

FCC SAR Test Report

APPLICANT : ZTE CORPORATION
EQUIPMENT : EVDO WiMAX Dual Mode USB Modem
BRAND NAME : ZTE
MODEL NAME : U226
FCC ID : Q78-ZTEAD226
STANDARD : FCC 47 CFR Part 2 (2.1093)
IEEE C95.1-1999
IEEE 1528-2003
FCC OET Bulletin 65 Supplement C (Edition 01-01)

The product was received on Mar. 18, 2010 and completely tested on Mar. 23, 2010. We, SPORTON INTERNATIONAL INC., would like to declare that the tested sample has been evaluated in accordance with the procedures and shown the compliance with the applicable technical standards.

The test results in this report apply exclusively to the tested model / sample. Without written approval of SPORTON INTERNATIONAL INC., the test report shall not be reproduced except in full.

Reviewed by:



Roy Wu / Manager



SPORTON INTERNATIONAL INC.

No. 52, Hwa Ya 1st Rd., Hwa Ya Technology Park, Kwei-Shan Hsiang, Tao Yuan Hsien, Taiwan, R.O.C.



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Revision History

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
FA9N2716-01B	Rev. 01	Initial issue of report	Apr. 02, 2010



1. Statement of Compliance

The maximum result of Specific Absorption Rate (SAR) was found during testing for **ZTE CORPORATION EVDO WiMAX Dual Mode USB Modem ZTE U226**, which is as follows (with expanded uncertainty 21.4 % for 300 MHz to 3 GHz, and 25.6 % for 3 GHz to 6 GHz).

Band	Position	SAR_{1g} (W/kg)
802.16e	Body	0.714

They are in compliance with Specific Absorption Rate (SAR) for general population/uncontrolled exposure limits (1.6 W/kg) specified in FCC 47 CFR part 2 (2.1093) and ANSI/IEEE C95.1-1999, and had been tested in accordance with the measurement methods and procedures specified in IEEE 1528-2003 and FCC OET Bulletin 65 Supplement C (Edition 01-01).

2. Administration Data

2.1 Testing Laboratory

Test Site	SPORTON INTERNATIONAL INC.
Test Site Location	No. 52, Hwa Ya 1 st Rd., Hwa Ya Technology Park, Kwei-Shan Hsiang, Tao Yuan Hsien, Taiwan, R.O.C. TEL: +886-3-327-3456 FAX: +886-3-328-4978
Test Site No.	Sporton Site No. : SAR01-HY

2.2 Applicant

Company Name	ZTE CORPORATION
Address	ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan District, Shenzhen, Guangdong, 518057, P.R.China

2.3 Manufacturer

Company Name	ZTE CORPORATION
Address	ZTE Plaza, Keji Road South, Hi-Tech Industrial Park, Nanshan District, Shenzhen, Guangdong, 518057, P.R.China

2.4 Application Details

Date of Receipt of Application	Mar. 18, 2010
Date of Start during the Test	Mar. 22, 2010
Date of End during the Test	Mar. 23, 2010

3. General Information

3.1 Description of Device Under Test (DUT)

Product Feature & Specification	
DUT Type	EVDO WiMAX Dual Mode USB Modem
Brand Name	ZTE
Model Name	U226
FCC ID	Q78-ZTEAD226
Tx Frequency	2496 MHz ~ 2690 MHz
Rx Frequency	2496 MHz ~ 2690 MHz
Maximum Output Power to Antenna	BW 5M : 23.75 dBm BW 10M : 23.34 dBm
Antenna Type	Monopole Antenna
Type of Modulation	Uplink : OFDMA (QPSK / 16QAM)
DUT Stage	Identical Prototype

Remark: The above DUT's information was declared by manufacturer. Please refer to the specifications or user's manual for more detailed description.

3.2 Product Photos

Please refer to Appendix D.

3.3 Applied Standards

The Specific Absorption Rate (SAR) testing specification, method and procedure for this EVDO WiMAX Dual Mode USB Modem is in accordance with the following standards:

- FCC 47 CFR Part 2 (2.1093)
- IEEE C95.1-1999
- IEEE 1528-2003
- FCC OET Bulletin 65 Supplement C (Edition 01-01)
- FCC KDB 447498 D01 v04
- FCC KDB 447498 D02 v02
- FCC KDB 615223 D01 v01

3.4 Device Category and SAR Limits

This device belongs to portable device category because its radiating structure is allowed to be used within 20 centimeters of the body of the user. Limit for General Population/Uncontrolled exposure should be applied for this device, it is 1.6 W/kg as averaged over any 1 gram of tissue.

3.5 Test Conditions

3.5.1 Ambient Condition

Ambient Temperature	20 to 24 °C
Humidity	< 60 %

3.5.2 Test Configuration

The test device is a 2.6 GHz WiMax USB dongle transceiver using the BECEEM BCSM250 chipset. It provides one completed transmitter and two receivers. This dongle has two built-in antennas and it supports Tx antenna diversity function.

The device transmits using PUSC zone type only. The AMC, FUSC and other zone types are not used by this device for uplink transmissions. The maximum DL:UL (downlink-to-uplink) symbol ratio is determined according to the PUSC requirements. The system transmits an odd number of symbols using DL-PUSC, consisting of even multiples of traffic and control symbols, plus one symbol for the preamble. The device transmits in multiples of three symbols using UL-PUSC. The OFDMA symbol time allows up to 48 downlink and uplink symbols to be transmitted in each 5 ms frame. The system transmits on 5 ms frames using 5 MHz and 10 MHz channels. TTG and RTG are also included in each frame as DL/UL transmission gaps; therefore, the system can only allow 47 or less symbols per frame. The maximum DL:UL symbol ratio allowed for this device and determined according to these PUSC parameters is 29:18.

For PUSC zone type, the 10 MHz channel bandwidth uses 1024 sub-carriers and 35 sub-channels, with 184 spare/safeguard sub-carriers and 840 available for transmission, consisting of 560 data and 280 pilot sub-carriers. The 5 MHz channel bandwidth uses 512 sub-carriers and 17 sub-channels, with 104 spare/safeguard sub-carriers and 408 available for transmission, consisting 272 data and 136 pilot sub-carriers.

Control signals are transmitted in the first 3 symbols of each uplink burst. The rest of the uplink sub-frame contains normal traffic data bursts. The first 3 symbols are also used for ranging, which is shared with other users. During normal operation, the control symbols are transmitted at reduced power and the traffic symbols may transmit at maximum power. For SAR testing purposes, the configuration of control symbols is dependent on the test software and test equipment setup. The uplink allows a maximum of 15 traffic and 3 control symbols, 18 total, per frame. These conditions are applicable to both 5 and 10 MHz channel configurations used by this device.

The 802.16e/WiMAX device and system operating parameters is as below.

Description	Parameter		Comment
FCC ID	Q78-ZTEAD226		Identify all related FCC ID
Radio Service	Part 27 Subpart M		Rule parts
Transmit Frequency Range (MHz)	2496 MHz to 2690 MHz		System parameter
System/Channel Bandwidth (MHz)	5 MHz	10 MHz	System parameter
System Profile	Revision 1.7.0		Defined by WiMAX Forum
Modulation Schemes	QPSK, 16QAM		Identify all applicable UL modulations
Sampling Factor	28/25		System parameter
Sampling Frequency (MHz)	5.6 MHz	11.2 MHz	(F _s)
Sample Time (ns)	178.581 ns	89.3 ns	(1/F _s)
FFT Size (N _{FFT})	512	1024	(N _{FFT})
Sub-Carrier Spacing (kHz)	10.9375 kHz		(Δ f)
Useful Symbol Time (μs)	91.43 μs		(T _b =1/Δ f)
Guard Time (μs)	11.43 μs		(T _g =T _b /cp); cp = cyclic prefix
OFDMA Symbol Time (μs)	102.86 μs		(T _s =T _b +T _g)
Frame Size (ms)	5 ms		System parameter
TTG + RTG (μs or number of symbols)	165.7143 μs		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 Ratios	29:18		For determining UL duty factor
Power Class (dBm)	Power Class 2, 23±1 dBm		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 explanations on the types of control symbols and how the power levels are determined
Measured UL Burst Maximum Average Conducted Power	23.75 dBm	23.34 dBm	
UL Control Symbol Configuration	3 PUSC symbols (used for ranging, CQICH and ACK/NACK)		
UL Control Symbol Maximum Conducted Average Power	73.88 mW	35.88 mW	
UL Burst Peak-to-Average (Conducted) Power Ratio (PAPR)	PAPR is between 6.15 ~ 7.94 dB A Anritus wideband power meter was used to measure this item. Average, peak and PAPR are measured simultaneously. The test records please refer to section 11.1 of this report.		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 (%)	Theoretical duty cycle is 15 x 102.857 μs / 5000 μs = 30.86 %. Duty cycle was measured by a spectrum. The measured duty cycle is 31.4 % or 31.5 %. cf = 1/(duty cycle) = 3.18 or 3.17. These cf were used for SAR evaluation. The details please refer to section 3.5.2.		Show calculations separately and explain how the applicable CF (<i>crest factor</i>) used / to be use in the SAR measurements is derived and how the control symbols are accounted for

Time Vector Plots and Duty Cycle

The plot below shows the waveform characteristics of the signal used in the SAR measurement. The pulse duration corresponds to a DL:UL symbol ratio of 29:18 and control symbols are not active.

The time vector plots are shown as below. The plot A is used to get the frame length of test signal and the plot B is used to get the time of UL data symbols. Since there was no energy in the control symbols, the effective power is only across 15 data symbols. The calculation of duty cycle is as below:
Duty Cycle = 15 data symbols UL time / Frame Length x 100 %

The plots of time vector and calculation of duty cycle can be referred to appendix F. Summary table is shown as below.

Zone Type	Modulation	Coding Rate	Frequency (MHz)	Duty Cycle (%)
PUSC	16QAM (5M)	1/2	2498.5	31.4
PUSC	16QAM (5M)	1/2	2593.0	31.4
PUSC	16QAM (5M)	1/2	2687.5	31.4
PUSC	16QAM (10M)	1/2	2501.0	31.5
PUSC	16QAM (10M)	1/2	2593.0	31.4
PUSC	16QAM (10M)	1/2	2685.0	31.4
PUSC	16QAM (5M)	3/4	2498.5	31.4
PUSC	16QAM (5M)	3/4	2593.0	31.4
PUSC	16QAM (5M)	3/4	2687.5	31.4
PUSC	16QAM (10M)	3/4	2501.0	31.5
PUSC	16QAM (10M)	3/4	2593.0	31.4
PUSC	16QAM (10M)	3/4	2685.0	31.4
PUSC	QPSK (5M)	1/2	2498.5	31.4
PUSC	QPSK (5M)	1/2	2593.0	31.4
PUSC	QPSK (5M)	1/2	2687.5	31.4
PUSC	QPSK (10M)	1/2	2501.0	31.5
PUSC	QPSK (10M)	1/2	2593.0	31.4
PUSC	QPSK (10M)	1/2	2685.0	31.4
PUSC	QPSK (5M)	3/4	2498.5	31.4
PUSC	QPSK (5M)	3/4	2593.0	31.4
PUSC	QPSK (5M)	3/4	2687.5	31.4
PUSC	QPSK (10M)	3/4	2501.0	31.5
PUSC	QPSK (10M)	3/4	2593.0	31.4
PUSC	QPSK (10M)	3/4	2685.0	31.4

Note: Crest Factor = 1 / Duty Cycle.

**Test Software Details**

The test software, Beceem Diagnostic Control Panel (Version 3.4.0), is installed on a host laptop computer to configure the test device, a USB dongle, to transmit at maximum output power. For testing purposes, the device output power must be kept at its maximum using manufacturer supplied test software. The uplink transmission (signal characteristics) is maintained at a stable condition by the FCH, UL-MAP and DL-MAP information transmitted over the air from the signal generator. This enables the test device to transmit at maximum power with a constant duty factor according to the maximum DL:UL symbol ratio 29:18, using a specific modulation, zone type, sub-channel configuration and other operating requirements. The test software for this device serves only one purpose, to configure the test device to transmit at maximum power during the SAR measurements.

Signal Generator Details

A vector signal generator is used in conjunction with Beceem test software to configure the test device for the SAR measurements. A Agilent model N5182A MXG vector signal generator (VSG) is configured to transmit the downlink signals, containing the respective FCH, DL-MAP and UL-MAP required by the test device to configure the test device uplink transmissions. The waveform is configured for a DL:UL symbol ratio of 29:18, using the Beceem signal waveform software for 802.16 WiMax, on the laptop PC and downloaded to the VSG. The test device can synchronize itself to the signals received from the VSG, both in frequency and time. It then demodulates the DL-MAP and UL-MAP transmitted in each downlink sub-frame and determines the DL:UL symbol ratio (29:18). This downlink burst is repeated in each frame, every 5 ms, to simulate the transmission from a WiMax base station. The UL-MAP received by the device is used to configure the uplink burst with all data (traffic) symbols and sub-channels active.

No control channel transmissions are requested by the VSG. SAR measurement were taken in this configuration with the test device 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.

For FCC WiMAX SAR guidance, we got FCC approval under KDB 330078.

4. Specific Absorption Rate (SAR)

4.1 Introduction

SAR is related to the rate at which energy is absorbed per unit mass in an object exposed to a radio field. The SAR distribution in a biological body is complicated and is usually carried out by experimental techniques or numerical modeling. The standard recommends limits for two tiers of groups, occupational/controlled and general population/uncontrolled, based on a person's awareness and ability to exercise control over his or her exposure. In general, occupational/controlled exposure limits are higher than the limits for general population/uncontrolled.

4.2 SAR Definition

The SAR definition is the time derivative (rate) of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dv) of a given density (ρ). The equation description is as below:

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

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

SAR measurement can be either related to the temperature elevation in tissue by

$$SAR = C \left(\frac{\delta T}{\delta t} \right)$$

Where: C is the specific heat capacity, δT is the temperature rise and δt is the exposure duration, or related to the electrical field in the tissue by

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

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

However for evaluating SAR of low power transmitter, electrical field measurement is typically applied.

5. SAR Measurement System

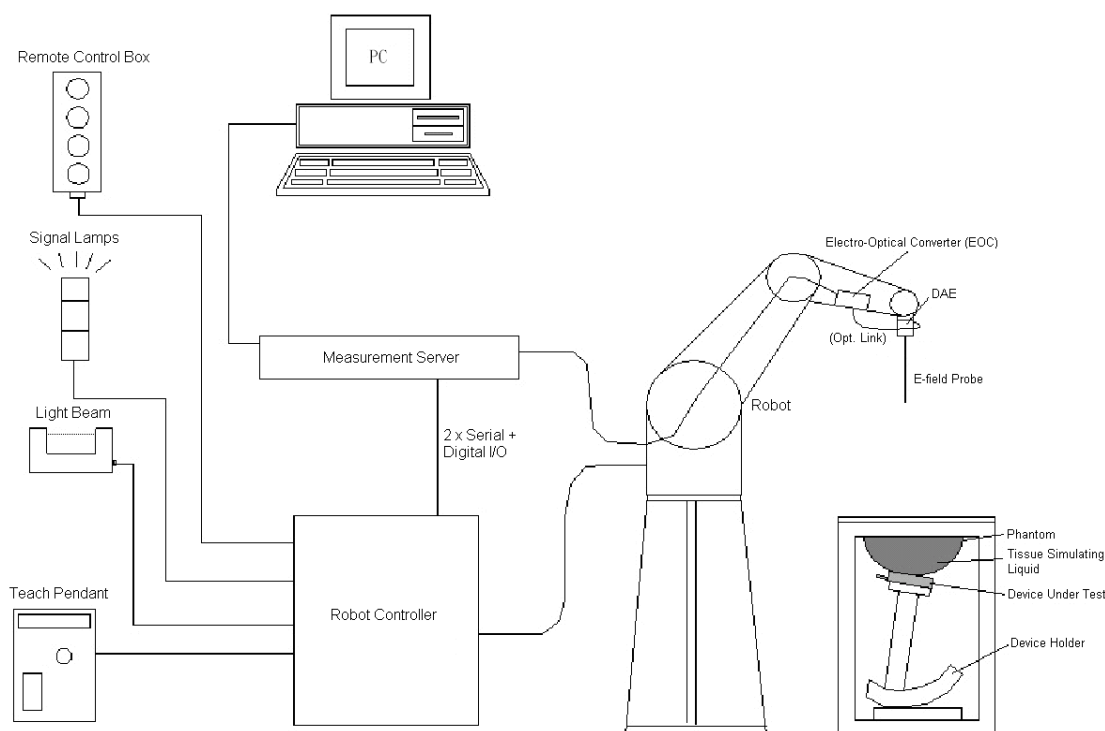


Fig 5.1 SPEAG DASY4 or DASY5 System Configurations

The DASY4 or DASY5 system for performance compliance tests is illustrated above graphically. This system consists of the following items:

- A standard high precision 6-axis robot with controller, a teach pendant and software
- A data acquisition electronic (DAE) attached to the robot arm extension
- A dosimetric probe equipped with an optical surface detector system
- The electro-optical converter (ECO) performs the conversion between optical and electrical signals
- A measurement server performs the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- A probe alignment unit which improves the accuracy of the probe positioning
- A computer operating Windows XP
- DASY4 or DASY5 software
- Remote control with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
- The SAM twin phantom
- A device holder
- Tissue simulating liquid
- Dipole for evaluating the proper functioning of the system

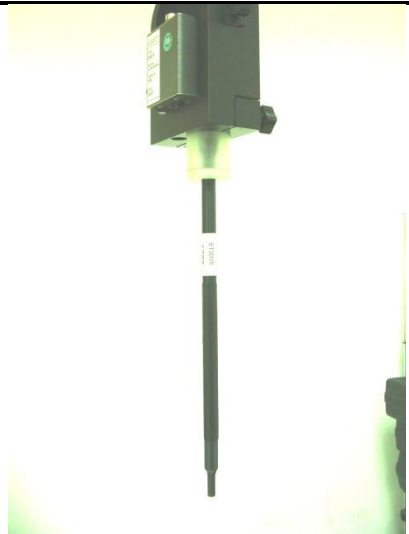
Some of the components are described in details in the following sub-sections.

5.1 E-Field Probe

The SAR measurement is conducted with the dosimetric probe (manufactured by SPEAG). The probe is specially designed and calibrated for use in liquid with high permittivity. The dosimetric probe has special calibration in liquid at different frequency. This probe has a built in optical surface detection system to prevent from collision with phantom.

5.1.1 E-Field Probe Specification

<ET3DV6>

Construction	Symmetrical design with triangular core Built-in optical fiber for surface detection system. Built-in shielding against static charges. PEEK enclosure material (resistant to organic solvents, e.g., DGBE)	 Fig 5.2 Photo of ET3DV6
Frequency	10 MHz to 3 GHz; Linearity: ± 0.2 dB	
Directivity	± 0.2 dB in HSL (rotation around probe axis) ± 0.4 dB in HSL (rotation normal to probe axis)	
Dynamic Range	5 μ W/g to 100 mW/g; Linearity: ± 0.2 dB	
Dimensions	Overall length: 330 mm (Tip: 16 mm) Tip diameter: 6.8 mm (Body: 12 mm) Distance from probe tip to dipole centers: 2.7 mm	

<EX3DV3 Probe>

Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)	 Fig 5.3 Photo of EX3DV3
Frequency	10 MHz to 6 GHz; Linearity: ± 0.2 dB	
Directivity	± 0.3 dB in HSL (rotation around probe axis) ± 0.5 dB in tissue material (rotation normal to probe axis)	
Dynamic Range	10 μ W/g to 100 mW/g; Linearity: ± 0.2 dB (noise: typically < 1 μ W/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	

5.1.2 E-Field Probe Calibration

Each probe needs to be calibrated according to a dosimetric assessment procedure with accuracy better than $\pm 10\%$. The spherical isotropy shall be evaluated and within ± 0.25 dB. The sensitivity parameters (NormX, NormY, and NormZ), the diode compression parameter (DCP) and the conversion factor (ConvF) of the probe are tested. The calibration data can be referred to appendix C of this report.

5.2 Data Acquisition Electronics (DAE)

The data acquisition electronics (DAE) 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 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 input impedance of the DAE is 200 MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.



Fig 5.4 Photo of DAE

5.3 Robot

The SPEAG DASY system uses the high precision robots (DASY4: RX90BL; DASY5: TX90XL) type from Stäubli SA (France). For the 6-axis controller system, the robot controller version (DASY4: CS7MB; DASY5: CS8c) from Stäubli is used. The Stäubli robot series have many features that are important for our application:

- High precision (repeatability ± 0.035 mm)
- High reliability (industrial design)
- Jerk-free straight movements
- Low ELF interference (the closed metallic construction shields against motor control fields)



Fig 5.5 Photo of DASY4



Fig 5.6 Photo of DASY5

5.4 Measurement Server

The measurement server is based on a PC/104 CPU board with CPU (DASY4: 166 MHz, Intel Pentium; DASY5: 400 MHz, Intel Celeron), chipdisk (DASY4: 32 MB; DASY5: 128 MB), RAM (DASY4: 64 MB, DASY5: 128 MB). The necessary circuits for communication with the DAE electronic box, as well as the 16 bit AD converter system for optical detection and digital I/O interface are contained on the DASY I/O board, which is directly connected to the PC/104 bus of the CPU board.

The measurement server performs all the real-time data evaluation for field measurements and surface detection, controls robot movements and handles safety operations.



Fig 5.7 Photo of Server for DASY4



Fig 5.8 Photo of Server for DASY5

5.5 Phantom

<SAM Twin Phantom>

Shell Thickness	2 ± 0.2 mm; Center ear point: 6 ± 0.2 mm
Filling Volume	Approx. 25 liters
Dimensions	Length: 1000 mm; Width: 500 mm; Height: adjustable feet
Measurement Areas	Left Hand, Right Hand, Flat Phantom

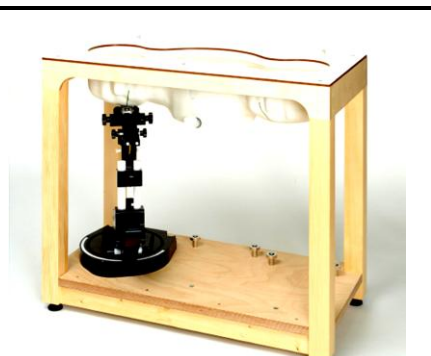


Fig 5.9 Photo of SAM Phantom

The bottom plate contains three pair of bolts for locking the device holder. The device holder positions are adjusted to the standard measurement positions in the three sections. A white cover is provided to tap the phantom during off-periods to prevent water evaporation and changes in the liquid parameters. On the phantom top, three reference markers are provided to identify the phantom position with respect to the robot.

<ELI4 Phantom>

Shell Thickness	2 ± 0.2 mm (sagging: <1%)
Filling Volume	Approx. 30 liters
Dimensions	Major ellipse axis: 600 mm Minor axis: 400 mm



Fig 5.10 Photo of ELI4 Phantom

The ELI4 phantom is intended for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI4 is fully compatible with standard and all known tissue simulating liquids.

5.6 Device Holder

<Device Holder for SAM Twin Phantom>

The SAR in the phantom is approximately inversely proportional to the square of the distance between the source and the liquid surface. For a source at 5 mm distance, a positioning uncertainty of ± 0.5 mm would produce a SAR uncertainty of ± 20 %. Accurate device positioning is therefore crucial for accurate and repeatable measurements. The positions in which the devices must be measured are defined by the standards.

The DASY device holder 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 center for both scales is the ear reference point (EPR). Thus the device needs no repositioning when changing the angles.

The DASY device holder is constructed of low-loss POM material having the following dielectric parameters: relative permittivity $\epsilon = 3$ and loss tangent $\delta = 0.02$. 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.



Fig 5.11 Device Holder

<Laptop Extension Kit>

The extension is lightweight and made of POM, acrylic glass and foam. It fits easily on the upper part of the mounting device in place of the phone positioned. The extension is fully compatible with the SAM Twin and ELI phantoms.

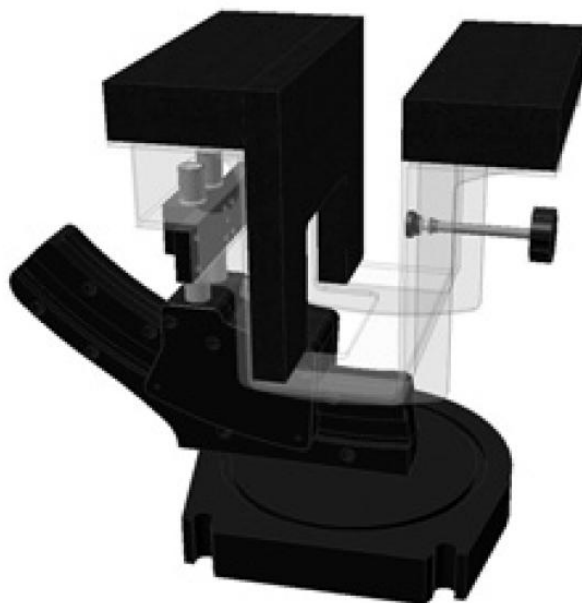


Fig 5.12 Laptop Extension Kit

5.7 Data Storage and Evaluation

5.7.1 Data Storage

The DASY software stores the assessed data from the data acquisition electronics as raw data (in microvolt readings from the probe sensors), together with all the necessary software parameters for the data evaluation (probe calibration data, liquid parameters and device frequency and modulation data) in measurement files. The post-processing software evaluates the desired unit and format for output each time the data is visualized or exported. This allows verification of the complete software setup even after the measurement and allows correction of erroneous parameter settings. For example, if a measurement has been performed with an incorrect crest factor parameter in the device setup, the parameter can be corrected afterwards and the data can be reevaluated.

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

5.7.2 Data Evaluation

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

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

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

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

The formula for each channel can be given as :

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

with V_i = compensated signal of channel i, (i = x, y, z)
 U_i = input signal of channel i, (i = x, y, z)
 cf = crest factor of exciting field (DASY parameter)
 dcp_i = diode compression point (DASY parameter)

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

$$\text{E-field Probes : } E_i = \sqrt{\frac{V_i}{\text{Norm}_i \cdot \text{ConvF}}}$$

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

with V_i = compensated signal of channel i, (i = x, y, z)
 Norm_i = sensor sensitivity of channel i, (i = x, y, z), $\mu\text{V}/(\text{V/m})^2$ for E-field Probes
 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) :

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

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

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

with SAR = local specific absorption rate in mW/g
 E_{tot} = total field strength in V/m
 σ = conductivity in [mho/m] or [Siemens/m]
 ρ = equivalent tissue density in g/cm^3

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

5.8 Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	Dosimetric E-Field Probe	ET3DV6	1787	May 26, 2009	May 25, 2010
SPEAG	Dosimetric E-Field Probe	ET3DV6	1788	Sep. 23, 2009	Sep. 22, 2010
SPEAG	Dosimetric E-Field Probe	EX3DV3	3514	Jan. 26, 2010	Jan. 25, 2011
SPEAG	835MHz System Validation Kit	D835V2	499	Mar. 17, 2008	Mar. 16, 2010
SPEAG	900MHz System Validation Kit	D900V2	190	Jul. 21, 2009	Jul. 20, 2011
SPEAG	1800MHz System Validation Kit	D1800V2	2d076	Jul. 20, 2009	Jul. 19, 2011
SPEAG	1900MHz System Validation Kit	D1900V2	5d041	Mar. 28, 2008	Mar. 27, 2010
SPEAG	2000MHz System Validation Kit	D2000V2	1010	Sep. 17, 2008	Sep. 16, 2010
SPEAG	2300MHz System Validation Kit	D2300V2	1006	Sep. 24, 2009	Sep. 23, 2011
SPEAG	2450MHz System Validation Kit	D2450V2	736	Jul. 20, 2009	Jul. 19, 2011
SPEAG	2600MHz System Validation Kit	D2600V2	1008	Sep. 24, 2009	Sep. 23, 2011
SPEAG	3500MHz System Validation Kit	D3500V2	1014	Sep. 17, 2009	Sep. 16, 2011
SPEAG	5GHz System Validation Kit	D5GHzV2	1006	Jan. 24, 2008	Jan. 23, 2010
SPEAG	Data Acquisition Electronics	DAE3	577	Aug. 24, 2009	Aug. 23, 2010
SPEAG	Data Acquisition Electronics	DAE4	778	Sep. 18, 2009	Sep. 17, 2010
SPEAG	Device Holder	N/A	N/A	NCR	NCR
SPEAG	SAM Phantom	QD 000 P40 C	TP-1303	NCR	NCR
SPEAG	SAM Phantom	QD 000 P40 C	TP-1383	NCR	NCR
SPEAG	SAM Phantom	QD 000 P40 C	TP-1446	NCR	NCR
SPEAG	SAM Phantom	QD 000 P40 C	TP-1477	NCR	NCR
SPEAG	ELI4 Phantom	QD 0VA 001 BB	1026	NCR	NCR
SPEAG	ELI4 Phantom	QD 0VA 001 BA	1029	NCR	NCR
Agilent	PNA Series Network Analyzer	E8358A	US40260131	Apr. 17, 2009	Apr. 16, 2010
Agilent	Wireless Communication Test Set	E5515C	MY48360820	Dec. 15, 2008	Dec. 14, 2010
Agilent	Wireless Communication Test Set	E5515C	GB46311322	Feb. 16, 2009	Feb. 15, 2011
R&S	Universal Radio Communication Tester	CMU200	108082	Jun. 08, 2009	Jun. 07, 2010
VSG	Agilent	E4438C	MY49070423	Oct. 29, 2009	Oct. 28, 2011
Agilent	Dielectric Probe Kit	85070D	US01440205	NCR	NCR
Agilent	Dual Directional Coupler	778D	50422	NCR	NCR
AR	Power Amplifier	5S1G4M2	0328767	NCR	NCR
R&S	Spectrum Analyzer	FSP7	101131	Mar. 17, 2009	Mar. 16, 2010
Agilent	VSG (System Simulator)	E4438C	MY49070423	Oct. 29, 2009	Oct. 28, 2011
Anritsu	Power Meter	ML2495A	0932001	Sep. 17, 2009	Sep. 16, 2010
Anritsu	Power Sensor	MA2411B	0846202	Sep. 10, 2009	Sep. 09, 2010

Table 5.1 Test Equipment List

Note: The calibration certificate of DASY can be referred to appendix C of this report.

6. Tissue Simulating Liquids

For the measurement of the field distribution inside the SAM phantom with DASY, the phantom must be filled with around 25 liters of homogeneous body tissue simulating liquid. For head SAR testing, the liquid height from the ear reference point (ERP) of the phantom to the liquid top surface is larger than 15 cm, which is shown in Fig. 6.1. For body SAR testing, the liquid height from the center of the flat phantom to the liquid top surface is larger than 15 cm, which is shown in Fig. 6.2.

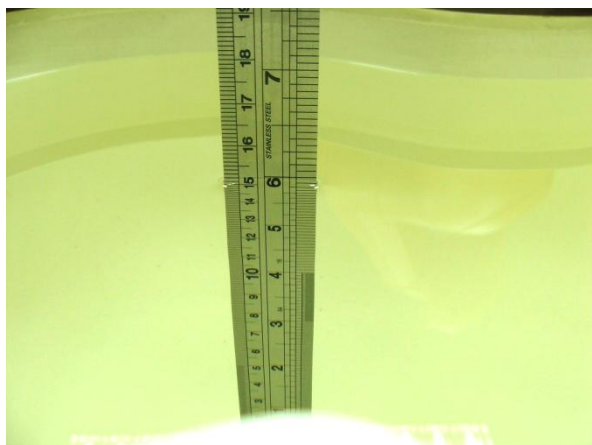


Fig 6.1 Photo of Liquid Height for Head SAR



Fig 6.2 Photo of Liquid Height for Body SAR

The following table gives the targets for tissue simulating liquid.

Frequency (MHz)	Liquid Type	Conductivity (σ)	$\pm 5\%$ Range	Permittivity (ϵ_r)	$\pm 5\%$ Range
2450	Body	1.95	1.85 ~ 2.05	52.7	50.1 ~ 55.3
2600	Body	2.16	2.05 ~ 2.27	52.5	49.9 ~ 55.1

Table 6.1 Targets of Tissue Simulating Liquid

The dielectric parameters of the liquids were verified prior to the SAR evaluation using an Agilent 85070D Dielectric Probe Kit and an Agilent Network Analyzer.

The following table shows the measuring results for simulating liquid.

Frequency (MHz)	Liquid Type	Temperature ($^{\circ}\text{C}$)	Conductivity (σ)	Permittivity (ϵ_r)	Measurement Date
2450	Body	21.6	1.92	53.2	Mar. 22, 2010
2600	Body	21.5	2.21	51.1	Mar. 22, 2010
2600	Body	21.4	2.17	53.8	Mar. 23, 2010

Table 6.2 Measuring Results for Simulating Liquid

7. Uncertainty Assessment

The component of uncertainty may generally be categorized according to the methods used to evaluate them. The evaluation of uncertainty by the statistical analysis of a series of observations is termed a Type A evaluation of uncertainty. The evaluation of uncertainty by means other than the statistical analysis of a series of observation is termed a Type B evaluation of uncertainty. Each component of uncertainty, however evaluated, is represented by an estimated standard deviation, termed standard uncertainty, which is determined by the positive square root of the estimated variance.

A Type A evaluation of standard uncertainty may be based on any valid statistical method for treating data. This includes calculating the standard deviation of the mean of a series of independent observations; using the method of least squares to fit a curve to the data in order to estimate the parameter of the curve and their standard deviations; or carrying out an analysis of variance in order to identify and quantify random effects in certain kinds of measurement.

A type B evaluation of standard uncertainty is typically based on scientific judgment using all of the relevant information available. These may include previous measurement data, experience and knowledge of the behavior and properties of relevant materials and instruments, manufacture's specification, data provided in calibration reports and uncertainties assigned to reference data taken from handbooks. Broadly speaking, the uncertainty is either obtained from an outdoor source or obtained from an assumed distribution, such as the normal distribution, rectangular or triangular distributions indicated in Table 7.1

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

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

(b) k is the coverage factor

Table 7.1 Standard Uncertainty for Assumed Distribution

The combined standard uncertainty of the measurement result represents the estimated standard deviation of the result. It is obtained by combining the individual standard uncertainties of both Type A and Type B evaluation using the usual "root-sum-squares" (RSS) methods of combining standard deviations by taking the positive square root of the estimated variances.

Expanded uncertainty is a measure of uncertainty that defines an interval about the measurement result within which the measured value is confidently believed to lie. It is obtained by multiplying the combined standard uncertainty by a coverage factor. Typically, the coverage factor ranges from 2 to 3. Using a coverage factor allows the true value of a measured quantity to be specified with a defined probability within the specified uncertainty range. For purpose of this document, a coverage factor two is used, which corresponds to confidence interval of about 95 %. The DASY uncertainty Budget is showed in Table 7.2 and Table 7.3.

Error Description	Uncertainty Value (±%)	Probability Distribution	Divisor	Ci (1g)	Standard Uncertainty (1g)
Measurement System					
Probe Calibration	5.5	Normal	1	1	± 5.5 %
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 %
Linearity	4.7	Rectangular	√3	1	± 2.7 %
System Detection Limits	1.0	Rectangular	√3	1	± 0.6 %
Readout Electronics	0.3	Normal	1	1	± 0.3 %
Response Time	0.8	Rectangular	√3	1	± 0.5 %
Integration Time	2.6	Rectangular	√3	1	± 1.5 %
RF Ambient Noise	3.0	Rectangular	√3	1	± 1.7 %
RF Ambient Reflections	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 %
Max. SAR Eval.	1.0	Rectangular	√3	1	± 0.6 %
Test Sample Related					
Device Positioning	2.9	Normal	1	1	± 2.9 %
Device Holder	3.6	Normal	1	1	± 3.6 %
Power Drift	5.0	Rectangular	√3	1	± 2.9 %
Phantom and Setup					
Phantom Uncertainty	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					± 10.7 %
Coverage Factor for 95 %					K = 2
Expanded Uncertainty					± 21.4 %

Table 7.2 Uncertainty Budget of DASY for frequency range 300 MHz to 3 GHz

Error Description	Uncertainty Value (±%)	Probability Distribution	Divisor	Ci (1g)	Standard Uncertainty (1g)
Measurement System					
Probe Calibration	6.55	Normal	1	1	± 6.55 %
Axial Isotropy	4.7	Rectangular	√3	0.7	± 1.9 %
Hemispherical Isotropy	9.6	Rectangular	√3	0.7	± 3.9 %
Boundary Effects	2.0	Rectangular	√3	1	± 1.2 %
Linearity	4.7	Rectangular	√3	1	± 2.7 %
System Detection Limits	1.0	Rectangular	√3	1	± 0.6 %
Readout Electronics	0.3	Normal	1	1	± 0.3 %
Response Time	0.8	Rectangular	√3	1	± 0.5 %
Integration Time	2.6	Rectangular	√3	1	± 1.5 %
RF Ambient Noise	3.0	Rectangular	√3	1	± 1.7 %
RF Ambient Reflections	3.0	Rectangular	√3	1	± 1.7 %
Probe Positioner	0.8	Rectangular	√3	1	± 0.5 %
Probe Positioning	9.9	Rectangular	√3	1	± 5.7 %
Max. SAR Eval.	4.0	Rectangular	√3	1	± 2.3 %
Test Sample Related					
Device Positioning	2.9	Normal	1	1	± 2.9 %
Device Holder	3.6	Normal	1	1	± 3.6 %
Power Drift	5.0	Rectangular	√3	1	± 2.9 %
Phantom and Setup					
Phantom Uncertainty	4.0	Rectangular	√3	1	± 2.3 %
Liquid Conductivity (Target)	5.0	Rectangular	√3	0.43	± 1.8 %
Liquid Conductivity (Meas.)	2.5	Normal	1	0.43	± 1.6 %
Liquid Permittivity (Target)	5.0	Rectangular	√3	0.49	± 1.7 %
Liquid Permittivity (Meas.)	2.5	Normal	1	0.49	± 1.5 %
Combined Standard Uncertainty					± 12.8 %
Coverage Factor for 95 %					K = 2
Expanded Uncertainty					± 25.6 %

Table 7.3 Uncertainty Budget of DASY for frequency range 3 GHz to 6 GHz

8. SAR Measurement Evaluation

Each DASY system is equipped with one or more system validation kits. These units, together with the predefined measurement procedures within the DASY software, enable the user to conduct the system performance check and system validation. System validation kit includes a dipole, tripod holder to fix it underneath the flat phantom and a corresponding distance holder.

8.1 Purpose of System Performance check

The system performance check verifies that the system operates within its specifications. System and operator errors can be detected and corrected. It is recommended that the system performance check be performed prior to any usage of the system in order to guarantee reproducible results. The system performance check uses normal SAR measurements in a simplified setup with a well characterized source. This setup was selected to give a high sensitivity to all parameters that might fail or vary over time. The system check does not intend to replace the calibration of the components, but indicates situations where the system uncertainty is exceeded due to drift or failure.

8.2 System Setup

In the simplified setup for system evaluation, the DUT is replaced by a calibrated dipole and the power source is replaced by a continuous wave that comes from a signal generator. The calibrated dipole must be placed beneath the flat phantom section of the SAM twin phantom with the correct distance holder. The distance holder should touch the phantom surface with a light pressure at the reference marking and be oriented parallel to the long side of the phantom. The equipment setup is shown below:

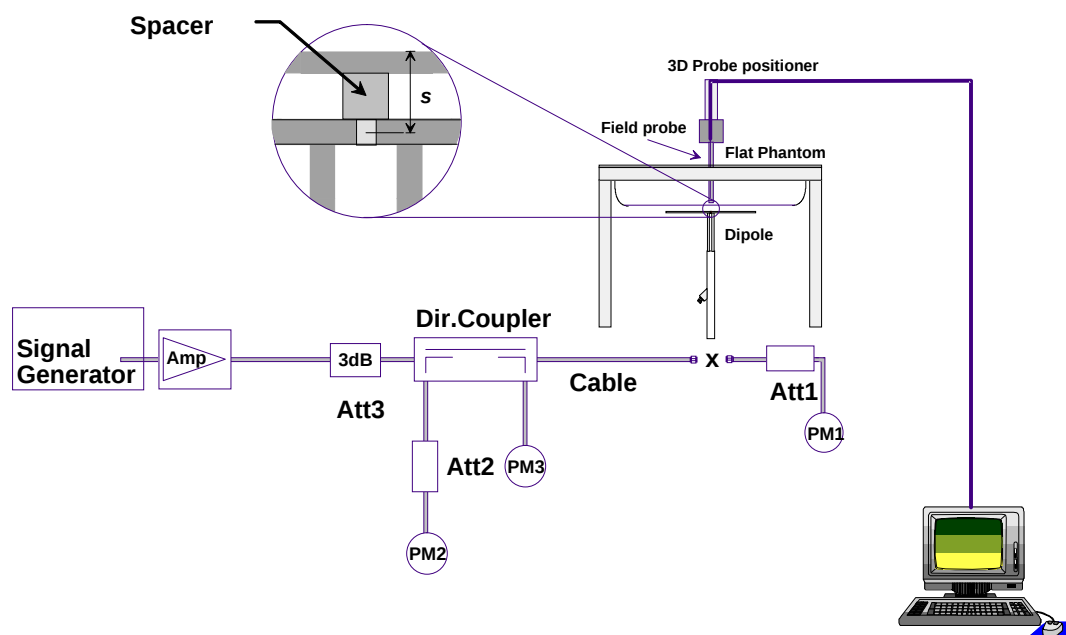


Fig 8.1 System Setup for System Evaluation

1. Signal Generator
2. Amplifier
3. Directional Coupler
4. Power Meter
5. Calibrated Dipole

The output power on dipole port must be calibrated to 20 dBm (100 mW) before dipole is connected.



Fig 8.2 Photo of Dipole Setup

8.3 Validation Results

Comparing to the original SAR value provided by SPEAG, the validation data should be within its specification of 10 %. Table 8.1 shows the target SAR and measured SAR after normalized to 1W input power. The table below indicates the system performance check can meet the variation criterion and the plots can be referred to Appendix A of this report.

Measurement Date	Frequency (MHz)	Targeted SAR _{1g} (W/kg)	Measured SAR _{1g} (W/kg)	Deviation (%)
Mar. 22, 2010	2450	53.00	50.70	-4.34
Mar. 22, 2010	2600	57.90	57.10	-1.38
Mar. 23, 2010	2600	57.90	55.90	-3.45

Table 8.1 Target and Measurement SAR after Normalized

9. DUT Testing Position

This DUT was tested in four different USB configurations and tip mode. They are “direct laptop plug-in for configuration 1 and 4”, “USB cable plug-in for configuration 2 and 3”, and “direct laptop plug-in the tip mode of the DUT”, shown as below. Both direct laptop plug-in and USB cable plug-in test configurations are tested with 5 mm separation between the particular dongle orientation and the flat phantom.

Please refer to Appendix E for the test setup photos.

			
Configuration 1 (Horizontal Up)	Configuration 2 (Horizontal Down)	Configuration 3 (Vertical Front)	Configuration 4 (Vertical Back)

Fig 9.1 Illustration for USB Connector Orientations

10. Measurement Procedures

The measurement procedures are as follows:

- (a) Use engineering software to transmit RF power continuously (continuous Tx) in the middle channel
- (b) Measure output power through RF cable and power meter
- (c) Place the DUT in the positions described in the last section
- (d) Set scan area, grid size and other setting on the DASY software
- (e) Taking data for the middle channel on each testing position
- (f) Find out the largest SAR result on these testing positions of each band
- (g) Measure SAR results for the lowest and highest channels in worst SAR testing position

According to the test standard, the recommended procedure for assessing the peak spatial-average SAR value consists of the following steps:

- (a) Power reference measurement
- (b) Area scan
- (c) Zoom scan
- (d) Power drift measurement

10.1 Spatial Peak SAR Evaluation

The procedure for spatial peak SAR evaluation has been implemented according to the test standard. It can be conducted for 1g and 10g, as well as for user-specific masses. The DASY software includes all numerical procedures necessary to evaluate the spatial peak SAR value.

The base for the evaluation is a "cube" measurement. The measured volume must include the 1g and 10g cubes with the highest averaged SAR values. For that purpose, the center of the measured volume is aligned to the interpolated peak SAR value of a previously performed area scan.

The entire evaluation of the spatial peak values is performed within the post-processing engine (SEMCAD). The system always gives the maximum values for the 1g and 10g cubes. The algorithm to find the cube with highest averaged SAR is divided into the following stages:

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

10.2 Scan Procedures

First Area Scan is used to locate the approximate location(s) of the local peak SAR value(s). The measurement grid within an Area Scan is defined by the grid extent, grid step size and grid offset. Next, in order to determine the EM field distribution in a three-dimensional spatial extension, Zoom Scan is required. The Zoom Scan measures 5x5x7 points with step size 8, 8 and 5 mm for 300 MHz to 3 GHz, and 8x8x8 points with step size 4.3, 4.3 and 3 mm for 3 GHz to 6 GHz. The Zoom Scan is performed around the highest E-field value to determine the averaged SAR-distribution over 10 g.

10.3 SAR Averaged Methods

In DASY, the interpolation and extrapolation are both based on the modified Quadratic Shepard's method. The interpolation scheme combines a least-square fitted function method and a weighted average method which are the two basic types of computational interpolation and approximation.

Extrapolation routines are used to obtain SAR values between the lowest measurement points and the inner phantom surface. The extrapolation distance is determined by the surface detection distance and the probe sensor offset. The uncertainty increases with the extrapolation distance. To keep the uncertainty within 1% for the 1 g and 10 g cubes, the extrapolation distance should not be larger than 5 mm.

11. SAR Test Results

11.1 Conducted Power (Unit: dBm)

Zone Type	Modulation	Coding Rate	Frequency	Main Antenna			Aux. Antenna		
				Peak Power	Average Power	PAPR	Peak Power	Average Power	PAPR
PUSC	QPSK (BW 5MHz)	1/2	2498.5	30.84	23.32	7.52	30.74	23.22	7.52
			2593.0	30.45	23.60	6.85	30.42	23.23	7.19
			2687.5	29.92	23.75	6.17	29.75	23.54	6.21
		3/4	2498.5	30.66	23.17	7.49	30.57	23.28	7.29
			2593.0	30.37	23.55	6.82	30.40	23.29	7.11
			2687.5	29.75	23.53	6.22	29.91	23.73	6.18
	16QAM (BW 5MHz)	1/2	2498.5	30.71	23.19	7.52	30.74	23.22	7.52
			2593.0	30.36	23.55	6.81	30.47	23.33	7.14
			2687.5	29.79	23.64	6.15	29.85	23.63	6.22
		3/4	2498.5	30.57	23.16	7.41	30.71	23.22	7.49
			2593.0	30.34	23.55	6.79	30.37	23.24	7.13
			2687.5	29.78	23.54	6.24	29.87	23.65	6.22
	QPSK (BW 10MHz)	1/2	2501.0	30.51	22.85	7.66	30.47	22.91	7.56
			2593.0	30.39	23.13	7.26	30.23	22.88	7.35
			2685.0	29.97	23.20	6.77	29.75	22.99	6.76
		3/4	2501.0	30.59	22.86	7.73	30.60	22.79	7.81
			2593.0	30.42	22.96	7.46	30.13	22.67	7.46
			2685.0	29.70	23.34	6.36	30.02	23.29	6.73
	16QAM (BW 10MHz)	1/2	2501.0	30.53	22.67	7.86	30.37	22.73	7.64
			2593.0	30.29	23.00	7.29	30.15	22.65	7.50
			2685.0	29.75	23.04	6.71	29.84	23.11	6.73
		3/4	2501.0	30.60	22.66	7.94	30.40	22.68	7.72
			2593.0	30.32	23.02	7.30	30.27	22.68	7.59
			2685.0	29.78	23.05	6.73	29.91	23.11	6.80

11.2 SAR Test Reduction Proposal

For WiMAX SAR test reduction, we got the FCC approval under KDB 432358. The test reduction steps are as below.

Step 1 : Find the Maximum Power Channel

An Anritus wideband power meter was used for measuring the conducted power.

Zone Type	Modulation	Coding Rate	Frequency (MHz)	Average Power (dBm)	
				Main Antenna	Aux. Antenna
PUSC	QPSK (BW 5MHz)	1/2	2498.5	23.32	23.22
			2593.0	23.60	23.23
			2687.5	23.75	23.54
	16QAM (BW 5MHz)	3/4	2498.5	23.17	23.28
			2593.0	23.55	23.29
			2687.5	23.53	23.73
		1/2	2498.5	23.19	23.22
			2593.0	23.55	23.33
			2687.5	23.64	23.63
	QPSK (BW 10MHz)	3/4	2498.5	23.16	23.22
			2593.0	23.55	23.24
			2687.5	23.54	23.65
		1/2	2501.0	22.85	22.91
			2593.0	23.13	22.88
			2685.0	23.20	22.99
	16QAM (BW 10MHz)	3/4	2501.0	22.86	22.79
			2593.0	22.96	22.67
			2685.0	23.34	23.29
		1/2	2501.0	22.67	22.73
			2593.0	23.00	22.65
			2685.0	23.04	23.11
		3/4	2501.0	22.66	22.68
			2593.0	23.02	22.68
			2685.0	23.05	23.11

According to above table, the above channel is marked which will be used for SAR pre-test.

Step 2 : Find the Worst Mode

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

Test SAR with maximum power channel of last step. The test results are listed as below:

Zone Type	Modulation	Coding Rate	Frequency (MHz)	Test Position	Antenna	SAR _{1g} (W/kg)
PUSC	QPSK (5M)	1/2	2687.5	Horizontal Up	Main	0.379
	QPSK (10M)	3/4	2685	Horizontal Up	Main	0.316

According to above table, worst mode is QPSK(5M)/high Channel. Therefore, this mode will be used to find out the worst position.

Step 3 : Find the Worst Position

This step is to assess which position and antenna produce higher SAR value.

Zone Type	Modulation	Coding Rate	Frequency (MHz)	Test Position	Antenna	SAR _{1g} (W/kg)
PUSC	QPSK (5M)	1/2	2687.5	Horizontal Up	Main	0.379
PUSC	QPSK (5M)	1/2	2687.5	Horizontal Up	Aux	0.478
PUSC	QPSK (5M)	1/2	2687.5	Horizontal Down	Main	0.252
PUSC	QPSK (5M)	1/2	2687.5	Horizontal Down	Aux	0.448
PUSC	QPSK (5M)	1/2	2687.5	Vertical Front	Main	0.351
PUSC	QPSK (5M)	1/2	2687.5	Vertical Front	Aux	0.077
PUSC	QPSK (5M)	1/2	2687.5	Vertical Back	Main	0.046
PUSC	QPSK (5M)	1/2	2687.5	Vertical Back	Aux	0.396
PUSC	QPSK (5M)	1/2	2687.5	Tip	Main	0.068
PUSC	QPSK (5M)	1/2	2687.5	Tip	Aux	0.133

According to above table, worst position is Horizontal-Up and worst antenna is Aux antenna. Therefore, this position and Aux antenna will be used to find out the worst SAR.

Step 4 : Find the Worst Measured SAR

This step is to find out the worst SAR value.

Use test software to transmit highest available power to test lowest, middle and highest channels for each modulation and bandwidth with the worst position and worst antenna. The test results are listed as below:

Zone Type	Modulation	Coding Rate	Frequency (MHz)	Test Position	Antenna	SAR _{1g} (W/kg)
PUSC	16QAM (5M)	1/2	2498.5	Horizontal Up	Aux	0.401
PUSC	16QAM (5M)	1/2	2593.0	Horizontal Up	Aux	0.438
PUSC	16QAM (5M)	1/2	2687.5	Horizontal Up	Aux	0.579
PUSC	16QAM (10M)	1/2	2501.0	Horizontal Up	Aux	0.371
PUSC	16QAM (10M)	1/2	2593.0	Horizontal Up	Aux	0.418
PUSC	16QAM (10M)	1/2	2685.0	Horizontal Up	Aux	0.485
PUSC	16QAM (5M)	3/4	2498.5	Horizontal Up	Aux	0.414
PUSC	16QAM (5M)	3/4	2593.0	Horizontal Up	Aux	0.509
PUSC	16QAM (5M)	3/4	2687.5	Horizontal Up	Aux	0.577
PUSC	16QAM (10M)	3/4	2501.0	Horizontal Up	Aux	0.42
PUSC	16QAM (10M)	3/4	2593.0	Horizontal Up	Aux	0.457
PUSC	16QAM (10M)	3/4	2685.0	Horizontal Up	Aux	0.558
PUSC	QPSK (5M)	1/2	2498.5	Horizontal Up	Aux	0.462
PUSC	QPSK (5M)	1/2	2593.0	Horizontal Up	Aux	0.475
PUSC	QPSK (5M)	1/2	2687.5	Horizontal Up	Aux	0.478
PUSC	QPSK (10M)	1/2	2501.0	Horizontal Up	Aux	0.368
PUSC	QPSK (10M)	1/2	2593.0	Horizontal Up	Aux	0.455
PUSC	QPSK (10M)	1/2	2685.0	Horizontal Up	Aux	0.467
PUSC	QPSK (5M)	3/4	2498.5	Horizontal Up	Aux	0.488
PUSC	QPSK (5M)	3/4	2593.0	Horizontal Up	Aux	0.484
PUSC	QPSK (5M)	3/4	2687.5	Horizontal Up	Aux	0.549
PUSC	QPSK (10M)	3/4	2501.0	Horizontal Up	Aux	0.365
PUSC	QPSK (10M)	3/4	2593.0	Horizontal Up	Aux	0.5
PUSC	QPSK (10M)	3/4	2685.0	Horizontal Up	Aux	0.474

As concluded above, 0.579 W/kg is worst SAR for measurement.

Step 5 : Scaling Factor Deriving

The testing was done at DL:UL symbol ratio, 29:18 as this is the maximum achievable ratio for the product. The 18 indicates the number of uplink symbols. Inside the uplink, 15 of the symbols are used for data, and 3 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.

<Scaling Factor for 5MHz BW>

This dongle is power class 2 device and the maximum power tolerance is 23±1 dBm.

The maximum rated output power of 5M BW is 24.00 dBm (251.19 mW).

Maximum power in 5M control traffic is 73.88 mW (5/17 of 251.19 mW).

$$\text{Scaling Factor} = (3 * 73.88 + 15 * 251.19) / (15 * \text{max. measured power of the channel tested})$$

$$= 3989.47 / (15 * \text{max. measured power of the channel tested})$$

Zone Type	Modulation	Coding Rate	Frequency (MHz)	Average Power for Main Antenna		Scaling Factor
				(dBm)	(mW)	
PUSC	QPSK (BW 5MHz)	1/2	2498.5	23.32	214.78	1.24
			2593.0	23.60	229.09	1.16
			2687.5	23.75	237.14	1.12
		3/4	2498.5	23.17	207.49	1.28
			2593.0	23.55	226.46	1.17
			2687.5	23.53	225.42	1.18
	16QAM (BW 5MHz)	1/2	2498.5	23.19	208.45	1.28
			2593.0	23.55	226.46	1.17
			2687.5	23.64	231.21	1.15
		3/4	2498.5	23.16	207.01	1.28
			2593.0	23.55	226.46	1.17
			2687.5	23.54	225.94	1.18

<Scaling Factor for 10MHz BW>

This dongle is power class 2 device and the maximum power tolerance is 23±1 dBm.

The maximum rated output power of 10M BW is 24.00 dBm (251.19 mW).

Maximum power in 10M control traffic is 35.88 mW (5/35 of 251.19 mW).

$$\text{Scaling Factor} = (3 * 35.88 + 15 * 251.19) / (15 * \text{max. measured power of the channel tested})$$

$$= 3875.48 / (15 * \text{max. measured power of the channel tested})$$

Zone Type	Modulation	Coding Rate	Frequency (MHz)	Average Power for Main Antenna		Scaling Factor
				(dBm)	(mW)	
PUSC	QPSK (BW 10MHz)	1/2	2501.0	22.85	192.75	1.34
			2593.0	23.13	205.59	1.26
			2685.0	23.20	208.93	1.24
		3/4	2501.0	22.86	193.20	1.34
			2593.0	22.96	197.70	1.31
			2685.0	23.34	215.77	1.20
	16QAM (BW 10MHz)	1/2	2501.0	22.67	184.93	1.40
			2593.0	23.00	199.53	1.29
			2685.0	23.04	201.37	1.28
		3/4	2501.0	22.66	184.50	1.40
			2593.0	23.02	200.45	1.29
			2685.0	23.05	201.84	1.28

Step 6 : Scaling Up SAR

Calculating used follow scheme for scale up SAR.

Scaled SAR = Measured SAR * Scaling Factor

Zone Type	Modulation	Coding Rate	Frequency (MHz)	Test Position	Antenna	Measured SAR _{1g} (W/kg)	Scaling Factor	Scaled SAR (W/kg)
PUSC	16QAM (5M)	1/2	2498.5	Horizontal Up	Aux	0.401	1.28	0.513
PUSC	16QAM (5M)	1/2	2593.0	Horizontal Up	Aux	0.438	1.17	0.512
PUSC	16QAM (5M)	1/2	2687.5	Horizontal Up	Aux	0.579	1.15	0.666
PUSC	16QAM (10M)	1/2	2501.0	Horizontal Up	Aux	0.371	1.40	0.519
PUSC	16QAM (10M)	1/2	2593.0	Horizontal Up	Aux	0.418	1.29	0.539
PUSC	16QAM (10M)	1/2	2685.0	Horizontal Up	Aux	0.485	1.28	0.621
PUSC	16QAM (5M)	3/4	2498.5	Horizontal Up	Aux	0.414	1.28	0.530
PUSC	16QAM (5M)	3/4	2593.0	Horizontal Up	Aux	0.509	1.17	0.596
PUSC	16QAM (5M)	3/4	2687.5	Horizontal Up	Aux	0.577	1.18	0.681
PUSC	16QAM (10M)	3/4	2501.0	Horizontal Up	Aux	0.42	1.40	0.588
PUSC	16QAM (10M)	3/4	2593.0	Horizontal Up	Aux	0.457	1.29	0.590
PUSC	16QAM (10M)	3/4	2685.0	Horizontal Up	Aux	0.558	1.28	0.714
PUSC	QPSK (5M)	1/2	2498.5	Horizontal Up	Aux	0.462	1.24	0.573
PUSC	QPSK (5M)	1/2	2593.0	Horizontal Up	Aux	0.475	1.16	0.551
PUSC	QPSK (5M)	1/2	2687.5	Horizontal Up	Aux	0.478	1.12	0.535
PUSC	QPSK (10M)	1/2	2501.0	Horizontal Up	Aux	0.368	1.34	0.493
PUSC	QPSK (10M)	1/2	2593.0	Horizontal Up	Aux	0.455	1.26	0.573
PUSC	QPSK (10M)	1/2	2685.0	Horizontal Up	Aux	0.467	1.24	0.579
PUSC	QPSK (5M)	3/4	2498.5	Horizontal Up	Aux	0.488	1.28	0.625
PUSC	QPSK (5M)	3/4	2593.0	Horizontal Up	Aux	0.484	1.17	0.566
PUSC	QPSK (5M)	3/4	2687.5	Horizontal Up	Aux	0.549	1.18	0.648
PUSC	QPSK (10M)	3/4	2501.0	Horizontal Up	Aux	0.365	1.34	0.489
PUSC	QPSK (10M)	3/4	2593.0	Horizontal Up	Aux	0.5	1.31	0.655
PUSC	QPSK (10M)	3/4	2685.0	Horizontal Up	Aux	0.474	1.20	0.569

As concluded above, 0.714 W/kg is worst scaled SAR.

11.3 Test Records for Body SAR Test

SAR Test Records for Step 2

Plot No.	Modulation	Coding Rate	BW (MHz)	Frequency (MHz)	Test Position	Separation Distance	Ant.	SAR _{1g} (W/kg)	Scaling Factor	Scaling SAR
#01	QPSK	1/2	5	2687.5	Horizontal Up (Laptop)	5 mm	Main	0.379	1.12	0.424
#02	QPSK	3/4	10	2685.0	Horizontal Up (Laptop)	5 mm	Main	0.316	1.20	0.379

SAR Test Records for Step 3

Plot No.	Modulation	Coding Rate	BW (MHz)	Frequency (MHz)	Test Position	Separation Distance	Ant.	SAR _{1g} (W/kg)	Scaling Factor	Scaling SAR
#01	QPSK	1/2	5	2687.5	Horizontal Up (Laptop)	5 mm	Main	0.379	1.12	0.424
#03	QPSK	1/2	5	2687.5	Horizontal Up (Laptop)	5 mm	Aux	0.478	1.12	0.535
#04	QPSK	1/2	5	2687.5	Horizontal Down (USB Cable)	5 mm	Main	0.252	1.12	0.282
#05	QPSK	1/2	5	2687.5	Horizontal Down (USB Cable)	5 mm	Aux	0.448	1.12	0.502
#06	QPSK	1/2	5	2687.5	Vertical Front (USB Cable)	5 mm	Main	0.351	1.12	0.393
#07	QPSK	1/2	5	2687.5	Vertical Front (USB Cable)	5 mm	Aux	0.077	1.12	0.086
#08	QPSK	1/2	5	2687.5	Vertical Back (Laptop)	5 mm	Main	0.046	1.12	0.052
#09	QPSK	1/2	5	2687.5	Vertical Back (Laptop)	5 mm	Aux	0.396	1.12	0.444
#10	QPSK	1/2	5	2687.5	Tip Mode (Laptop)	5 mm	Main	0.068	1.12	0.076
#11	QPSK	1/2	5	2687.5	Tip Mode (Laptop)	5 mm	Aux	0.133	1.12	0.149

SAR Test Records for Step 6

Plot No.	Modulation	Coding Rate	BW (MHz)	Frequency (MHz)	Test Position	Separation Distance	Ant.	SAR _{1g} (W/kg)	Scaling Factor	Scaling SAR
#12	16QAM	1/2	5	2498.5	Horizontal Up (Laptop)	5 mm	Aux	0.401	1.28	0.513
#13	16QAM	1/2	5	2593.0	Horizontal Up (Laptop)	5 mm	Aux	0.438	1.17	0.512
#14	16QAM	1/2	5	2687.5	Horizontal Up (Laptop)	5 mm	Aux	0.579	1.15	0.666
#15	16QAM	1/2	10	2501.0	Horizontal Up (Laptop)	5 mm	Aux	0.371	1.40	0.519
#16	16QAM	1/2	10	2593.0	Horizontal Up (Laptop)	5 mm	Aux	0.418	1.29	0.539
#17	16QAM	1/2	10	2685.0	Horizontal Up (Laptop)	5 mm	Aux	0.485	1.28	0.621
#18	16QAM	3/4	5	2498.5	Horizontal Up (Laptop)	5 mm	Aux	0.414	1.28	0.530
#19	16QAM	3/4	5	2593.0	Horizontal Up (Laptop)	5 mm	Aux	0.509	1.17	0.596
#20	16QAM	3/4	5	2687.5	Horizontal Up (Laptop)	5 mm	Aux	0.577	1.18	0.681
#21	16QAM	3/4	10	2501.0	Horizontal Up (Laptop)	5 mm	Aux	0.42	1.40	0.588
#22	16QAM	3/4	10	2593.0	Horizontal Up (Laptop)	5 mm	Aux	0.457	1.29	0.590
#23	16QAM	3/4	10	2685.0	Horizontal Up (Laptop)	5 mm	Aux	0.558	1.28	0.714
#24	QPSK	1/2	5	2498.5	Horizontal Up (Laptop)	5 mm	Aux	0.462	1.24	0.573
#25	QPSK	1/2	5	2593.0	Horizontal Up (Laptop)	5 mm	Aux	0.475	1.16	0.551
#03	QPSK	1/2	5	2687.5	Horizontal Up (Laptop)	5 mm	Aux	0.478	1.12	0.535
#26	QPSK	1/2	10	2501.0	Horizontal Up (Laptop)	5 mm	Aux	0.368	1.34	0.493
#27	QPSK	1/2	10	2593.0	Horizontal Up (Laptop)	5 mm	Aux	0.455	1.26	0.573
#28	QPSK	1/2	10	2685.0	Horizontal Up (Laptop)	5 mm	Aux	0.467	1.24	0.579
#29	QPSK	3/4	5	2498.5	Horizontal Up (Laptop)	5 mm	Aux	0.488	1.28	0.625
#30	QPSK	3/4	5	2593.0	Horizontal Up (Laptop)	5 mm	Aux	0.484	1.17	0.566
#31	QPSK	3/4	5	2687.5	Horizontal Up (Laptop)	5 mm	Aux	0.549	1.18	0.648
#32	QPSK	3/4	10	2501.0	Horizontal Up (Laptop)	5 mm	Aux	0.365	1.34	0.489
#33	QPSK	3/4	10	2593.0	Horizontal Up (Laptop)	5 mm	Aux	0.5	1.31	0.655
#34	QPSK	3/4	10	2685.0	Horizontal Up (Laptop)	5 mm	Aux	0.474	1.20	0.569

Test Engineer : Robert Liu and Eric Huang

11.4 Linearity Response Check

<Setup and Calculation Procedure>

Setup the DUT in the position of worst SAR, Horizontal Up, and separation distance between surface of DUT and phantom is 5 mm. The channel of maximum SAR for each Modulation/Bandwidth is chose for single point peak SAR testing. Using the same setup as complete 1g SAR and set the Beceem test software to configure the device to transmit at specified power and check by Anritus wideband power meter.

The reference line is based on measured SAR of 12.5 mW and the scale of average power. The following scheme is used for calculating reference line.

The SAR value of 12.5 mW is base. Next point of reference line is SAR value of 12.5 mW multiplied by average power ratio of next point power to 12.5 mW.

The example for 16QAM 1/2, BW 5M, 2687.5MHz is as below:

Base value = SAR of 12.5 mW = 0.041

Next point (25 mW) = Base value x (25 mW / 12.5 mW) = 0.041 x (25 / 12.5) = 0.082

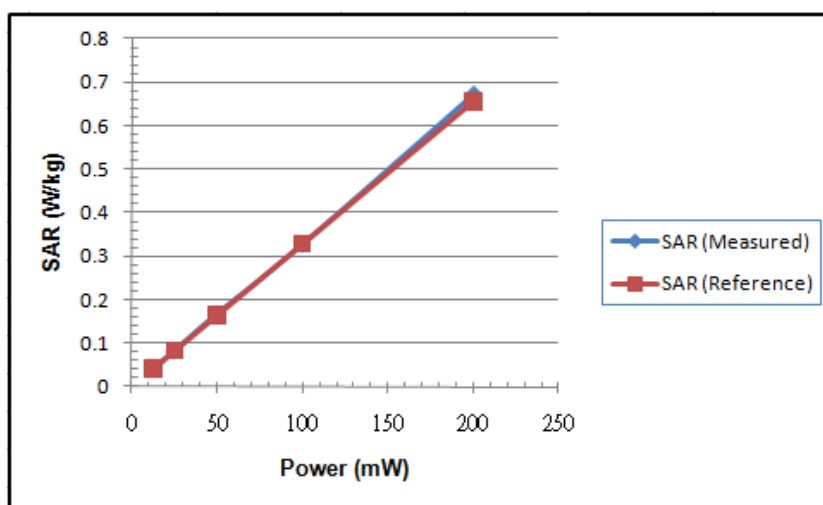
Next point (50 mW) = Base value x (50 mW / 12.5 mW) = 0.041 x (50 / 12.5) = 0.164

Next point (100 mW) = Base value x (100 mW / 12.5 mW) = 0.041 x (100 / 12.5) = 0.328

Next point (200 mW) = Base value x (200 mW / 12.5 mW) = 0.041 x (200 / 12.5) = 0.656

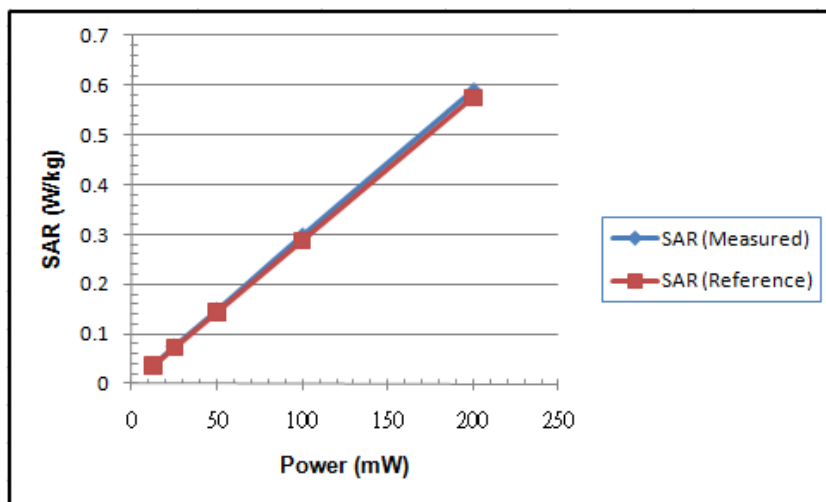
<For 16QAM, 1/2, BW 5M, 2687.5MHz>

Average Power (mW)	12.5	25	50	100	200
Single Point SAR (W/kg)	0.041	0.083	0.168	0.328	0.672
Reference Line (W/kg)	0.041	0.082	0.164	0.328	0.656
Deviation (%)	0.00	1.22	2.44	0.00	2.44



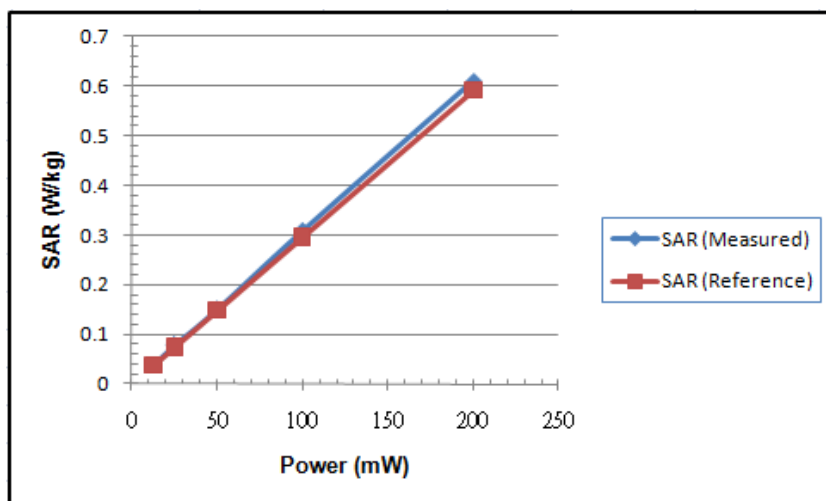
<For 16QAM, 3/4, BW 10M, 2685.0MHz>

Average Power (mW)	12.5	25	50	100	200
Single Point SAR (W/kg)	0.036	0.075	0.148	0.298	0.59
Reference Line (W/kg)	0.036	0.072	0.144	0.288	0.576
Deviation (%)	0.00	4.17	2.78	3.47	2.43



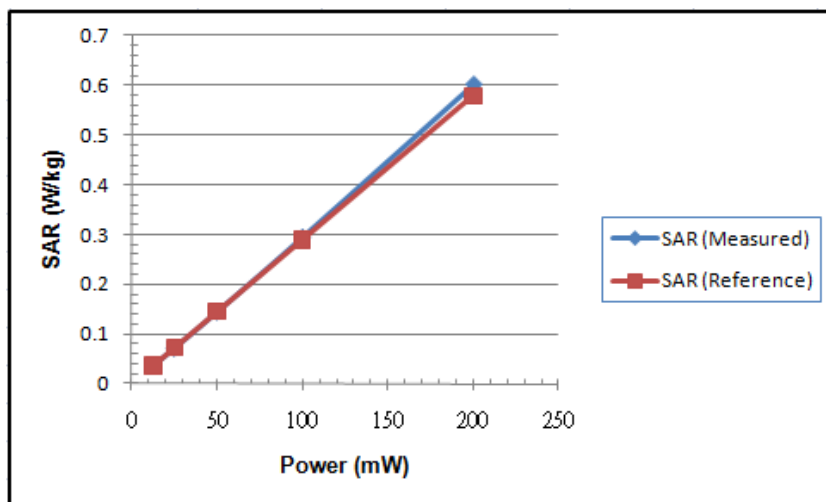
<For QPSK, 3/4, BW 5M, 2498.5MHz>

Average Power (mW)	12.5	25	50	100	200
Single Point SAR (W/kg)	0.037	0.078	0.15	0.308	0.61
Reference Line (W/kg)	0.037	0.074	0.148	0.296	0.592
Deviation (%)	0.00	5.41	1.35	4.05	3.04



<For QPSK, 3/4, BW 10M, 2593.0MHz>

Average Power (mW)	12.5	25	50	100	200
Single Point SAR (W/kg)	0.0362	0.072	0.145	0.295	0.602
Reference Line (W/kg)	0.0362	0.0724	0.1448	0.2896	0.5792
Deviation (%)	0.00	-0.55	0.14	1.86	3.94



<Conclusion>

From the above test results, the SAR probe can measure SAR correctly under high PAPR of OFDM/OFDMA, and the pretest SAR is not underestimated.

11.5 Compare with Different Scan Resolution

Retest the maximum raw 1g SAR with the same DUT setting on the different scan resolution. The test results are shown as below.

Scan Resolution (mm)	Measured SAR _{1g} (W/kg)
5.0	0.579
2.5	0.568

<Conclusion>

From the above test results, the different scan resolution has no significant change.

12. References

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- [2] IEEE Std. C95.1-1999, “IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz”, 1999
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- [4] FCC OET Bulletin 65 (Edition 97-01) Supplement C (Edition 01-01), “Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields”, June 2001
- [5] SPEAG DASY System Handbook
- [6] FCC KDB 248227 D01 v01r02, “SAR Measurement Procedures for 802.11 a/b/g Transmitters”, May 2007
- [7] FCC KDB 447498 D01 v04, “Mobile and Portable Device RF Exposure Procedures and Equipment Authorization Policies”, November 2009
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- [9] FCC KDB 616217 D01 v01r01, “SAR Evaluation Considerations for Laptop Computers with Antennas Built-in on Display Screens”, November 2009
- [10] FCC KDB 616217 D03 v01, “SAR Evaluation Considerations for Laptop/Notebook/Netbook and Tablet Computers”, November 2009
- [11] FCC KDB 648474 D01 v01r05, “SAR Evaluation Considerations for Handsets with Multiple Transmitters and Antennas”, September 2008
- [12] FCC KDB 941225 D01 v02, “SAR Measurement Procedures for 3G Devices – CDMA 2000 / Ev-Do / WCDMA / HSDPA / HSPA”, October 2007
- [13] FCC KDB 941225 D03 v01, “Recommended SAR Test Reduction Procedures for GSM / GPRS / EDGE”, December 2008



Appendix A. Plots of System Performance Check

The plots are shown as follows.



Appendix B. Plots of SAR Measurement

The plots are shown as follows.



Appendix C. DASY Calibration Certificate

The DASY calibration certificates are shown as follows.