outcome of an exposure to electromagnetic fields, any protection guide shall consider maximal amplification of biological effects as a result of field-body interactions, environmental conditions, and physiological variables.

23. REFERENCES

[1] Federal Communications Commission, ET Docket 93-62, Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation, Aug. 1996.
[2] ANSI/IEEE C95.1 - 2005, American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 300kHz to 100GHz, New York: IEEE, April 2006.
[3] ANSI/IEEE C95.3 - 2002, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave, New York: IEEE, December 2002.
[4] Federal Communications Commission, OET Bulletin 65 (Edition 97-01), Supplement C (Edition 01-01),Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields,July 2001.
[5] IEEE Standards Coordinating Committee 34 — IEEE Std. 1528-2003, Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques.
[6] NCRP, National Council on Radiation Protection and Measurements, Biological Effects and Exposure Criteria for Radio Frequency Electromagnetic Fields, NCRP Report No. 86, 1986. Reprinted Feb. 1995.
[7] T. Schmid, O. Egger, N. Kuster, Automated E-field scanning system for dosimetric assessments, IEEE transaction on Microwave Theory and Techniques, vol. 44, Jan. 1996, pp. 105-113.
[8] K. Pokovic, T. Schmid, N. Kuster, Robust setup for precise calibration of E-field probes in tissue simulating liquids at mobile communications frequencies, ICECOM97, Oct. 1997, pp. 120-124.
[9] K. Polovċ,T.Schmid,and N.Kuster ,E-field Probe with improved isotropy in brain simulating liquids. Proceedings of the ELMAR, Zadar, Croatia, June 23-25, 1996, pp. 172-175.
[10] Schmid & Partner Engineering AG, Application Note: Data Storage and Evaluation, June 1998, p2.
[11] V. Hombach, K. Meier, M. Burkhardt, E. Kuhn, N. Kuster, The Dependence of EM Energy Absorption upon Human Head Modeling at 900 MHz, IEEE Transaction on Microwave Theory and Techniques, vol. 44 no. 10, Oct. 1996, pp. 1865-1873.
[12] N. Kuster and Q. Balzano, Energy absorption mechanism by biological bodies in the near field of dipole antennas above 300MHz, IEEE Transaction on Vehicular Technology, vol. 41, no. 1, Feb. 1992, pp. 17-23.
[13] G. Hartsgrove, A. Kraszewski, A. Surowiec, Simulated Biological Materials for Electromagnetic Radiation Absorption Studies, University of Ottawa, Bioelectromagnetics, Canada: 1987, pp. 29-36.
[14] Q. Balzano, O. Garay, T. Manning Jr., Electromagnetic Energy Exposure of Simulated Users of Portable Cellular Telephones, IEEE Transactions on Vehicular Technology, vol. 44, no.3, Aug. 1995.
[15] W. Gander, Computermathematick, Birkhaeuser, Basel, 1992.
[16] W.H. Press, S.A. Teukolsky, W.T. Vetterling, and B.P. Flannery, Numerical Recepies in C, The Art of Scientific Computing, Second edition, Cambridge University Press, 1992.
[17] Federal Communications Commission, OET Bulletin 65, Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields. Supplement C, Dec. 1997.
[18] N. Kuster, R. Kastle, T. Schmid, Dosimetric evaluation of mobile communications equipment with known precision, IEEE Transaction on Communications, vol. E80-B, no. 5, May 1997, pp. 645-652.
[19] CENELEC CLC/SC111B, European Prestandard (prENV 50166-2), Human Exposure to Electromagnetic Fields High-frequency: 10kHz-300GHz, Jan. 1995.
[20] Prof. Dr. Niels Kuster ,ETH,EidgenŐssische Technische Technische Hoschschule Zűrich,Dosimetric Evaluation of the Cellular Phone.
[21] FCC SAR Measurement Procedures for 3G Devices v2.0, October 2007
[22] FCC SAR Considerations for Cell Phones with Multiple Transmitters v01r02 #648474, April 2008
[23] 447498 DO1 Mobile Portable RF Exposure v03r02, Published on: Jul 28 2008
[24] 447498 DO2 Mobile Portable RF Exposure v03r02, Published on: Dec 02 2008
[25] 802.16e/WiMax SAR Measurement Guidance