SAR EVALUATION REPORT
FCC 2.1093 & IEEE 1528:2003

For

Zebra Technologies Corp.

333 Corporate Woods Parkway,
Vernon Hills, IL 60061

FCC ID: I28MD-ZLAN11G

Printer Model: MZ220

This Report Concerns:	Product Name:
☒ Original Report	Portable label printer with 802.11b/g

Test Engineer:	Eric Hong
Report No.:	R0608282S MZ220
Report Date:	2006-09-11
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DECLARATION OF COMPLIANCE SAR EVALUATION

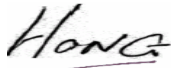|	
Rule Part(s):	**FCC §2.1093 & IEEE 1528:2003**
Test Procedure(s):	**FCC OET Bulletin 65 Supplement C & IEEE 1528**
Device Type:	**label printer with 802.11b/g**
Model:	**MZ220**
Modulation:	**DSSS**
TX Frequency Range:	**2412– 2462MHz**
Max. Conducted Power Tested:	**75.9 mw**
Antenna Type(s):	**Internal Antenna**
Body-Worn Accessories:	**Belt Clip**

0.049 mw/g (1g) (Body-Worn, 802.11g Mode), 0.036 mw/g (1g) (Body-Worn, 802.11b Mode)

BACL Corp. declares under its sole responsibility that this wireless portable device has been determined to be in compliance for localized specific absorption rate (SAR) for uncontrolled exposure and general population exposure limits specified in FCC OET Bulletin 65 Supplement C and has been tested in accordance with the measurement procedures specified in ANSI IEEE C95.3:2002 & IEEE 1528.

All measurements reported herein were performed under my supervision and believed to be accurate to the best of my knowledge. I further attest for the completeness of these measurements and vouch for the qualifications any and all personnel performing such measurements.

The results and statements contained in this report pertain only to the device(s) evaluated.

/signature/

Hong

Eric Hong
Bay Area Compliance Laboratory Corp.

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REFERENCE, STANDARDS, AND GUILDELINES

FCC:

The Report and Order requires routine SAR evaluation prior to equipment authorization of portable transmitter devices, including portable telephones. For consumer products, the applicable limit is 1.6 mw/g as recommended by the ANSI/IEEE standard C95.1-1992 [6] for an uncontrolled environment (Paragraph 65). According to the Supplement C of OET Bulletin 65 "Evaluating Compliance with FCC Guide-lines for Human Exposure to Radio frequency Electromagnetic Fields", released on Jun 29, 2001 by the FCC, the device should be evaluated at maximum output power (radiated from the antenna) under "worst-case" conditions for normal or intended use, incorporating normal antenna operating positions, device peak performance frequencies and positions for maximum RF energy coupling.

This report describes the methodology and results of experiments performed on wireless data terminal. The objective was to determine if there is RF radiation and if radiation is found, what is the extent of radiation with respect to safety limits. SAR (Specific Absorption Rate) is the measure of RF exposure determined by the amount of RF energy absorbed by human body (or its parts) – to determine how the RF energy couples to the body or head which is a primary health concern for body worn devices. The limit below which the exposure to RF is considered safe by regulatory bodies in North America is 1.6 mw/g average over 1 gram of tissue mass.

CE:

The order requires routine SAR evaluation prior to equipment authorization of portable transmitter devices, including portable telephones. For consumer products, the applicable limit is 2 mw/g as recommended by the EN50360 for an uncontrolled environment. According to the Standard, the device should be evaluated at maximum output power (radiated from the antenna) under "worst-case" conditions for normal or intended use, incorporating normal antenna operating positions, device peak performance frequencies and positions for maximum RF energy coupling.

This report describes the methodology and results of experiments performed on wireless data terminal. The objective was to determine if there is RF radiation and if radiation is found, what is the extent of radiation with respect to safety limits. SAR (Specific Absorption Rate) is the measure of RF exposure determined by the amount of RF energy absorbed by human body (or its parts) – to determine how the RF energy couples to the body or head which is a primary health concern for body worn devices. The limit below which the exposure to RF is considered safe by regulatory bodies in Europe is 2 mw/g average over 10 gram of tissue mass.

The test configurations were laid out on a specially designed test fixture to ensure the reproducibility of measurements. Each configuration was scanned for SAR. Analysis of each scan was carried out to characterize the above effects in the device.

There was no SAR of any concern measured on the device for any of the investigated configurations.

SAR Limits

FCC Limit (1g)

EXPOSURE LIMITS	SAR (W/kg)	
	(General Population / Uncontrolled Exposure Environment)	**(Occupational / Controlled Exposure Environment)**
Spatial Average (averaged over the whole body)	0.08	0.4
Spatial Peak (averaged over any 1 g of tissue)	1.60	8.0
Spatial Peak (hands/wrists/feet/ankles averaged over 10 g)	4.0	20.0

CE Limit (10g)

EXPOSURE LIMITS	SAR (W/kg)	
	(General Population / Uncontrolled Exposure Environment)	**(Occupational / Controlled Exposure Environment)**
Spatial Average (averaged over the whole body)	0.08	0.4
Spatial Peak (averaged over any 1 g of tissue)	2.0	10
Spatial Peak (hands/wrists/feet/ankles averaged over 10 g)	4.0	20.0

Population/Uncontrolled Environments are defined as locations where there is the exposure of individual who have no knowledge or control of their exposure.

Occupational/Controlled Environments are defined as locations where there is exposure that may be incurred by people who are aware of the potential for exposure (i.e. as a result of employment or occupation).

General Population/Uncontrolled environments Spatial Peak limit 1.6 w/kg (FCC) & 2 w/kg (CE) applied to the EUT.

EUT DESCRIPTION

The *Zebra Technologies Corp.* product, MODEL: MZ220 or the "EUT" as referred to in this report is a portable printer with 802.11b/g, which measures approximately 135 mm L, 80 mm W, and 54 mm H. The EUT operates at the frequency range of 2412– 2462MHz (802.11b/g mode)

** The test data gathered are from production sample, serial number: **XXMZ06-08-5104**, provided by the manufacturer.*

DESCRIPTION OF TEST SYSTEM

These measurements were performed with the automated near-field scanning system DASY4 from Schmid & Partner Engineering AG (SPEAG) which is the fourth generation of the system shown in the figure hereinafter:

The system is based on a high precision robot (working range greater than 0.9m), which positions the probes with a positional repeatability of better than ±0.02mm. Special E- and H-field probes have been developed for measurements close to material discontinuity, the sensors of which are directly loaded with a Schottky diode and connected via highly resistive lines to the data acquisition unit.

The SAR measurements were conducted with the dosimetric probe ET3DV6 SN: 1604 (manufactured by SPEAG), designed in the classical triangular configuration and optimized for dosimetric evaluation. The probe has been calibrated according to the procedure with accuracy of better than ±10%. The spherical isotropy was evaluated with the procedure and found to be better than ±0.25dB.

The phantom used was the Generic Twin Phantom. The ear was simulated as a spacer of 4 mm thickness between the earpiece of the phone and the tissue simulating liquid. The Tissue simulation liquid used for each test is in according with the FCC OET65 supplement C as listed below.

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

IEEE SCC-34/SC-2 P1528 Recommended Tissue Dielectric Parameters

Frequency	Head		Body	
(MHz)	ε_r	$\acute{O}$ (S/m)	ε_r	$\acute{O}$ (S/m)
150	52.3	0.76	61.9	0.80
300	45.3	0.87	58.2	0.92
450	43.5	0.87	56.7	0.94
835	41.5	0.90	55.2	0.97
900	41.5	0.97	55.0	1.05
915	41.5	0.98	55.0	1.06
1450	40.5	1.20	54.0	1.30
1610	40.3	1.29	53.8	1.40
1800-2000	40.0	1.40	53.3	1.52
2450	39.2	1.80	52.7	1.95
3000	38.5	2.40	52.0	2.73
5800	35.3	5.27	48.2	6.00

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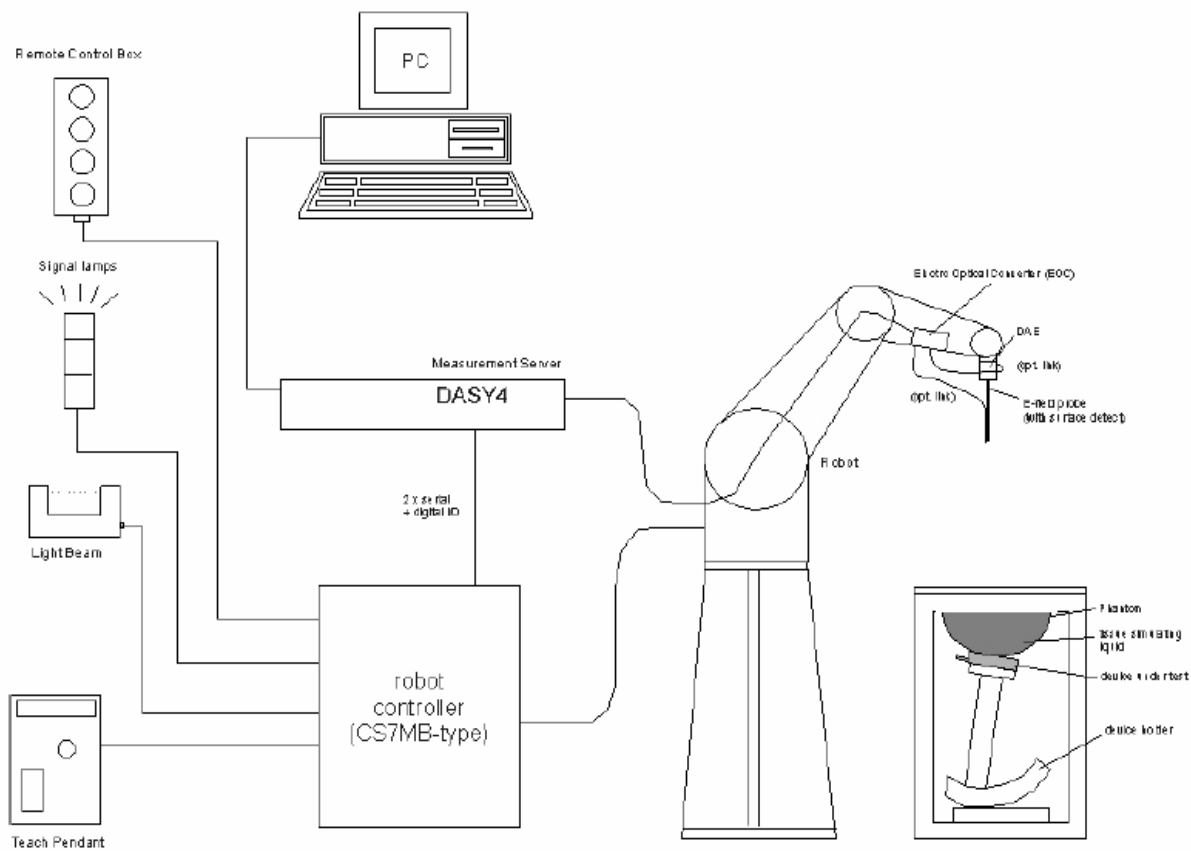
The DASY4 system for performing compliance tests consists of the following items:

• A standard high precision 6-axis robot (Stäubli RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).

• A dosimetric probe, i.e., an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.

• A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.

• The Electro-optical converter (EOC) performs the conversion between optical and electrical of the signals for the digital communication to the DAE and for the analog signal from the optical surface detection. The EOC is connected to the measurement server.

• The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.

• A probe alignment unit which improves the (absolute) accuracy of the probe positioning.

• A computer operating Windows 2000 or Windows XP.

• DASY4 software.

• Remote control with teach pendant and additional circuitry for robot safety such as warning lamps, etc.

• The SAM twin phantom enabling testing left-hand and right-hand usage.

• The device holder for handheld mobile phones.

• Tissue simulating liquid mixed according to the given recipes.

• Validation dipole kits allowing to validate the proper functioning of the system.

System Components

• DASY4 Measurement Server
• Data Acquisition Electronics
• Probes
• Light Beam Unit
• Medium
• SAM Twin Phantom
• Device Holder for SAM Twin Phantom
• System Validation Kits
•Robot

DASY4 Measurement Server

The DASY4 measurement server is based on a
PC/104 CPU board with a 166MHz low-power
Pentium, 32MB chip disk and 64MB RAM. The
necessary circuits for communication with either
the DAE4 (or DAE3) electronic box as well as
the 16-bit AD-converter system for optical detection
and digital I/O interface are contained on the
DASY4 I/O-board, which is directly connected to
the PC/104 bus of the CPU board.

The measurement server performs all real-time data evaluation for field measurements and surface
detection, controls robot movements and handles safety operation. The PC-operating system cannot interfere
with these time critical processes. All connections are supervised by a watchdog, and disconnection of any of
the cables to the measurement server will automatically disarm the robot and disable all program-controlled
robot movements. Furthermore, the measurement server is equipped with two expansion slots which are
reserved for future applications. Please note that the expansion slots do not have a standardized pinout and
therefore only the expansion cards provided by SPEAG can be inserted. Expansion cards from any other
supplier could seriously damage the measurement server.

Data Acquisition Electronics

The data acquisition electronics 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 measurement
server is accomplished through an optical downlink for
data and status information as well as an optical uplink
for commands and the clock.

Probes

The DASY system can support many different probe types.

Dosimetric Probes: These probes are specially designed and calibrated for use in liquids with high
permittivities. They should not be used in air, since the spherical isotropy in air is poor (±2 dB). The
dosimetric probes have special calibrations in various liquids at different frequencies.

Free Space Probes: These are electric and magnetic field probes specially designed for measurements
in free space. The z-sensor is aligned to the probe axis and the rotation angle of the x-sensor is specified.
This allows the DASY system to automatically align the probe to the measurement grid for field component
measurement. The free space probes are generally not calibrated in liquid. (The H-field probes can be used in
liquids without any change of parameters.)

Temperature Probes: Small and sensitive temperature probes for general use. They use a
completely different parameter set and different evaluation procedures. Temperature rise features
allow direct SAR evaluations with these probes.

ET3DV6 Probe Specification

Construction Symmetrical design with triangular core
Built-in optical fiber for surface detection System
Built-in shielding against static charges
Calibration In air from 10 MHz to 2.5 GHz
In brain and muscle simulating tissue at
Frequencies of 450 MHz, 900 MHz and
1.8 GHz (accuracy ± 8%)
Frequency 10 MHz to > 6 GHz; Linearity: ± 0.2 dB
(30 MHz to 3 GHz)
Directivity ± 0.2 dB in brain tissue (rotation around
probe axis)
± 0.4 dB in brain tissue (rotation normal probe axis)
Dynamic 5 mw/g to > 100 mw/g;
Range Linearity: ± 0.2 dB
Surface ± 0.2 mm repeatability in air and clear liquids
Detection over diffuse reflecting surfaces.
Dimensions Overall length: 330 mm
Tip length: 16 mm
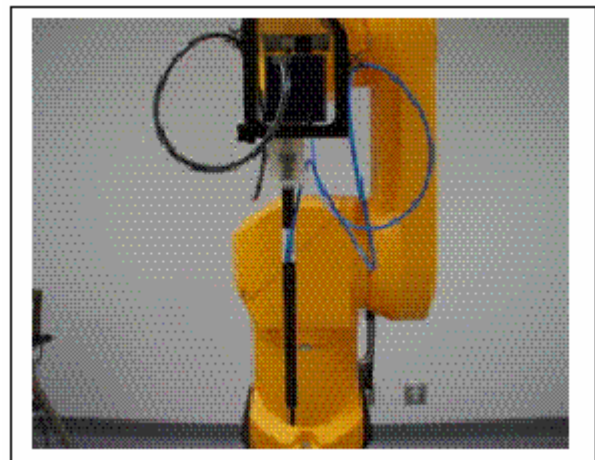
Photograph of the probe

Body diameter: 12 mm
Tip diameter: 6.8 mm
Distance from probe tip to dipole centers: 2.7 mm
Application General dosimetric up to 3 GHz
Compliance tests of mobile phones
Fast automatic scanning in arbitrary phantoms

The SAR measurements were conducted with the dosimetric probe
ET3DV6 designed in the classical triangular configuration 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 multi-fiber line
ending at the front of the probe tip. 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 DASY3 software reads the reflection
during a software approach and looks for the maximum using a 2nd
order fitting. The approach is stopped when reaching the maximum.
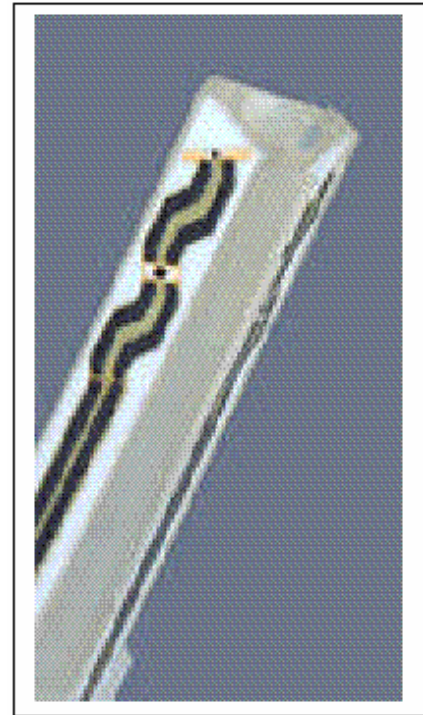
Inside view of
ET3DV6 E-field Probe

E-Field Probe Calibration Process

Each probe is calibrated according to a dosimetric assessment procedure described in [6] with accuracy
better than +/- 10%. The spherical isotropy was evaluated with the procedure described in [7] 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 are tested.

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

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
dielectric medium. For temperature correlation calibration a RF transparent thermistor-based temperature
probe is used in conjunction with the E-field probe.

Data Evaluation

The DASY4 postprocessing 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   Normi, ai0, ai1, ai2
                     - Conversion factor   ConvFi
                     - Diode compression point   dcpi

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 multimeter 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   Vi   = compensated signal of channel i (i =x, y, z)
       Ui   = 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:

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

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

With   Vi   = compensated signal of channel i (i =x, y, z)
       $Norm_i$ = sensor sensitivity of channel i (i =x, y, z)
                  μV/ (V/m)² for E-field probes
       ConF   = sensitivity enhancement in solution
       a_{ij} = sensor sensitivity factors for H-field probes
       f   = carrier frequency [GHz]
       Ei   = electric field strength of channel in V/m
       Hi   = diode compression point (DASY parameter)

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

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

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

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

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

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

Light Beam Unit

The light beam switch allows automatic "tooling" of the probe. During the process, the actual position of the probe tip with respect to the robot arm is measured, as well as the probe length and the horizontal probe offset. The software then corrects all movements, so that the robot coordinates are valid for the probe tip. The repeatability of this process is better than 0.1 mm. If a position has been taught with an aligned probe, the same position will be reached with another aligned probe within 0.1 mm, even if the other probe has different dimensions. During probe rotations, the probe tip will keep its actual position.

Medium

Parameters

The parameters of the tissue simulating liquid strongly influence the SAR in the liquid. The parameters for the different frequencies are defined in the corresponding compliance standards (e.g., EN 50361, IEEE 1528-2003).

Parameter measurements

Several measurement systems are available for measuring the dielectric parameters of liquids:

• The open coax test method (e.g., HP85070 dielectric probe kit) is easy to use, but has only moderate
  accuracy. It is calibrated with open, short, and deionized water and the calibrations a critical process.

• The transmission line method (e.g., model 1500T from DAMASKOS, INC.) measures the transmission
  and reflection in a liquid filled high precision line. It needs standard two port calibration and is probably
  more accurate than the open coax method.

• The reflection line method measures the reflection in a liquid filled shorted precision lined.The method
  is not suitable for these liquids because of its low sensitivity.

• The slotted line method scans the field magnitude and phase along a liquid filled line. The evaluation is
  straight forward and only needs a simple response calibration. The method is very accurate, but can
  only be used in high loss liquids and at frequencies above 100 to 200MHz. Cleaning the line can be
  tedious.

SAM Twin Phantom

The SAM twin phantom is a fiberglass shell phantom with
2mm shell thickness (except the ear region where shell
thickness increases to 6mm). It has three measurement
areas:

• Left hand
• Right hand
• Flat phantom

The phantom table comes in two sizes: A 100 x 50 x 85 cm
(L x W x H) table for use with free standing robots (DASY4
professional system option) or as a second phantom and a
100 x 75 x 85 cm(L x W x H) table with reinforcements for
table mounted robots (DASY4 compact system option) .
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. Only one device holder is necessary if
two phantoms are used (e.g., for different liquids) A white cover is provided to tap the phantom during o_-
periods to prevent water evaporation and changes in the liquid parameters. Free space scans of devices on the
cover are possible. On the phantom top, three reference markers are provided to identify the phantom
position with respect to the robot.

The phantom can be used with the following tissue simulating liquids:

• Water-sugar based liquids can be left permanently in the phantom. Always cover the liquid if the system
  is not used, otherwise the parameters will change due to water evaporation.

• Glycol based liquids should be used with care. As glycol is a softener for most plastics, the liquid should
  be taken out of the phantom and the phantom should be dried when the system is not used (desirable at
  least once a week).

• Do not use other organic solvents without previously testing the phantom resistiveness.

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 in 5mm distance, a positioning uncertainty of ±0.5mm would produce a SAR uncertainty of ±20%. An 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 centers for both scales is the ear reference point ERP). Thus the device needs no repositioning when changing the angles.

The DASY device holder has been made out of low-loss POM material having the following dielectric parameters: relative permittivity "=3 and loss tangent _=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.

System Validation Kits

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. For that purpose a well defined SAR distribution in the flat section of the SAM twin phantom is produced.

System validation kit includes a dipole, tripod holder to fix it underneath the flat phantom and a corresponding distance holder. Dipoles are available for the variety of frequencies between 300MHz and 6 GHz (dipoles for other frequencies or media and other calibration conditions are available upon request).

The dipoles are highly symmetric and matched at the center frequency for the specified liquid and distance to the flat phantom (or flat section of the SAM-twin phantom). The accurate distance between the liquid surface and the dipole center is achieved with a distance holder that snaps on the dipole.

Robot

The DASY4 system uses the high precision industrial robots RX60L, RX90 and RX90L, as well as the RX60BL and RX90BL types out of the newer series from Stäubli SA (France). The RX robot series offers many features that are important for our application:

• High precision (repeatability 0.02mm)
• High reliability (industrial design)
• Low maintenance costs (virtually maintenance-free due to direct drive gears; no belt drives)
• Jerk-free straight movements (brushless synchron motors; no stepper motors)
• Low ELF interference (the closed metallic construction shields against motor control fields)

For the newly delivered DASY4 systems as well as for the older DASY3 systems delivered since 1999, the CS7MB robot controller version from Stäubli is used. Previously delivered systems have either a CS7 or CS7M controller; the differences to the CS7MB are mainly in the hardware, but some procedures in the robot software from Stäubli are also not completely the same. The following descriptions about robot hard- and software correspond to CS7MB controller with software version 13.1 (edit S5). The actual commands, procedures and configurations, also including details in hardware, might differ if an older robot controller is in use. In this case please also refer to the Stäubli manuals for further information.

TESTING EQUIPMENT

Equipments List & Calibration Info

Type / Model	Cal. Date	S/N:
DASY4 Professional server	N/A	N/A
Robot RX60L	N/A	F00/5H31A1/A/01
Robot Controller	N/A	F01/5J72A1/A/01
Dell Computer Dimension 3000	N/A	N/A
Pentium(R) 4CPU 3.00GHz, Windows XP	N/A	N/A
SPEAG EDC3	N/A	N/A
SPEAG DAE3	2005-10-18	456
Probe, SAR Sensor ET3DV6	2006-05-02	1604
SPEAG Generic Twin Phantom	N/A	N/A
SPEAG Light Alignment Sensor	N/A	278
Antenna Dipole D-2450-S-1 (2450MHz)	2006-08-28	BCL-141
Brain Equivalent Matter (2450MHz)	Each Use	N/A
Muscle Equivalent Matter (2450MHz)	Each Use	N/A
Robot Table	Each Use	N/A
Phone Holder	Each Use	N/A
Phantom Cover	Each Use	N/A
HP Spectrum Analyzer HP8566A	N/R	2240A01930
Power Meter Agilent E4419B	2005-08-31	MY4121511
Power Sensor Agilent E4412A	2005-09-08	US38488542
Dielectric Probe Kit HP85070A	Each Use	US99360201
Signal Generator HP-83650B	2005-05-10	3614A00276
Amplifier, ST181-20	N/R	E012-0101
Spectrum Analyzer Agilent E4446A	2006-03-06	US44300386

SAR MEASUREMENT SYSTEM VERIFICATION

System Accuracy Verification

Prior to the assessment, the system validation kit was used to test whether the system was operating within its specifications of ±10%. The validation results are tabulated below. And also the corresponding SAR plot is attached as well in the SAR plots files.

IEEE P1528 recommended reference value for head

Frequency (MHz)	1 g SAR	10 g SAR	Local SAR at surface (above feed point)	Local SAR at surface (v=2cm offset from feed point)
300	3.0	2.0	4.4	2.1
450	4.9	3.3	7.2	3.2
835	9.5	6.2	14.1	4.9
900	10.8	6.9	16.4	5.4
1450	29.0	16.0	50.2	6.5
1800	38.1	19.8	69.5	6.8
1900	39.7	20.5	72.1	6.6
2000	41.1	21.1	74.6	6.5
2450	52.4	24.0	104.2	7.7
3000	63.8	25.7	140.2	9.5

Validation Dipole SAR Reference Test Result for Body (2450 MHz)

Validation Measurement	SAR @ 0.025mW Input averaged over 1g	SAR @ 1W Input averaged over 1g	SAR @ 0.025mW Input averaged over 10g	SAR @ 1W Input averaged over 10g
Test 1	14.2	56.80	6.33	25.32
Test 2	14.3	57.20	6.34	25.36
Test 3	14.2	56.80	6.33	25.32
Test 4	14.1	56.40	6.32	25.28
Test 5	14.3	57.20	6.33	25.32
Test 6	14.0	56.00	6.31	25.24
Test 7	14.2	56.80	6.33	25.32
Test 8	14.2	56.80	6.33	25.32
Test 9	14.4	57.60	6.34	25.36
Test 10	14.2	56.80	6.32	25.28
Average	14.21	56.84	6.32	25.31

EUT TEST STRATEGY AND METHODOLOGY

SAR Evaluation Procedure

The evaluation was performed with the following procedure:

Step 1: Measurement of the SAR value at a fixed location above the ear point or central position was used as a reference value for assessing the power drop.

Step 2: The SAR distribution at the exposed side of the head was measured at a distance of 3.9 mm from the inner surface of the shell. The area covered the entire dimension of the head or EUT and the horizontal grid spacing was 20 mm x 20 mm. Based on these data, the area of the maximum absorption was determined by spline interpolation.

Step 3: Around this point, a volume of 32 mm x 32 mm x 34 mm was assessed by measuring 5 x 5 x 7 points. On the basis of this data set, the spatial peak SAR value was evaluated under the following procedure:

1. The data at the surface were 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 1.2 mm. The extrapolation was based on a least square algorithm [11]. 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.

2. The maximum interpolated value was searched with a straightforward algorithm. Around this maximum the SAR values averaged over the spatial volumes (1 g or 10 g) were computed by the 3D-Spline interpolation algorithm. The 3D-Spline is composed of three onedimensional splines with the "Not a knot"-condition (in x, y and z-directions) [11], [12]. The volume was integrated with the trapezoidal-algorithm. One thousand points (10 x 10 x 10) were interpolated to calculate the average.

3. All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.

Step 4: Re-measurement of the SAR value at the same location as in Step 1. If the value changed by more than 5%, the evaluation was repeated.

CONCLUSION

This page summarizes the results of the performed dosimetric evaluation. The plots with the corresponding SAR distributions, which reveal information about the location of the maximum SAR with respect to the device could be found in Appendix E.

SAR Body & Head Worst-Case Test Data

Environmental Conditions

Ambient Temperature:	22° C
Relative Humidity:	51%
ATM Pressure:	1013 mbar

* Testing was performed by Eric Hong from 2006-09-06

802.11g Mode 2412-2462 MHz

EUT position	Frequency (MHz)	Conducted Power (mw)	Test Type	Liquid	Phantom	Notes / Accessories	Measured (mw/g) (1 g)	Limit (mw/g)	Plot #
Back touch to flat phantom	2412	31.6	Body worn	body	flat	Belt clip	0.025	1.6	1
Perpendicular to flat phantom	2412	31.6	Body worn	body	flat	Belt clip	0.049	1.6	2
Perpendicular to flat phantom	2442	31.6	Body worn	body	flat	Belt clip	0.017	1.6	3
Perpendicular to flat phantom	2462	30.9	Body worn	body	flat	Belt clip	0.027	1.6	4

802.11b Mode 2412-2462 MHz

EUT position	Frequency (MHz)	Conducted Power (mw)	Test Type	Liquid	Phantom	Notes / Accessories	Measured (mw/g) (1 g)	Limit (mw/g)	Plot #
Back touch to flat phantom	2412	75.9	Body worn	body	flat	Belt clip	0.027	1.6	5
Perpendicular to flat phantom	2412	75.9	Body worn	body	flat	Belt clip	0.036	1.6	6
Perpendicular to flat phantom	2442	69.2	Body worn	body	flat	Belt clip	0.032	1.6	7
Perpendicular to flat phantom	2462	72.4	Body worn	body	flat	Belt clip	0.024	1.6	8

APPENDIX A – MEASUREMENT UNCERTAINTY

The uncertainty budget has been determined for the DASY4 measurement system and is given in the following Table.

DASY4 Uncertainty Budget
According to IEEE 1528 [1]

Error Description	Uncertainty value	Prob. Dist.	Div.	(c_i) 1g	(c_i) 10g	Std. Unc. (1g)	Std. Unc. (10g)	(v_i) v_{eff}
Measurement System								
Probe Calibration	±5.9%	N	1	1	1	±5.9%	±5.9%	∝
Axial Isotropy	±4.7%	R	$\sqrt{3}$	0.7	0.7	±1.9%	±1.9%	∝
Hemispherical Isotropy	±9.6%	R	$\sqrt{3}$	0.7	0.7	±3.9%	±3.9%	∝
Boundary Effects	±1.0%	R	$\sqrt{3}$	1	1	±0.6%	±0.6%	∝
Linearity	±4.7%	R	$\sqrt{3}$	1	1	±2.7%	±2.7%	∝
System Detection Limits	±1.0%	R	$\sqrt{3}$	1	1	±0.6%	±0.6%	∝
Readout Electronics	±0.3%	N	1	1	1	±0.3%	±0.3%	∝
Response Time	±0.8%	R	$\sqrt{3}$	1	1	±0.5%	±0.5%	∝
Integration Time	±2.6%	R	$\sqrt{3}$	1	1	±1.5%	±1.5%	∝
RF Ambient Conditions	±3.0%	R	$\sqrt{3}$	1	1	±1.7%	±1.7%	∝
Probe Positioner	±0.4%	R	$\sqrt{3}$	1	1	±0.2%	±0.2%	∝
Probe Positioning	±2.9%	R	$\sqrt{3}$	1	1	±1.7%	±1.7%	∝
Max. SAR Eval.	±1.0%	R	$\sqrt{3}$	1	1	±0.6%	±0.6%	∝
Test Sample Related								
Device Positioning	±2.9%	N	1	1	1	±2.9%	±2.9%	145
Device Holder	±3.6%	N	1	1	1	±3.6%	±3.6%	5
Power Drift	±5.0%	R	$\sqrt{3}$	1	1	±2.9%	±2.9%	∝
Phantom and Setup								
Phantom Uncertainty	±4.0%	R	$\sqrt{3}$	1	1	±2.3%	±2.3%	∝
Liquid Conductivity (target)	±5.0%	R	$\sqrt{3}$	0.64	0.43	±1.8%	±1.2%	∝
Liquid Conductivity (meas.)	±2.5%	N	1	0.64	0.43	±1.6%	±1.1%	∝
Liquid Permittivity (target)	±5.0%	R	$\sqrt{3}$	0.6	0.49	±1.7%	±1.4%	∝
Liquid Permittivity (meas.)	±2.5%	N	1	0.6	0.49	±1.5%	±1.2%	∝
Combined Std. Uncertainty						±10.8%	±10.6%	330
Expanded STD Uncertainty						**±21.6%**	**±21.1%**	

DASY4 Uncertainty Budget
According to CENELEC EN 50361 [2]

Error Description	Uncertainty value	Prob. Dist.	Div.	(c_i) 1g	(c_i) 10g	Std. Unc. (1g)	Std. Unc. (10g)	(v_i) v_{eff}
Measurement Equipment								
Probe Calibration	±5.9%	N	1	1	1	±5.9%	±5.9%	∞
Axial Isotropy	±4.7%	R	$\sqrt{3}$	0.7	0.7	±1.9%	±1.9%	∞
Spherical Isotropy	±9.6%	R	$\sqrt{3}$	0.7	0.7	±3.9%	±3.9%	∞
Probe Linearity	±4.7%	R	$\sqrt{3}$	1	1	±2.7%	±2.7%	∞
Detection Limit	±1.0%	R	$\sqrt{3}$	1	1	±0.6%	±0.6%	∞
Boundary Effects	±1.0%	R	$\sqrt{3}$	1	1	±0.6%	±0.6%	∞
Readout Electronics	±0.3%	N	1	1	1	±0.3%	±0.3%	∞
Response Time	±0.8%	N	1	1	1	±0.8%	±0.8%	∞
Noise	±0%	N	1	1	1	±0%	±0%	∞
Integration Time	±2.6%	N	1	1	1	±2.6%	±2.6.%	∞
Mechanical Constraints								
Scanning System	±0.4%	R	$\sqrt{3}$	1	1	±0.2%	±0.2%	∞
Phantom Shell	±4.0%	R	$\sqrt{3}$	1	1	±2.3%	±2.3%	∞
Probe Positioning	±2.9%	R	$\sqrt{3}$	1	1	±1.7%	±1.7%	∞
Device Positioning	±2.9%	N	1	1	1	±2.9.%	±2.9%	145
Physical Parameters								
Liquid Conductivity (target)	±5.0%	R	$\sqrt{3}$	0.7	0.5	±2.0%	±1.4%	∞
Liquid Conductivity (meas.)	±4.3%	R	$\sqrt{3}$	0.7	0.5	±1.7%	±1.2%	∞
Liquid Permittivity (target)	±5.0%	R	$\sqrt{3}$	0.6	0.5	±1.7%	±1.4%	∞
Liquid Permittivity (meas.)	±4.3%	R	$\sqrt{3}$	0.6	0.5	±1.5%	±1.2%	∞
Power Drift	±5.0%	R	$\sqrt{3}$	1	1	±2.9%	±2.9%	∞
RF Ambient Conditions	±3.0%	R	$\sqrt{3}$	1	1	±1.7%	±1.7%	∞
Post-Processing								
Extrap. and Integration	±1.0%	R	$\sqrt{3}$	1	1	±0.6%	±0.6%	∞
Combined Std. Uncertainty						± 10.9%	± 10.6%	18125
Expanded Std. Uncertainty						**±21.7%**	**±12.1%**	

APPENDIX B – PROBE CALIBRATION CERTIFICATES

Calibration Laboratory of
Schmid & Partner
  Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

ilac-MRA

SWISS CALIBRATION

S   Schweizerischer Kalibrierdienst
C   Service suisse d'étalonnage
S   Servizio svizzero di taratura
    Swiss Calibration Service

Accredited by the Swiss Federal Office of Metrology and Accreditation
The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client   **Bay Area**

Certificate No: **ET3-1604_May06**

CALIBRATION CERTIFICATE

Object	ET3DV6 - SN: 1604
Calibration procedure(s)	QA CAL-01.v5 and QA CAL-12.v4 Calibration procedure for dosimetric E-field probes
Calibration date:	May 2, 2006
Condition of the calibrated item	In Tolerance

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Calibrated by, Certificate No.)	Scheduled Calibration
Power meter E4419B	GB41293874	5-Apr-06 (METAS, No. 251-00557)	Apr-07
Power sensor E4412A	MY41495277	5-Apr-06 (METAS, No. 251-00557)	Apr-07
Power sensor E4412A	MY41498087	5-Apr-06 (METAS, No. 251-00557)	Apr-07
Reference 3 dB Attenuator	SN: S5054 (3c)	11-Aug-05 (METAS, No. 251-00499)	Aug-06
Reference 20 dB Attenuator	SN: S5086 (20b)	4-Apr-06 (METAS, No. 251-00558)	Apr-07
Reference 30 dB Attenuator	SN: S5129 (30b)	11-Aug-05 (METAS, No. 251-00500)	Aug-06
Reference Probe ES3DV2	SN: 3013	2-Jan-06 (SPEAG, No. ES3-3013_Jan06)	Jan-07
DAE4	SN: 654	2-Feb-06 (SPEAG, No. DAE4-654_Feb06)	Feb-07

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (SPEAG, in house check Nov-05)	In house check: Nov-07
Network Analyzer HP 8753E	US37390585	18-Oct-01 (SPEAG, in house check Nov-05)	In house check: Nov 06

	Name	Function	Signature
Calibrated by:	Katja Pokovic	Technical Manager	
Approved by:	Niels Kuster	Quality Manager	

Issued: May 3, 2006

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

Certificate No: ET3-1604_May06   Page 1 of 9

Calibration Laboratory of
Schmid & Partner
  Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

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SWISS CALIBRATION

S   Schweizerischer Kalibrierdienst
C   Service suisse d'étalonnage
S   Servizio svizzero di taratura
    Swiss Calibration Service

Accredited by the Swiss Federal Office of Metrology and Accreditation
The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Glossary:

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConF	sensitivity in TSL / NORMx,y,z
DCP	diode compression point
Polarization φ	φ rotation around probe axis
Polarization ϑ	ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\vartheta = 0$ is normal to probe axis

Calibration is Performed According to the Following Standards:
    a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
    b) CENELEC EN 50361, "Basic standard for the measurement of Specific Absorption Rate related to human exposure to electromagnetic fields from mobile phones (300 MHz - 3 GHz), July 2001

Methods Applied and Interpretation of Parameters:
- *NORMx,y,z*: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not effect the E^2-field uncertainty inside TSL (see below *ConF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConF*.
- *DCPx,y,z*: DCP are numerical linearization parameters assessed based on the data of power sweep (no uncertainty required). DCP does not depend on frequency nor media.
- *ConF and Boundary Effect Parameters*: Assessed in flat phantom using E-field (or Temperature Transfer Standard for $f \leq 800$ MHz) and inside waveguide using analytical field distributions based on power measurements for $f > 800$ MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORMx,y,z * ConF whereby the uncertainty corresponds to that given for *ConF*. A frequency dependent *ConF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.

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