UltraTech
Group of Labs

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February 11th, 2002

FCC ID: **AFJIC-M2A**
FCC Application Processing Branch
Correspondence Reference Number: **21949**
731 Confirmation Number: **EA940445**

Attn: **Mr. Martin Perrine**

With respect to your recent queries concerning this application, please find following the information you have requested for clarification on certain items.

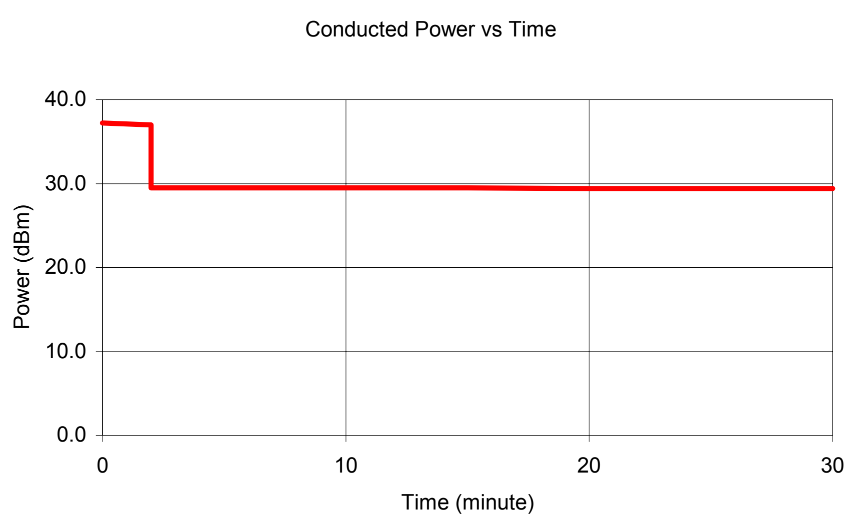
A) The alkaline battery pack cannot sustain high power mode (5W) operation; therefore, spurious radiated emissions will be performed at low power mode (1W) for comparison with Ni-Cd battery pack.

Frequency (MHz)	E-Field @ 3 m (dBµV/m)	EMI Detector	Antenna Polarization (H/V)
Highest spurious emissions with transmitter operating at 156.050 MHz			
624.2	62.14	Peak	V
624.2	65.81	Peak	H
Highest spurious emissions with transmitter operating at 157.425 MHz			
629.7	63.50	Peak	V
629.7	64.78	Peak	H

The highest spurious emissions measured with the alkaline battery pack are less than the spurious emissions measured with Ni-Cd battery pack. This confirmed that the original data for spurious radiated emissions is the worst case.

B) Conducted power versus time using alkaline battery pack:

The EUT was initially set to operate at high power mode (5W) with fresh alkaline battery pack, in a period of less than 2 minutes it defaults to low power mode (1W) automatically, as shown below:



C) The SAR System validation was performed on a MAXON phone Model MX-1111 that operated at 836MHz. It was initially tested at 3D-EMC facility in Ft. Lauderdale – Florida by Mr. Oscar Garay and he provided us with the reference SAR value for this sample. This sample was selected because it was analogue CW with a fixed antenna and no headset wires and it operated at 835MHz which is optimal for SAR system evaluations.

SAR 1g Values (W/Kg)	3D-EMC Value	Ultratech Value
Head Left Ear	1.55	1.50

We re-tested the sample and produced a full report to characterize this sample which we are attaching for your reference. At that time, there were no established system verification procedures and testing a reference sample against 3D-EMC's reference system which was well known by Mr. Kwok Chan at that time, seemed the most prudent course to take. Our system validation procedure now has been adapted to comply with the IEEE P1528 standard based on a dipole rather than a reference sample.

D) For the Brain Tissue, the tissue parameters are as follows:

Tissue Parameters	Conductivity	Dielectric Constant
Target Value	0.76	52.30
Measured Value	0.81	62.58

SAR is defined as $$SAR = \frac{|E|^2 \cdot \sigma}{\rho}$$

where:
σ = Simulated tissue conductivity,
ρ = Tissue density

From the above equation, it can be seen that SAR is directly proportional to the conductivity in a linear relationship. As the conductivity of the tissue increases, so proportionally does the SAR so for the measured tissue, a higher SAR is expected to be obtained over the target parameter by 0.81/0.76 or 6.6% higher so the measured reading is 6.6% higher than if the target tissue were used. The dielectric constant is not directly used by this system in the calculation of local or average SAR.

Based on data provided by N. Kuster and Q. Balzano, "Energy absorption mechanism by biological bodies in the near field of dipole antennas above 300MHz", IEEE Transactions on Vehicular Technology, vol. 41(1), pp. 17-23, 1992, we have extrapolated the SAR sensitivity with respect to the dielectric constant for 150MHz to be –0.17 using a 5th order polynomial curve fit. Attached are the reference data and the curve fit chart. The change in the SAR due to dielectric constant would therefore be changed by a factor of 52.3/62.58*(0.17) = 0.142 increase (14.2% increase). Compensating for both conductivity (decrease of 6.6%) and permitivity (increase of 14.2%), the SAR due to tissue parameters used for the head would therefore increase by 7.6% from 0.76 to **0.82** W/Kg which is still well below the 1.6W/Kg limit and the body tissue still results in the higher SAR value obtained

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E) The boundary effects can occur where there are hot spots that have very narrow peaks and occupy a relatively small area of the zoom scan. The boundary effect has been found to cause an oversensitivity of the probe to the measured E-Field resulting in an overestimation of the local SAR in the vicinity of 3 to 4mm from the liquid/phantom surface. The attenuation vs. depth curves obtained during these measurements were not compensated for boundary effects and the affected curves can provide a large overestimate in some cases of the 1g average SAR. Boundary effect compensation has not been implemented and will be carried out in all future SAR measurements.

Should there be any further clarifications required, please do not hesitate to contact me at your earliest convenience.

Best Regards,

Victor H. Kee, P.Eng

Attached.

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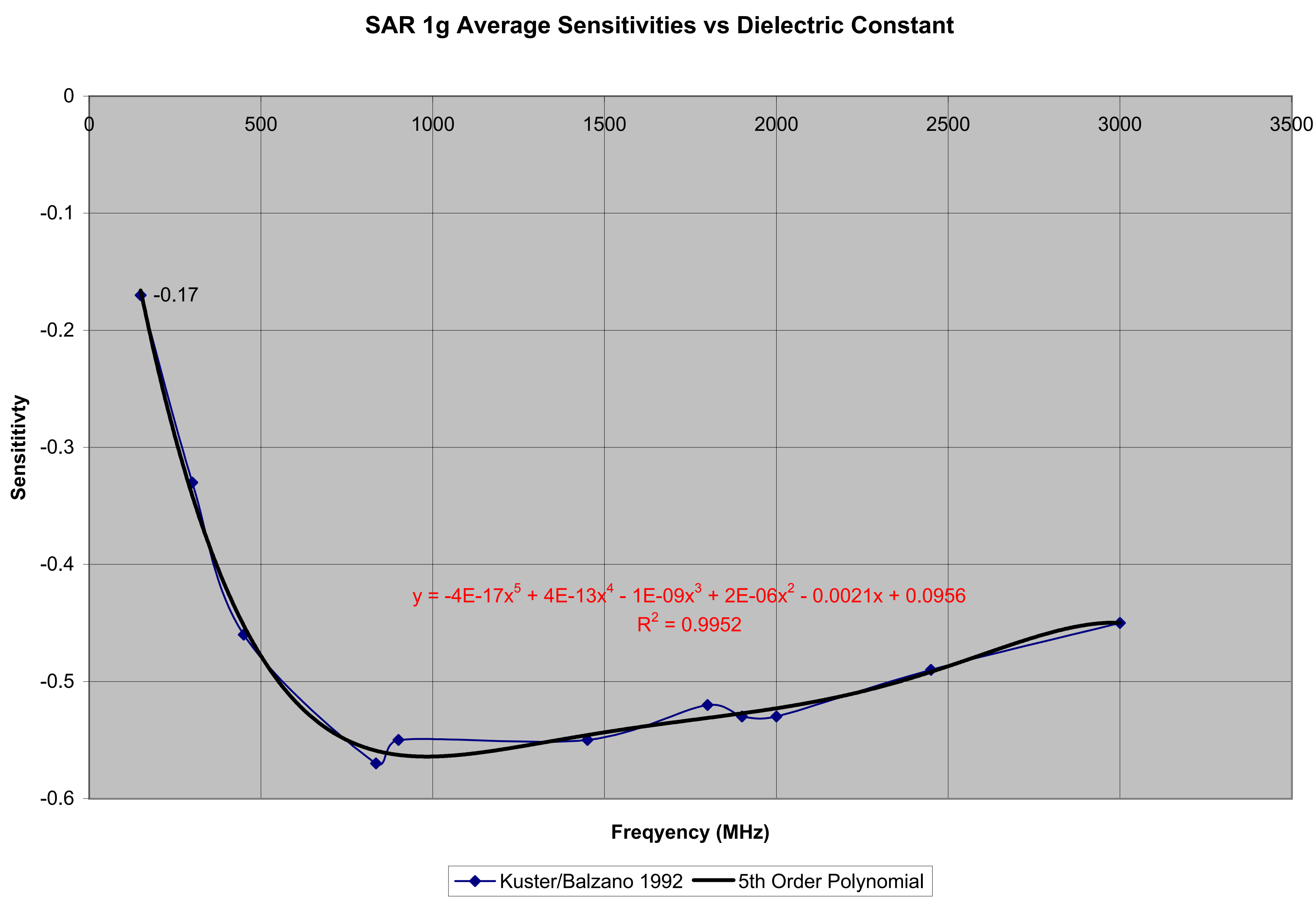
SAR 1g Average Sensitivities vs Dielectric Constant
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
0
500
1000
1500
2000
2500
3000
3500
Sensititivty
-0.17
y = -4E-17x5 + 4E-13x4 - 1E-09x3 + 2E-06x2 - 0.0021x + 0.0956
R2 = 0.9952
Freqyency (MHz)
Kuster/Balzano 1992
5th Order Polynomial

Application Note: SAR Sensitivities

Introduction

The measured SAR-values in homogeneous phantoms depend strongly on the electrical parameters of the liquid. Liquids with exactly matching parameters are difficult to produce; there is always a small error involved in the production or measurement of the liquid parameters. The following sensitivities allow the estimation of the influence of small parameter errors on the measured SAR values. The calculations are based on an approximation formula [1] for the SAR of an electrical dipole near the phantom surface and a adapted plane wave approximation for the penetration depth. The sensitivities are given in percent SAR change per percent change in the controlling parameter:

$$S(x) = \frac{d\,SAR / SAR}{d\,x / x}$$

The controlling parameters x are:

- ε : permitivity
- σ : conductivity
- ρ : brain density (= one over integration volume)

For example: If The liquid permitivity increases by 2 percent and the sensitivity of the SAR to permitivity is -0.6 then the SAR will decrease by 1.2 percent.

The sensitivities are given for surface SAR values and averaged SAR values for 1 g and 10 g cubes and for dipole distances d of 10mm (for frequencies below 1000 MHz) and 15mm (for frequencies above 1000 MHz) from the liquid surface.

Liquid parameters are as proposed in the new standards (e.g., IEEE 1528).

References

[1] N. Kuster and Q. Balzano, “Energy absorption mechanism by biological bodies in the near field of dipole antennas above 300 MHz”, *IEEE Transacions on Vehicular Technology*, vol. 41(1), pp. 17-23, 1992.

Parameter	ε	σ	ρ
f=300 MHz (εr=45.3, σ=0.87S/m, ρ=1g/cm³)			
d=15mm: Surface	- 0.41	+ 0.48	—
1 g	- 0.33	+ 0.28	0.08
10 g	- 0.26	+ 0.09	0.16
f=450 MHz (εr=43.5, σ=0.87S/m, ρ=1g/cm³)			
d=15mm: Surface	- 0.56	+ 0.67	—
1 g	- 0.46	+ 0.43	0.09
10 g	- 0.37	+ 0.22	0.17
f=835 MHz (εr=41.5, σ=0.90S/m, ρ=1g/cm³)			
d=15mm: Surface	- 0.70	+ 0.86	—
1 g	- 0.57	+ 0.59	0.10
10 g	- 0.45	+ 0.35	0.18
f=900 MHz (εr=41.5, σ=0.97S/m, ρ=1g/cm³)			
d=15mm: Surface	- 0.69	+ 0.86	—
1 g	- 0.55	+ 0.57	0.10
10 g	- 0.44	+ 0.32	0.19
f=1450 MHz (εr=40.5, σ=1.20/m, ρ=1g/cm³)			
d=10mm: Surface	- 0.73	+ 0.91	—
1 g	- 0.55	+ 0.55	0.12
10 g	- 0.42	+ 0.27	0.22
f=1800 MHz (εr=40.0, σ=1.40S/m, ρ=1g/cm³)			
d=10mm: Surface	- 0.73	+ 0.92	—
1 g	- 0.52	+ 0.51	0.14
10 g	- 0.38	+ 0.21	0.24
f=1900 MHz (εr=40.0, σ=1.40S/m, ρ=1g/cm³)			
d=10mm: Surface	- 0.73	+ 0.93	—
1 g	- 0.53	+ 0.51	0.14
10 g	- 0.39	+ 0.22	0.24
f=2000 MHz (εr=40.0, σ=1.40S/m, ρ=1g/cm³)			
d=10mm: Surface	- 0.74	+ 0.94	—
1 g	- 0.53	+ 0.52	0.14
10 g	- 0.39	+ 0.22	0.24
f=2450 MHz (εr=39.2, σ=1.80S/m, ρ=1g/cm³)			
d=10mm: Surface	- 0.74	+ 0.93	—
1 g	- 0.49	+ 0.41	0.17
10 g	- 0.34	+ 0.12	0.28
f=3000 MHz (εr=38.5, σ=2.40S/m, ρ=1g/cm³)			
d=10mm: Surface	- 0.75	+ 0.90	—
1 g	- 0.45	+ 0.28	0.21
10 g	- 0.32	+ 0.02	0.31

ENGINEERING TEST REPORT

Maxon
Model No.: MX-1111

Applicant: **Maxon America Inc.**
10828 North West Air World Drive
Kansas, MO 64153-1238
USA

Tested in Accordance With

SAR (Specific Absorption Rate) Requirements using guidelines established in IEEE C95.1-1991, FCC OET Bulletin 65 (Supplement C) and Industry Canada RSS-102(Issue 1)

UltraTech's File No.: MXA-002Q

This Test report is Issued under the Authority of Tri M. Luu, Professional Engineer, Vice President of Engineering UltraTech Group of Labs …………………………………………………………… Date: ………………………	
Report Prepared by: JaeWook Choi …………………………..……………………………….	Tested by: JaeWook Choi, SAR Engineer …………………………..………………………………..
Issued Date: June 26, 2000	Test Dates: June 06, 2000

The results in this Test Report apply only to the sample(s) tested, which has been randomly selected.

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EXHIBIT 1. INTRODUCTION

1.1. SCOPE

Reference:	SAR (Specific Absorption Rate) Requirements IEEE C95.1-1991, FCC OET Bulletin 65 (Supplement C) , Industry Canada RSS-102 (Issue 1).
Title	Safety Levels with respect to human exposure to Radio Frequency Electromagnetic Fields Guideline for Evaluating the Environmental Effects of Radio frequency Radiation
Purpose of Test:	To show compliance with Federal regulated SAR requirements in Canada and the US.
Method of Measurements:	IEEE C95.1-1991, FCC OET Bulletin 65 (Supplement C) and Industry Canada RSS-102(Issue 1)
Exposure Category	[X] General population, uncontrolled exposure [ ] occupational, controlled exposure

1.2. REFERENCES

The methods and procedures used for the measurements contained in this report are details in the following reference standards:

Publications	**Year**	**Title**
Industry Canada RSS102	1999	"Evaluation Procedure for Mobile and Portable Radio Transmitters with respect to Health Canada's Safety Code 6 for Exposure of Humans to Radio Frequency Fields"
NCRP Report No.86	1986	"Biological Effects and Exposure Criteria for radio Frequency Electromagnetic Fields"
FCC OET Bulletin 65	1997	"Evaluating Compliance with FCC Guidelines for Human Exposure to radio Frequency Fields"
ANSI/IEEE C95.3	1992	"Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave"
ANSI/IEEE C95.1	1992	"Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3kHz to 300GHz"

EXHIBIT 2. SUMMARY OF TEST RESULTS & GENERAL STATEMENT OF CERTIFICATION

SAR Limits	Test Requirements	Compliance (Yes/No)
General population/Uncontrolled exposure 0.08W/kg whole body average and spatial peak SAR of 1.6W/kg, averaged over 1gram of tissue Hands, wrist, feet and ankles have a peak SAR not to exceed 4 W/kg, averaged over 10 grams of tissue.	Requirements using guidelines established in IEEE C95.1-1991, FCC OET Bulletin 65 (Supplement C), Industry Canada RSS-102 (Issue 1).	Yes
Occupational/Controlled Exposure 0.4W/kg whole body average and spatial peak SAR of 8W/kg, averaged over 1gram of tissue Hands, wrist, feet and ankles have a peak SAR not to exceed 20 W/kg, averaged over 10 grams of tissue.	Requirements using guidelines established in IEEE C95.1-1991, FCC OET Bulletin 65 (Supplement C), Industry Canada RSS-102 (Issue 1).	N/A

TESTIMONIAL AND STATEMENT OF CERTIFICATION

THIS IS TO CERTIFY:

1) *THAT the application was prepared either by, or under the direct supervision of the undersigned.*

2) *THAT the measurement data supplied with the application was taken under my direction and supervision.*

3) *THAT the data was obtained on representative production units, representative.*

4) *THAT, to the best of my knowledge and belief, the facts set forth in the application and accompanying technical data are true and correct.*

Certified by:

____
Tri Minh Luu, P. Eng.
V.P., Engineering

DATE: June 26, 2000

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EXHIBIT 3. GENERAL INFORMATION

3.1. APPLICANT AND MANUFACTURER

APPLICANT:	
Name:	Maxon America Inc.
Address:	10828 North West Air World Drive Kansas, MO 64153-1238 USA
Contact Person:	Mr. Roger Bisby Phone #: +1-816-891-3434 (721) Fax #: +1-816-891-8815 Email Address: Roger.bisby@maxonusa.com

MANUFACTURER:	
Name:	Maxon Electronics Co LTD
Address:	70-55 Song Jeong Dong Hung Duk Ku Cheong Ju City, Korea
Contact Person:	Mr. Roger Bisby Phone #: +1-816-891-3434 (721) Fax #: +1-816-891-8815 Email Address: Roger.bisby@maxonusa.com

3.2. DEVICE UNDER TEST (DUT)

The following information are supplied by the applicant.

Manufacturer	Maxon Electronics Co LTD
Trade Name	Maxon
Type/Model Number	MX-1111
Serial Number	AR10601011005000042
Type of Equipment	Cellular Telephone
Frequency of Operation	824 MHz ~ 849 MHz
Rated RF Power	0.5 W
Antenna Type	Helix
External Power Supply	Ni-MH Battery Pack (DC 3.6V 600mAh)
Primary User Functions of DUT:	Voice Radio Communication Through Air

3.3. PHOTOGRAPH OF DUT

< Front View >

< Rear View >

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3.4. LIST OF DUT'S ACCESSORIES:

None

3.5. SPECIAL CHANGES ON THE DUT'S HARDWARE/SOFTWARE FOR TESTING PURPOSES

None

3.6. ANCILLARY EQUIPMENT

None

3.7. GENERAL TEST CONFIGURATIONS

3.7.1. General

3.7.1.1. Equipment Configuration

Power and signal distribution, grounding, interconnecting cabling and physical placement of equipment of a test system shall simulate the typical application and usage in so far as is practicable, and shall be in accordance with the relevant product specifications of the manufacturer.

The configuration that tends to maximize the DUT's emission or minimize its immunity is not usually intuitively obvious and in most instances selection will involve some trial and error testing. For example, interface cables may be moved or equipment re-orientated during initial stages of testing and the effects on the results observed.

Only configurations within the range of positions likely to occur in normal use need to be considered.

The configuration selected shall be fully detailed and documented in the test report, together with the justification for selecting that particular configuration.

3.7.1.2. Exercising Equipment

The exercising equipment and other auxiliary equipment shall be sufficiently decoupled from the EUT so that the performance of such equipment does not significantly influence the test results.

3.7.2. Specific Operating Conditions

Not specified.

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3.8. GENERAL BLOCK DIAGRAM OF TEST SETUP

The EUT was configured as normal intended use. The following block diagram shows the equipment arrangement during tests:

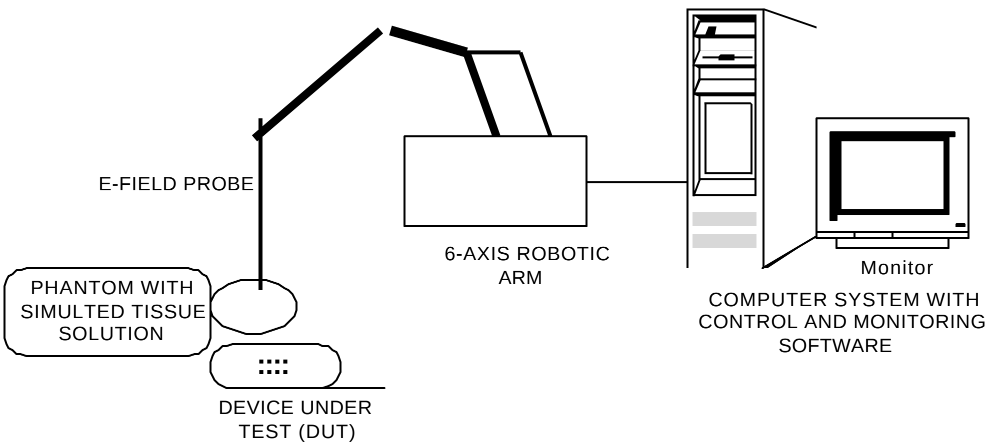


EXHIBIT 4. SUMMARY OF TEST RESULTS

4.1. LOCATION OF TESTS

All of the measurements described in this report were performed at Ultratech Group of Labs located in:

3000 Bristol Circle, Oakville, Ontario, Canada.

4.2. SUMMARY OF SAR TEST RESULTS

The maximum SAR was found to be 1.50 W/Kg at 824 MHz measured on the fixed antenna configuration. The DUT was found to be in compliance with the 1.6 W/Kg limit.

EXHIBIT 5. RADIO INFORMATION

5.1. MEASUREMENT

EUT Information		Condition	
Radio Type	Cellular phone	Robot Type	6 Axis
Model Number	MX-1111	Scan Type	SAR
Serial Number	AR10601011005000042	Measured Field	E
Frequency Band (MHz)	824 ~ 849	Phantom Type	Head Left Ear
Frequency Tested (MHz)	824, 836, 849	Phantom Position	Left Ear
Nominal Output Power (W)	0.5	Room Temperature	24 ± 1 °C
Antenna Type	Helix		
Signal Type	AMPS		
Duty Cycle	100 %		

Type of Tissue	Brain	
Target Frequency (MHz)	835	
Target Dielectric Constant	46.1	
Target Conductivity (S/m)	0.74	
Composition (by weight)	Tap Water (43.69%) Sugar (56.25%) HEC (0.05%) Bactericide (0.01%)	
Measured Dielectric Constant	44.4	
Measured Conductivity (S/m)	0.76	
Probe Name	E	
Probe Orientation	Isotropic	
Probe Offset (mm)	3.0	
Sensor Factor	10.8	
Conversion Factor	0.61	
Calibration Date (MM/DD/YY)	03/24/99	

5.2. SAR MEASUREMENT DATA

Maximum Field at (5 , -35)				
DUT Positioning	Frequency (MHz)	Measured Power (dBm)	SAR (W/Kg)	DUT Configuration
Head – Left Ear	836	26.5 avg	1.50	

DUT Positioning	Frequency (MHz)	Measured Power (dBm)	SAR (W/Kg)	DUT Configuration
Head – Left Ear	824	26.5 avg	1.50	
	836	26.1 avg	1.23	
	849	24.3 avg	0.89	

5.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSE

None

EXHIBIT 6. MEASUREMENTS, EXAMINATIONS & TEST DATA FOR SAR

6.1. LOCATION OF TEST

All tests were performed at Ultratech Group of Labs located at:

3000 Bristol Circle, Oakville, Ontario, Canada.

6.2. MEASUREMENT SYSTEM SPECIFICATIONS

Positioner	Probe
Type : 3D Near Field Scanner Location Repeatability : 0.1mm Speed 180 ^{o}/sec AC motors	Sensor : E-Field Spatial Resolution : 0.1 cm^3 Isotropic Response : ± 0.25 dB Dynamic Range : 2 μW/g to 100 mW/g
Computer	**Phantom**
Type : 166 MHz Pentium Memory : 32 Meg. RAM Operating System : Windows NT Monitor : 17" SVGA	Tissue : Simulated Tissue with electrical characteristics similar to those of the human at normal body temperature. Shell : Fiberglass human shell shaped (1.5 mm thick)

6.3. TEST PROCEDURES

In the SAR measurement, the positioning of the probes must be performed with sufficient accuracy to obtain repeatable measurements in the presence of rapid spatial attenuation phenomena. The accurate positioning of the E-field probe is accomplished by using a high precision robot. The robot can be taught to position the probe sensor following a specific pattern of points. In a first sweep, the sensor is positioned as close as possible to the interface, with the sensor enclosure touching the inside of the fiberglass shell. The SAR is measured on a grid of points, which covers the curved surface of the phantom in an area larger than the size of the DUT. After the initial scan, a high- resolution grid is used to locate the absolute maximum measured energy point. At this location, attenuation versus depth scan will be accomplished by the measurement system to calculate the SAR value.

6.4. PHANTOM

The phantom used in the evaluation of the RF exposure of the user of the wireless device is a clear fiberglass enclosure 1.5 mm thick, shaped like a human head or body and filled with a mixture simulating the dielectric characteristics of the brain, muscle or other types of human tissue. The maximum width of the cranial model is 17 cm, the cephalic index is 0.7 and the crown circumference of the cranial model is 61 cm. The ear is 6 mm above the outer surface of the shell.

6.5. SIMULATED TISSUE

Simulated Tissue: Suggested in a paper by George Hartsgrove and colleagues in University of Ottawa Ref.: Bioelectromagnetics 8:29-36 (1987)

Ingredient	Quantity
Water	40.4 %
Sugar	56.0 %
Salt	2.5 %
HEC	1.0 %
Bactericide	0.1 %

Table. Example of composition of simulated tissue.

This simulated tissue is mainly composed of water, sugar and salt. At higher frequencies, in order to achieve the proper conductivity, the solution does not contain salt. Also, at these frequencies, D.I. water and alcohol is preferred.

Tissue Density : Approximately 1.25 g/cm^3

6.5.1. Preparation

We determine the volume needs and carefully measure all components. A clean container is used were the ingredients will be mixed. A stirring paddle and a hand drill is used to stir the mixture. First we heat the DI water to about 40 ^{o}C to help the ingredients to dissolve and then we pour the salt and the bactericide. We stir until all the ingredients are completely dissolved. We continue stirring slowly while adding the sugar. We avoid high RPM from the mixing device to prevent air bubbles in the mixture. Later on, we add the HEC to maintain the solution homogeneous. Mixing time is approximately 30 to 40 min.

6.6. MEASUREMENT OF ELECTRICAL CHARACTERISTICS OF SIMULATED TISSUE

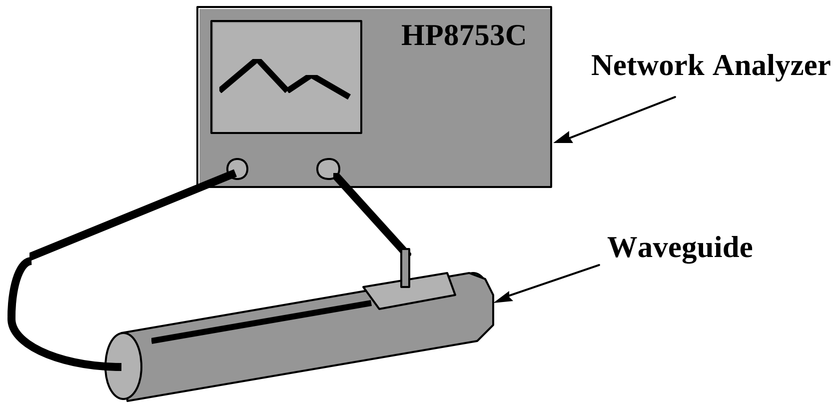
1) Network Analyzer HP8753C or others
2) Slotted Coaxial Waveguide

6.6.1. Description of the slotted coaxial waveguide

The cylindrical waveguide is constructed with copper tube of about 30 to 40 cm of length, generally 12.5 mm diameter, with connectors at both ends. Inside of this tube, a conductive rod about 6.3 mm is coaxial supported by the two ends connectors (radiator). A slot 3 mm wide start at the beginning of the tube to almost the two third of the tube length. The outer edge of the slotted tube is marked in centimeters (10 to 12) every 1 centimeter, 0.5 if higher frequencies. A saddle piece containing the sampling probe is inserted in the slot so the tip of the probe is close but not in contact with the inner conductor (radiator).

To measure the electrical characteristics of the liquid simulated tissue, we fill the coaxial waveguide, select CW frequency and measure amplitude and phase with the Network Analyzer for every point in the slot (typically 11). An effort is made to keep the results dielectric constant and conductivity within 5 % of published data.

Electrical Characteristics
Measurement Setup



$$c = 3 \cdot 10^{8} \ \mathrm{m/s}$$

$$A = \frac{\Delta A}{20} \ln_{10} \frac{1}{m}$$

$$\theta = \frac{\Delta\theta \cdot 2\pi}{360}$$

$$\lambda = \frac{c}{f} \cdot \frac{100}{2.54} \text{inches}$$

$$\varepsilon_{re} = \frac{(A^{2} + \theta^{2}) \cdot \lambda^{2}}{4\pi^{2}}$$

$$\theta' = \left| \frac{|A| \cdot \lambda}{4\pi \sqrt{\varepsilon_{re}}} \right|$$

$$S = \tan(2\theta')$$

$$\varepsilon_{r} = \frac{\varepsilon_{re}}{\sqrt{(1 + S^{2})}}$$

$$\sigma = S \cdot 2\pi \cdot f \cdot 8.854 \cdot 10^{12} \cdot \varepsilon_{r} \ (S/m)$$

where;

ΔA is the amplitude attenuation in dB

$\Delta\theta$ is the phase change in degrees for 5 cm of wave propagation in the slotted line

f is the frequency of interest in Hz

6.7. SYSTEM DESCRIPTION

The measurement system consists of an E-field probe, instrumentation amplifiers, RF transparent cable connecting the amplifiers to the computer, the robotics arm with its extension and proximity sensors, a phantom with simulated tissue and a radio holder to support the device under test. The E-field probe is a three channel device used to measure RF electric fields in the near vicinity of the source. The three sensors are mutually orthogonal positioned dipoles, and are constructed over a quartz substrate. Located in the center of the dipole is a Schottky diode. High impedance lines are connecting the sensor to the amplifier and then optically linked to the computer. The probe has an isotropic response and is transparent to the RF fields.

Calibration is performed by two steps:

1) Determination of free space E-field from amplified probe outputs in a test RF field. This calibration is performed in a TEM cell when the frequency is below 1 GHz and in a waveguide or some other methodologies above 1 GHz. For the free space calibration, we place the probe in the volumetric center of the cavity and at the proper orientation with the field. The probe is then rotated 360 degrees until the three channels show the maximum reading. This reading equate to $1mW/cm^2$ if that power density is available in the correspondent cavity.

2) Correlation of the measured free space E-field, to temperature rise in a dielectric medium. E-field temperature correlation calibration is performed in a planar phantom filled with the appropriate simulated tissue.

For temperature correlation calibration, a RF transparent thermistor-based temperature probe is used in conjunction with the E-field probe. First, the location of the maximum E-field close to the phantom's inner surface is determined as a function of power into the RF source; in this case, a dipole. Then, the E-field probe is moved sideways so that the temperature probe, while affixed to the E-field probe is placed at the previous location of the E-field probe. Finally, temperature changes for 30 seconds exposure at the same RF power levels used for the E-field measurement are recorded. The following equation relates SAR to initial temperature slope:

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

where:
Δt = exposure time (30 seconds),
C = heat capacity of tissue (brain or muscle),
ΔT = temperature increase due to RF exposure.

The heat capacity used for brain simulated tissue is 2.7 joules/^{0}C/g and 3.0 joules/^{0}C/g for muscle.

SAR is proportional to ? T / ?t, the initial rate of tissue heating, before thermal diffusion takes place. Now, it's possible to quantify the electric field in the simulated tissue by equating the thermally derived SAR to the E-field;

$$SAR = \frac{|E|^2 \cdot s}{r}$$

where:
σ = Simulated tissue conductivity,
ρ = Tissue density (1.25 g/cm^3 for simulated tissue)

6.8. DATA EXTRAPOLATION (CURVE FITTING)

There is a distance from the center of the sensor (diode) to the end of the protective tube called 'probe offset'. To compensate we use an exponential curve fitting method to obtain the peak surface value from the voltages measured at the distance from the inner surface of the phantom. At the point where the highest voltage was recorded, the field is measured as close as possible to the phantom's surface and every 1mm along the ` Z ` axis for a distance of 50 mm. The appropriate exponential curve is obtained from all the points measured and used to define an exponential decay of the energy density versus depth.

$$E(z) = E_0 \cdot e^{-z/d} \text{ (mV)}$$

6.9. INTERPOLATION AND GRAM AVERAGING

The voltage, (1 cm) above the phantoms surface (E_{tot} 1 cm), is needed to calculate the exposure over one gram of tissue. This SAR value that estimates the average over 1 gram of tissue, is obtained by taking the integral over 1 cm^2 surface of the measured field along the exponential decay curve of the energy density with depth.

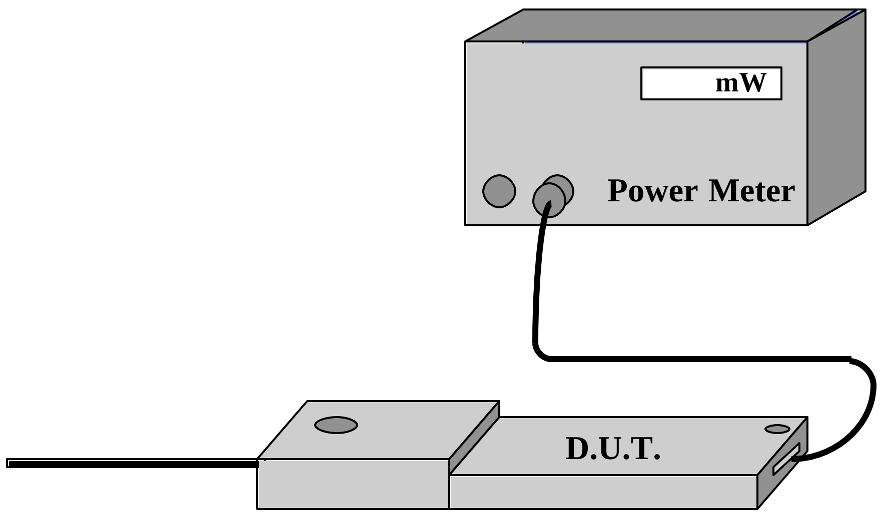
$$SAR(mW/g) = \int_{v=1g} SAR(\bullet)dv = \int_{s=1cm^2} \int_0^{1cm} E(z) \cdot \frac{CF}{SensorFactor} dzds$$

3000 Bristol Circle, Oakville, Ontario, Canada L6H 6G4
Tel. #: 905-829-1570, Fax. #: 905-829-8050, Email: vhk.ultratech@sympatico.ca, Website: http://www.ultratech-labs.com

6.10. POWER MEASUREMENT

When ever possible, a conducted power measurement is performed. To accomplish this, we utilize a fully charged battery, a calibrated power meter and a cable adapter provided by the manufacturer. The data of the cable and related circuit losses are also provided by the manufacturer. The power measurement is then performed across the operational band and the channel with the highest output power is recorded.

Power measurement is performed before and after the SAR to verify if the battery was delivering full power for the time of test. A difference in output power would determinate a need for battery replacement and repetition the SAR test.



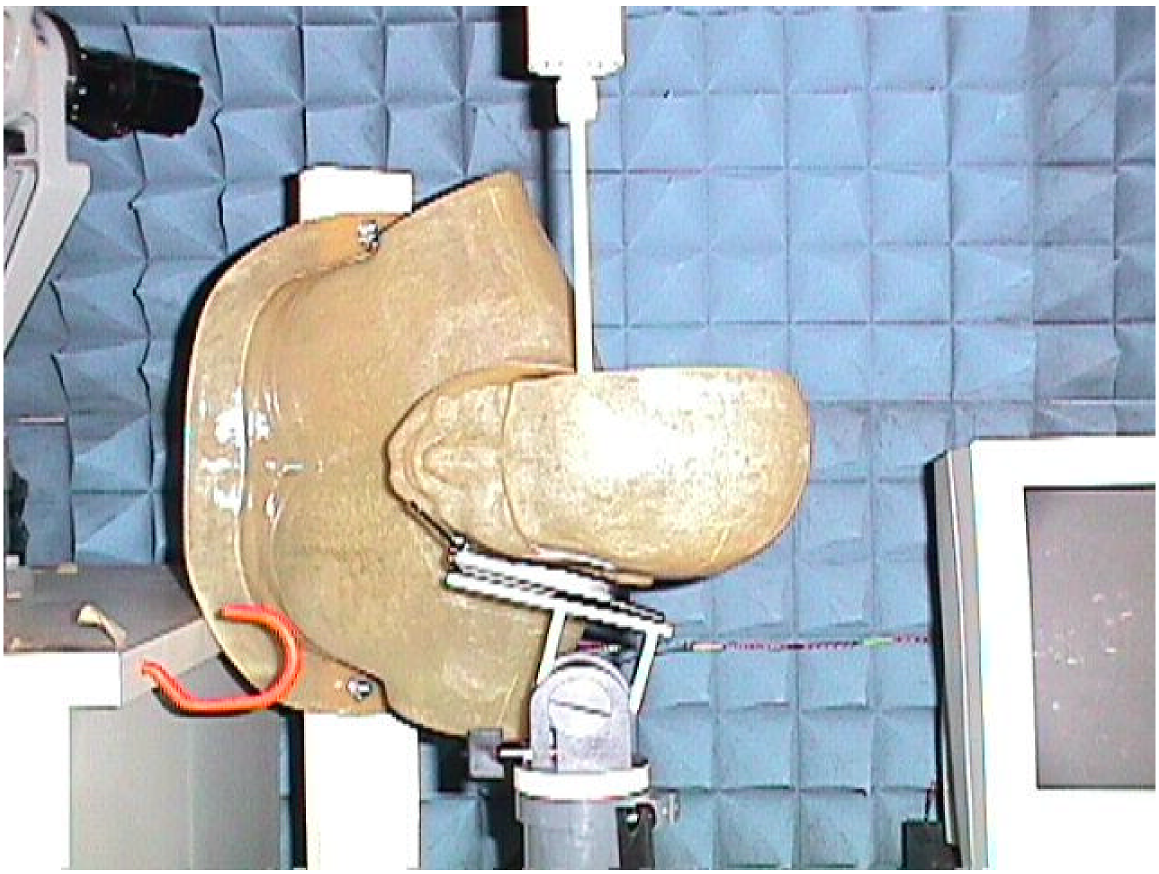
Measured Power Measured Power + Cable and Switching Mechanism Loss

6.11. POSITIONING OF D.U.T.

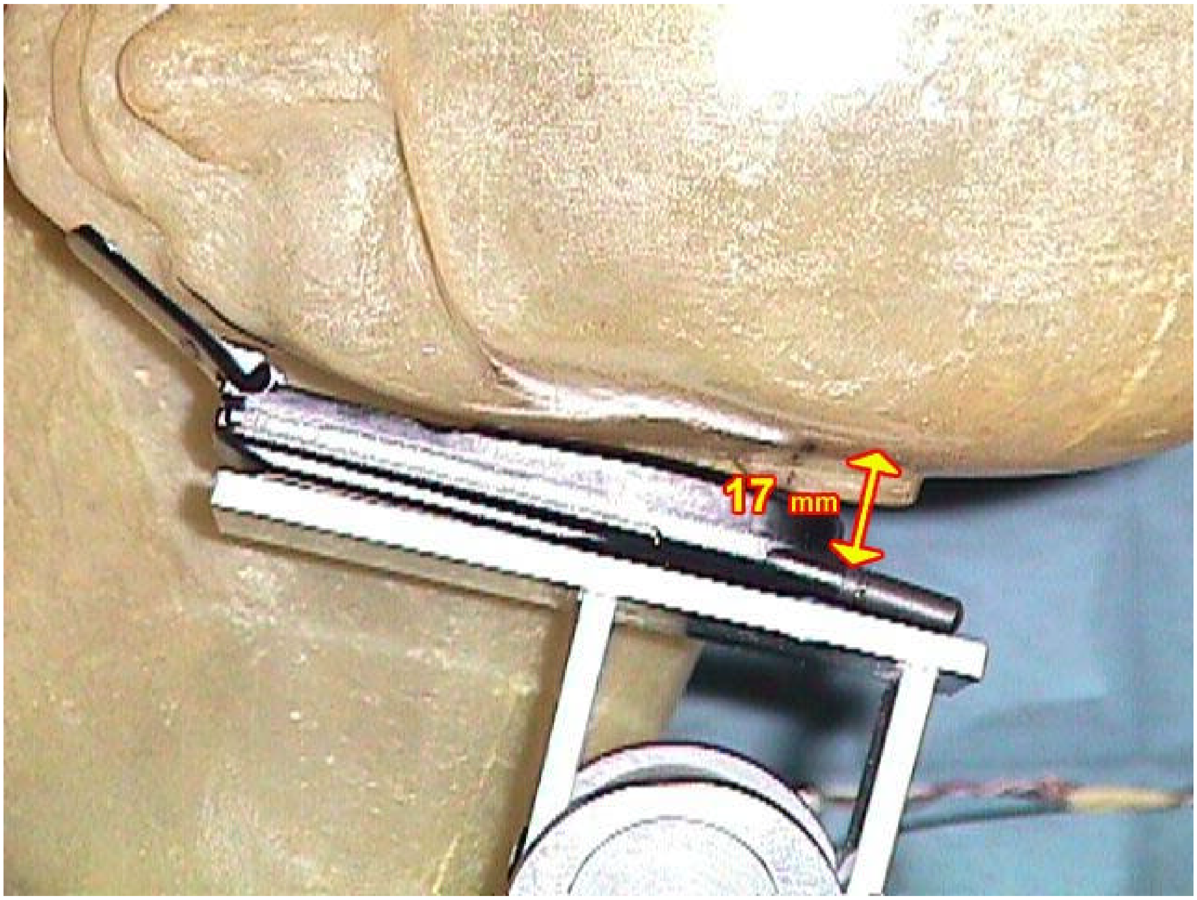
The clear fiberglass phantom shell have been previously marked with a highly visible line, so can easily be seen through the liquid simulated tissue. In the case of testing a cellular phone, this line is connecting the ear channel with the corner of the lips. The D.U.T. is then placed by centering the speaker with the ear channel and the center of the radio width with the corner of the mouth. At the same time the surface of the D.U.T. is always in contact with the phantoms shell. Three points contact; two in the ear region and one on the chin in addition to the previously describe alignment will assure repeatability of the test.

For HAND HELD devices (push-to-talk), or any other type of wireless transmitters, the D.U.T. will be positioned as suggested by manufacturer operational manuals.

Positions of the D.U.T



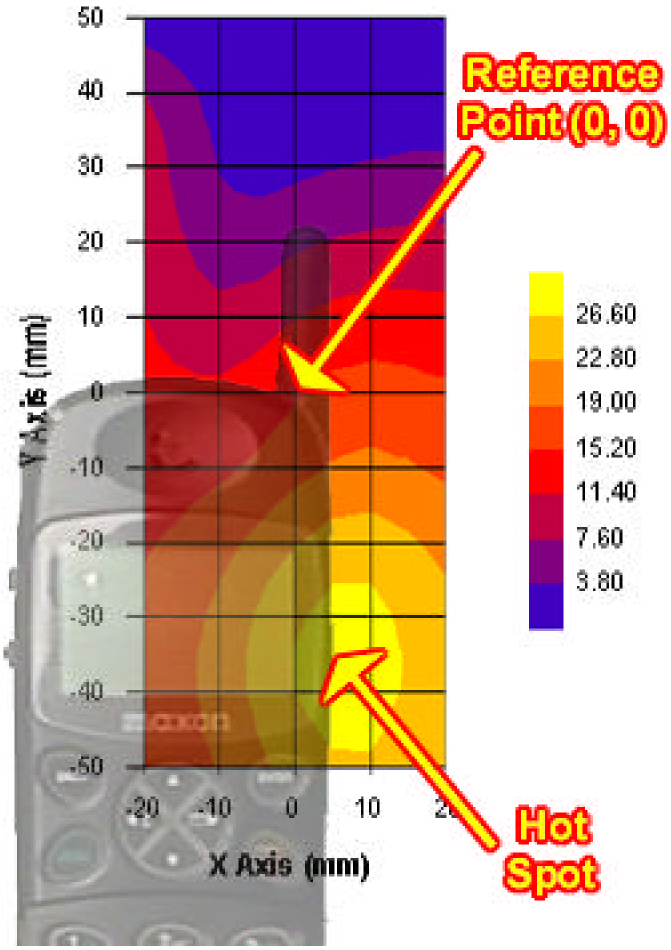
< Head Left Ear >



< Head Left Ear >

Maximum Field Location

(See page 10 & 11 for details)



ANNEX A: Head Left Ear SAR MEASUREMENT

Test Information

Date : 6/6/00
Time : 1:53:31 PM

Product	: Cellular Phone	**Test**	: SAR
Manufacturer	: Maxon	**Frequency (MHz)**	: 824
Model Number	: MX-1111	**Nominal Output Power (W)**	: 0.5
Serial Number	: AR10601011005000042	**Antenna Type**	: Helix
FCC ID Number	: F3JMX1111	**Signal**	: AMPS

Phantom	: Head - Left Ear	**Dielectric Constant**	: 44.4
Simulated Tissue	: Brain	**Conductivity**	: 0.76

Probe	: E	**Antenna Position**	: FIX
Probe Offset (mm)	: 3.00	**Measured Power (dBm) (conducted)**	: 25.8
Sensor Factor (mV)	: 10.8		
Conversion Factor	: 0.61	**Cable Insertion Loss (dB)**	: 0.7
Calibrated Date	: 3/24/99	**Compensated Power (dBm)**	: 26.5

Amplifier Setting :
Channel 1 : 0.0045   Channel 2 : 0.0039   Channel 3 : 0.0031

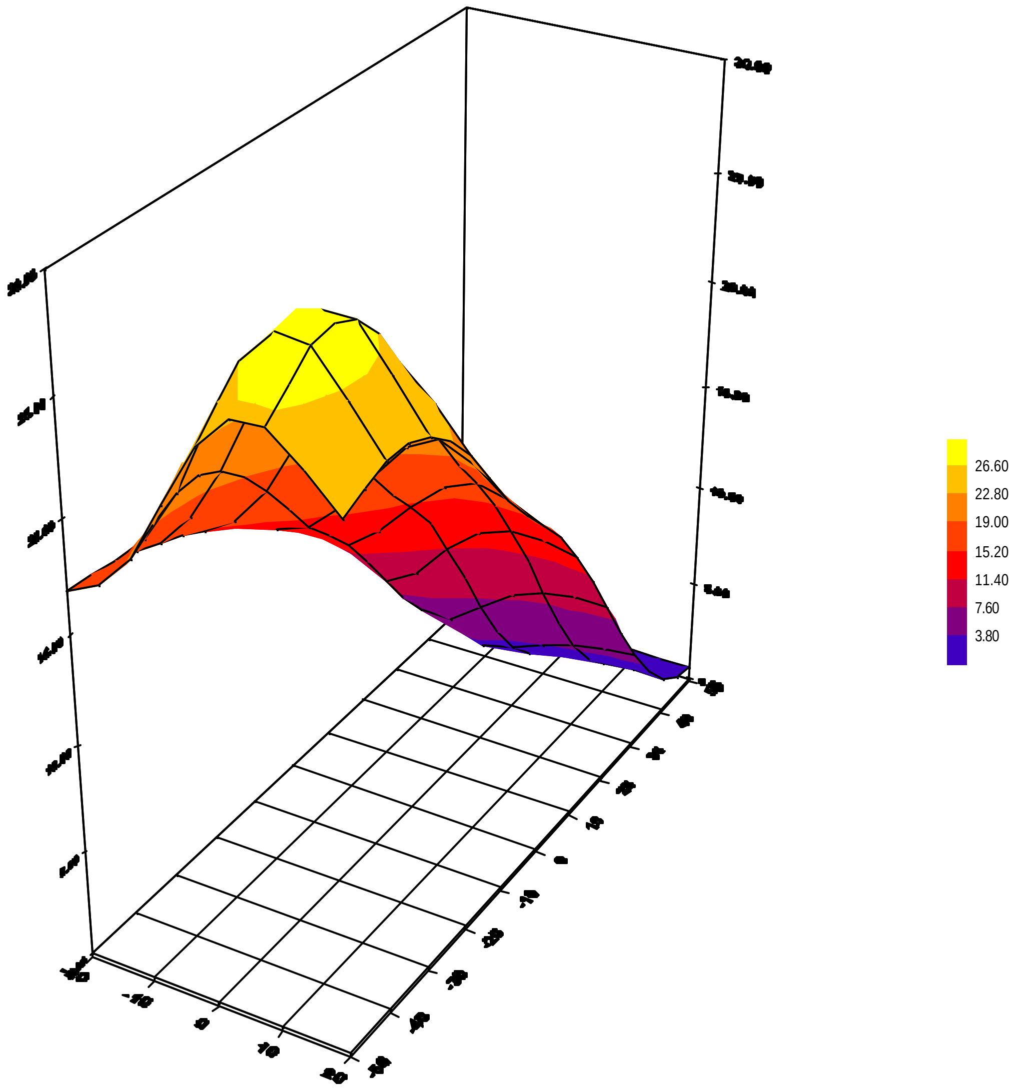
Location of Maximum Field :

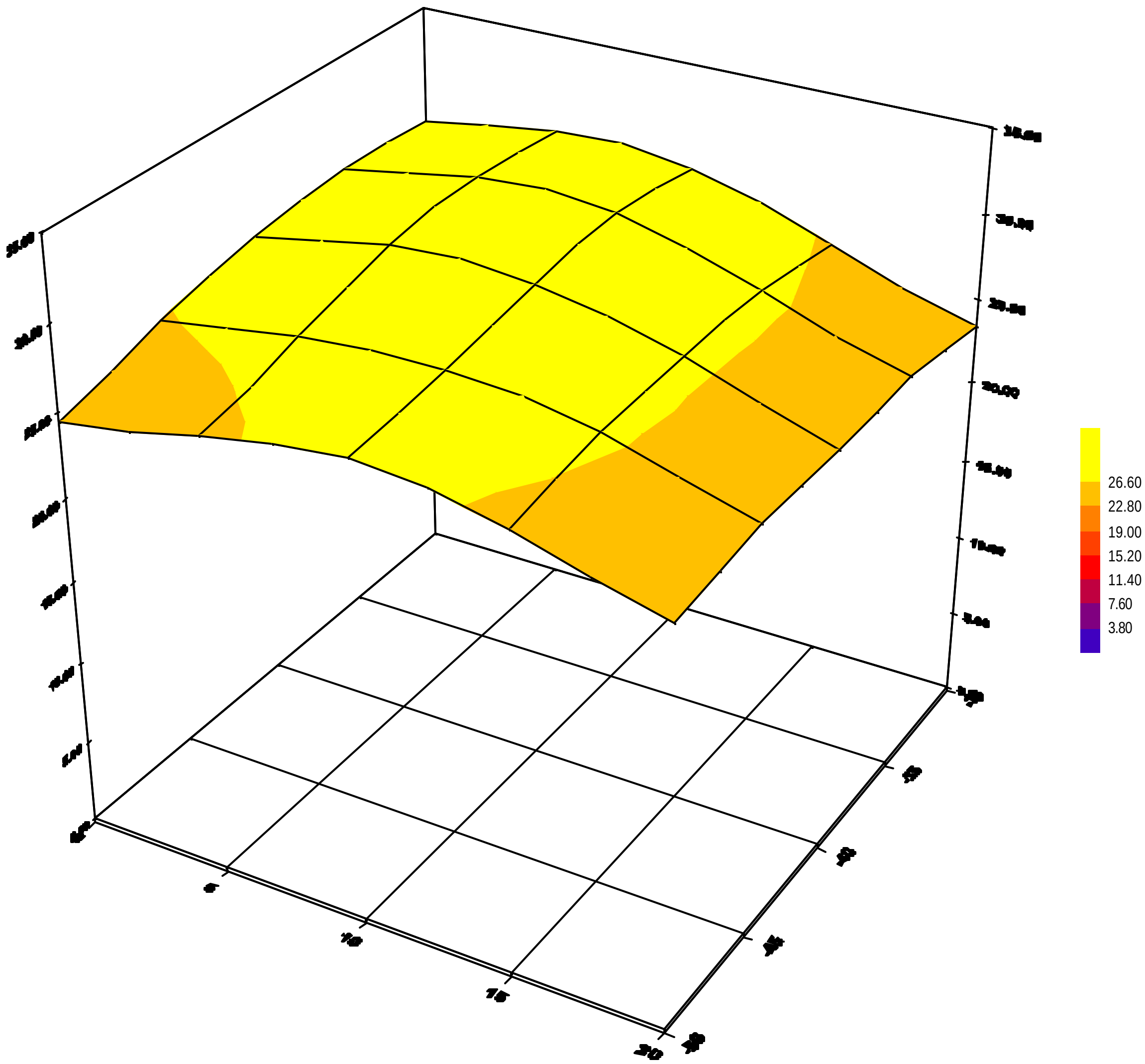
X = 5   Y = -35

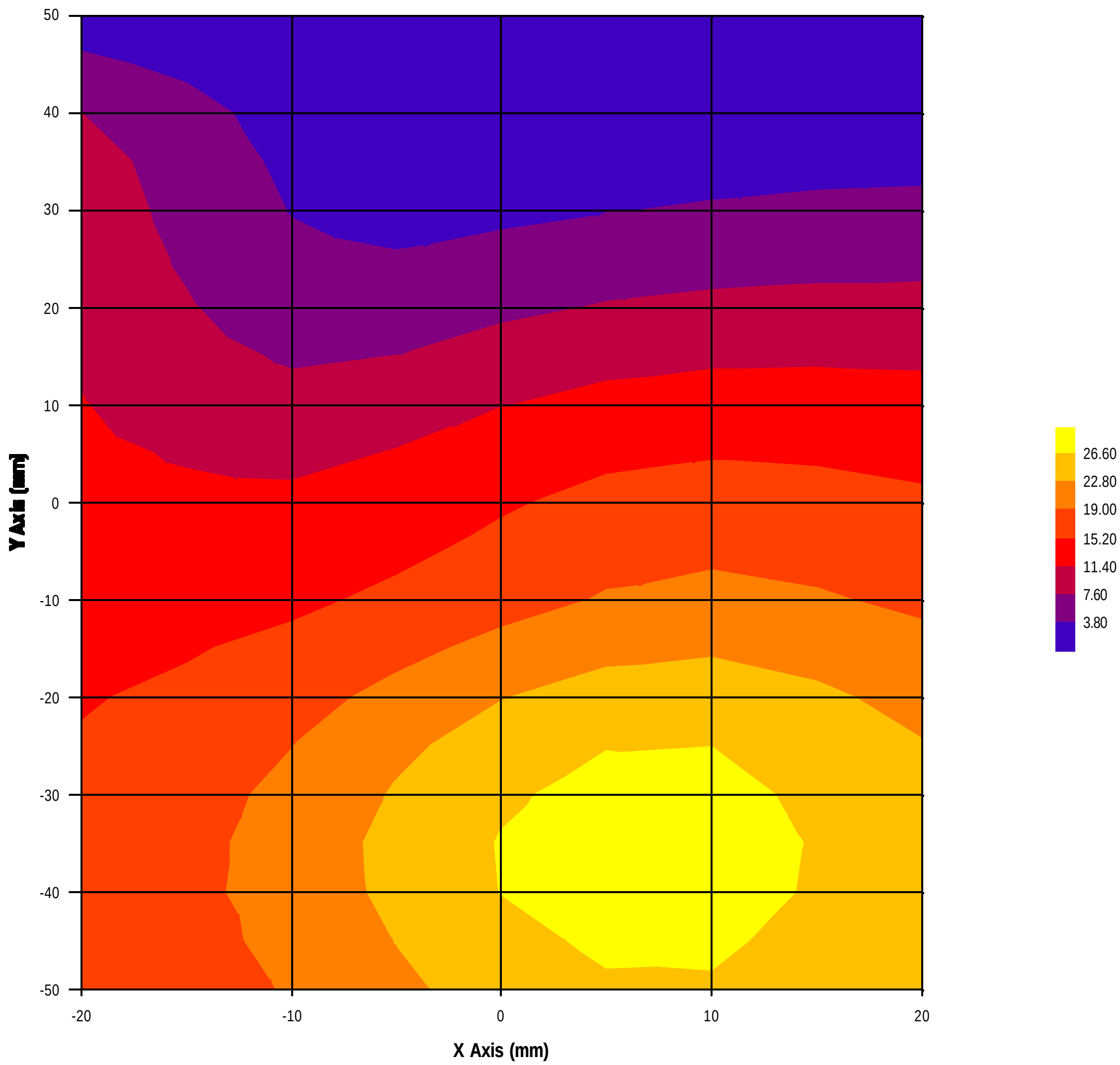
Measured Values (mV) :

29.34	26.89	25.17	23.88	22.81	21.84
20.97	20.08	19.23	18.42	17.63	

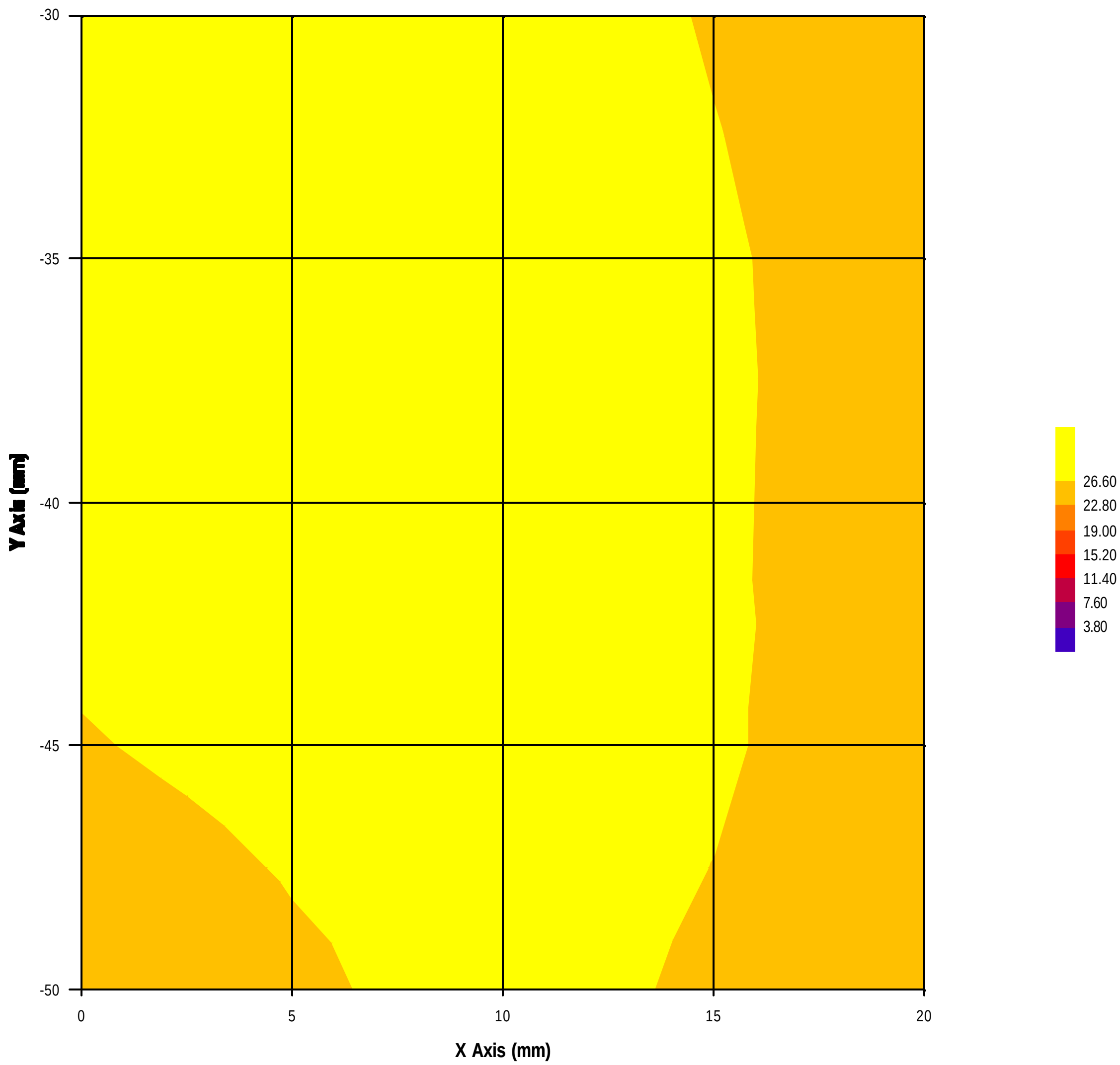
Peak Voltage (mV) : 33.89   **1 Cm Voltage (mV)** : 19.51   **SAR (W/Kg)** : 1.50

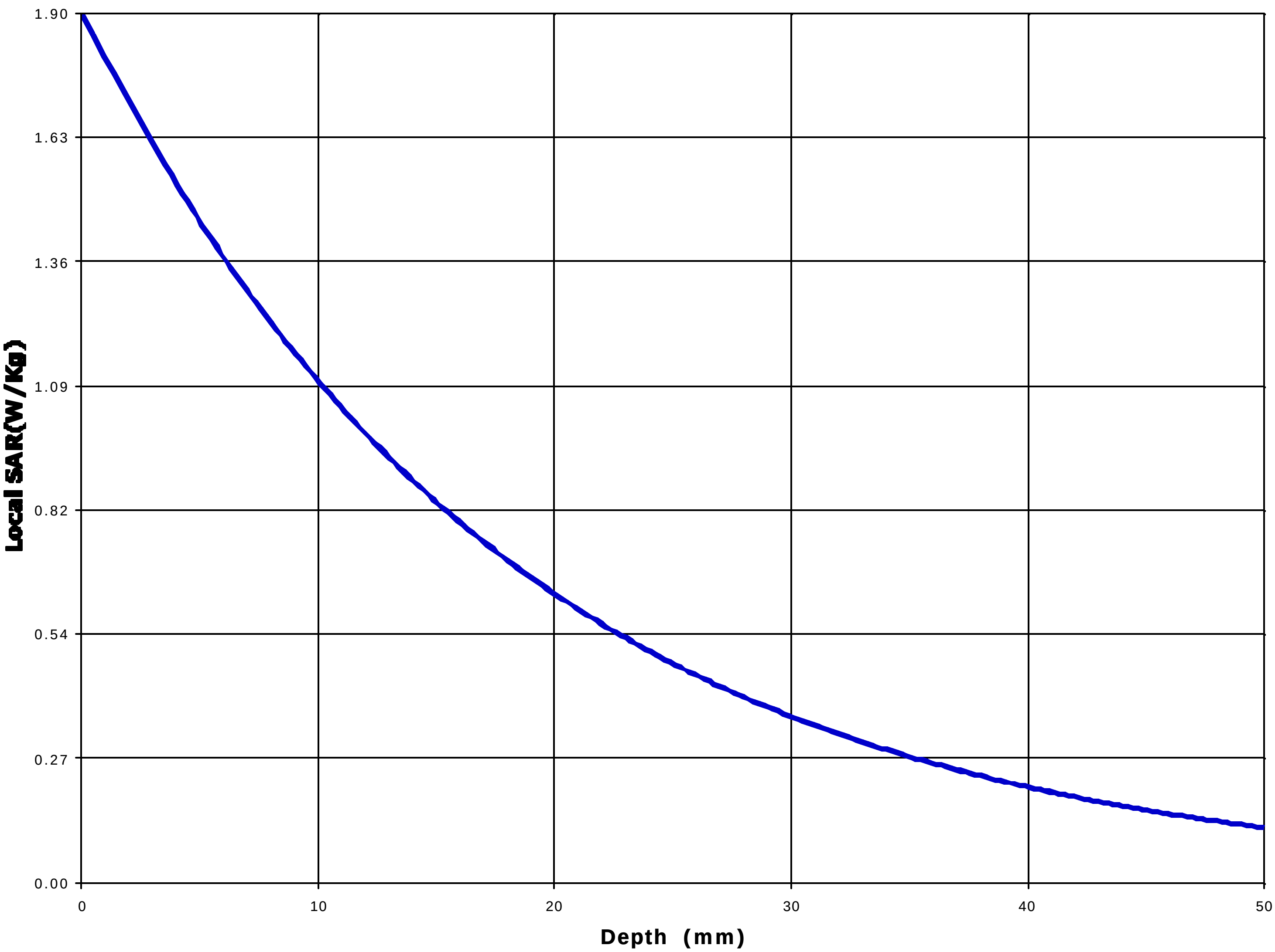

26.60
22.80
19.00
15.20
11.40
7.60
3.80


26.60
22.80
19.00
15.20
11.40
7.60
3.80

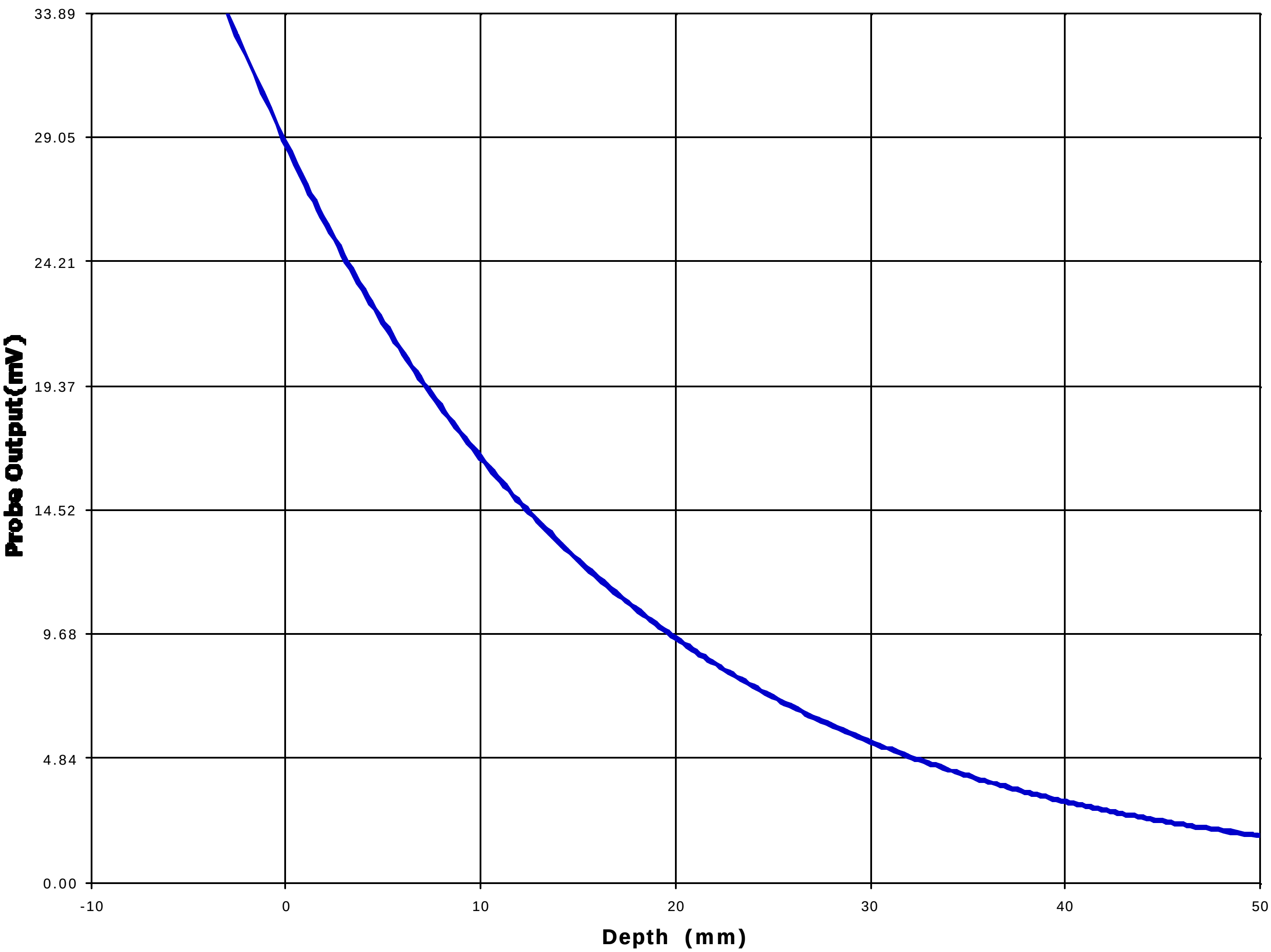


50
40
30
20
10
0
-10
-20
-30
-40
-50
Y Axis (mm)
-20
-10
0
10
20
X Axis (mm)
26.60
22.80
19.00
15.20
11.40
7.60
3.80


-30
-35
-40
-45
-50
0
5
10
15
20
X Axis (mm)
Y Axis (mm)
26.60
22.80
19.00
15.20
11.40
7.60
3.80



Local SAR(W/Kg)
1.90
1.63
1.36
1.09
0.82
0.54
0.27
0.00
0
10
20
30
40
50
Depth (mm)



33.89
29.05
24.21
19.37
14.52
9.68
4.84
0.00
Probe Output(mV)
-10
0
10
20
30
40
50
Depth (mm)

Test Information

Date : 6/6/00
Time : 2:46:46 PM

Product	: Cellular Phone	**Test**	: SAR
Manufacturer	: Maxon	**Frequency (MHz)**	: 836
Model Number	: MX-1111	**Nominal Output Power (W)**	: 0.5
Serial Number	: AR10601011005000042	**Antenna Type**	: Helix
FCC ID Number	: F3JMX1111	**Signal**	: AMPS

Phantom	: Head - Left Ear	**Dielectric Constant**	: 44.4
Simulated Tissue	: Brain	**Conductivity**	: 0.76

Probe	: E	**Antenna Position**	: FIX
Probe Offset (mm)	: 3.00	**Measured Power (dBm) (conducted)**	: 25.4
Sensor Factor (mV)	: 10.8		
Conversion Factor	: 0.61	**Cable Insertion Loss (dB)**	: 0.7
Calibrated Date	: 3/24/99	**Compensated Power (dBm)**	: 26.1

Amplifier Setting :
Channel 1 : 0.0045 Channel 2 : 0.0039 Channel 3 : 0.0031

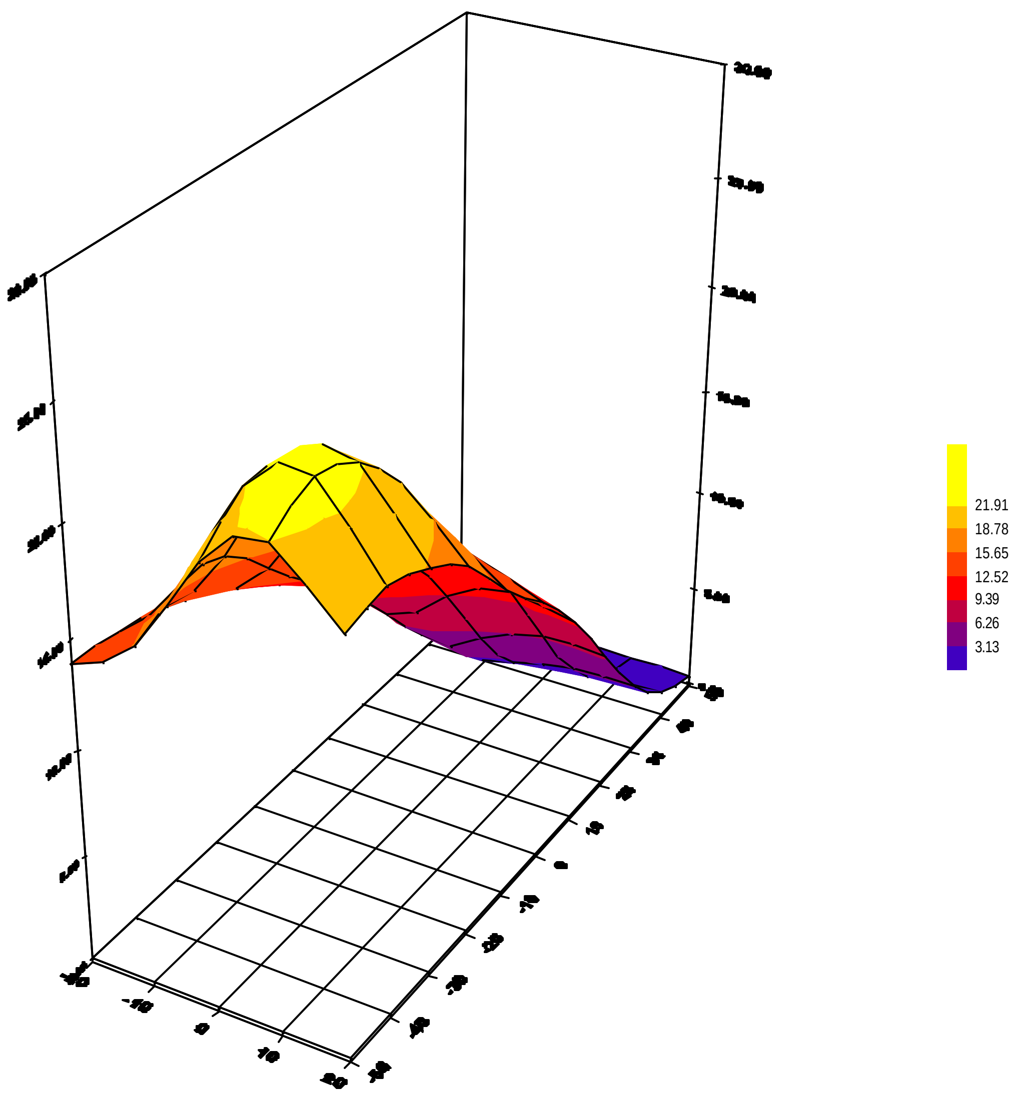
Location of Maximum Field :

X = 5 Y = -35

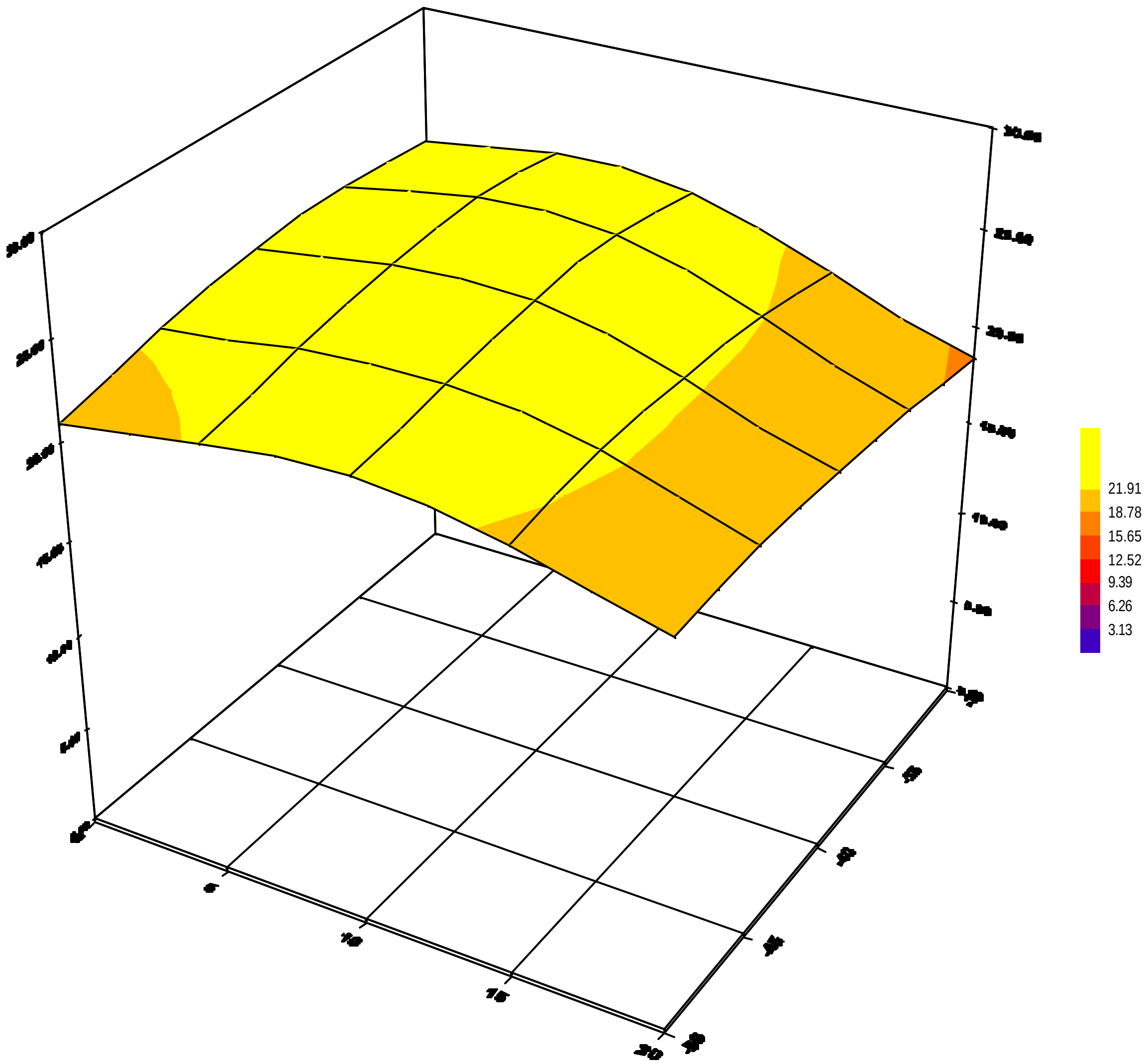
Measured Values (mV) :

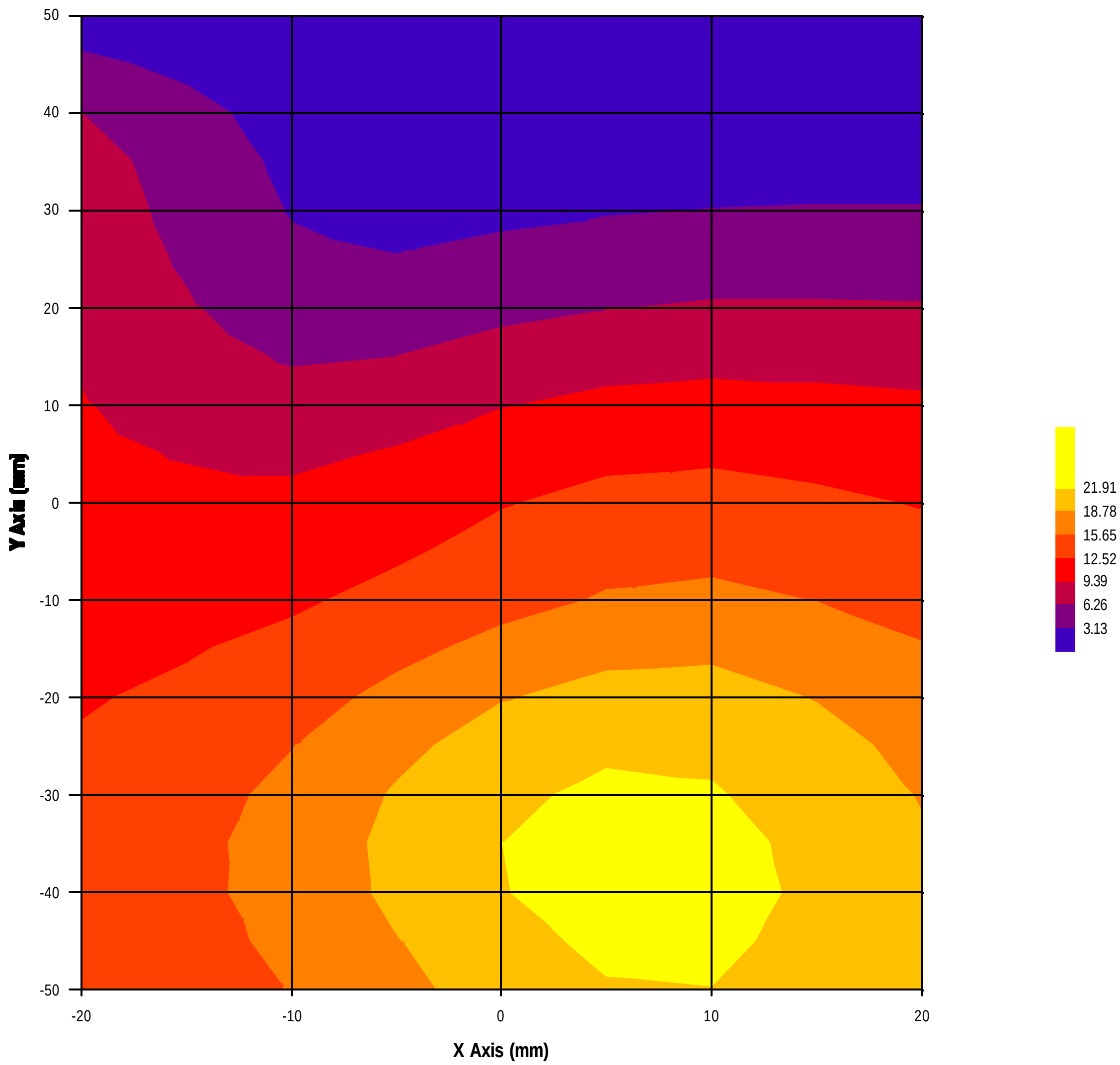
24.44	22.27	20.79	19.74	18.83	18.01
17.44	16.56	15.82	15.13	14.51	

Peak Voltage (mV) : 28.26 **1 Cm Voltage (mV)** : 16.06 **SAR (W/Kg)** : 1.23

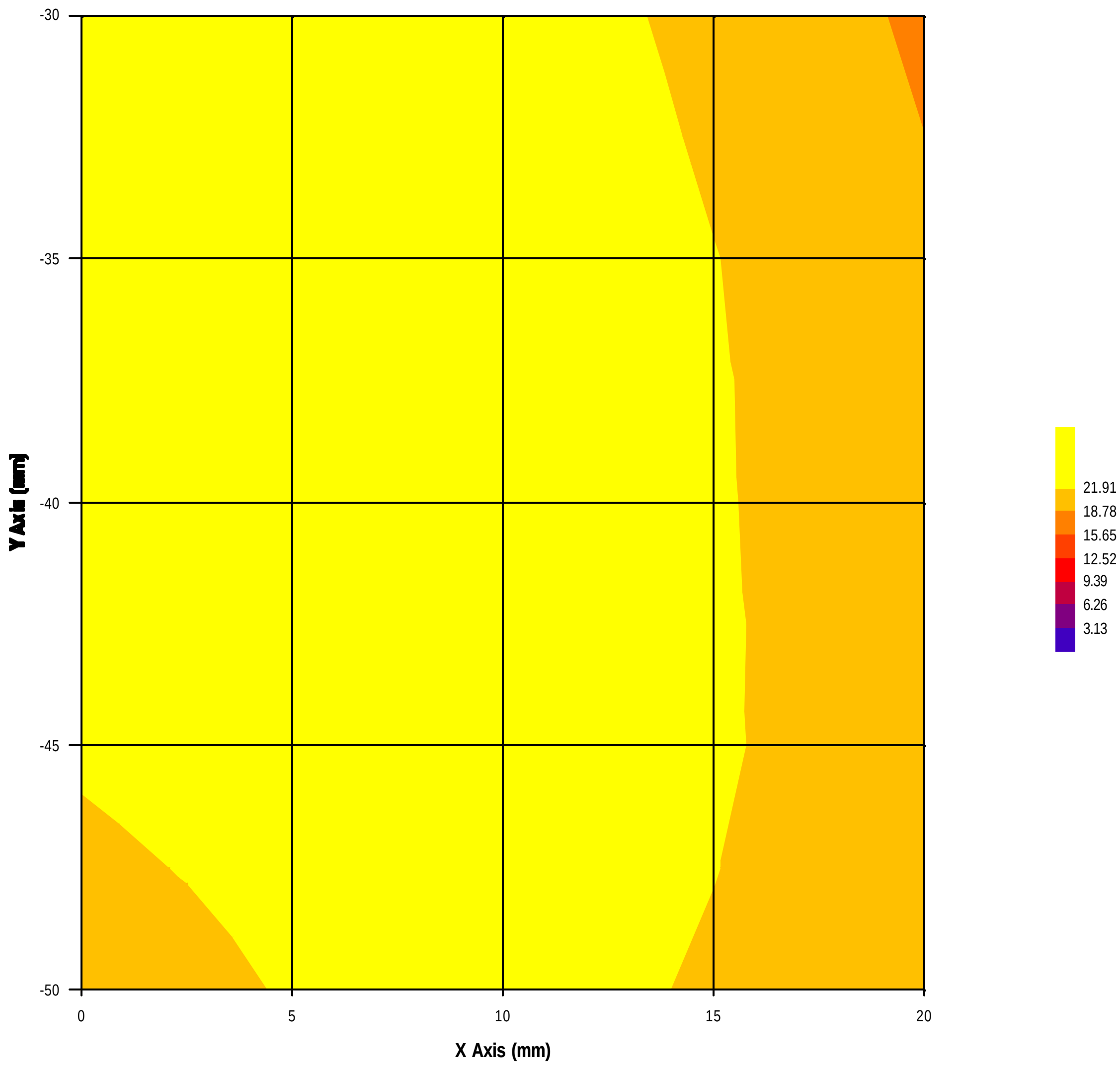


21.91
18.78
15.65
12.52
9.39
6.26
3.13

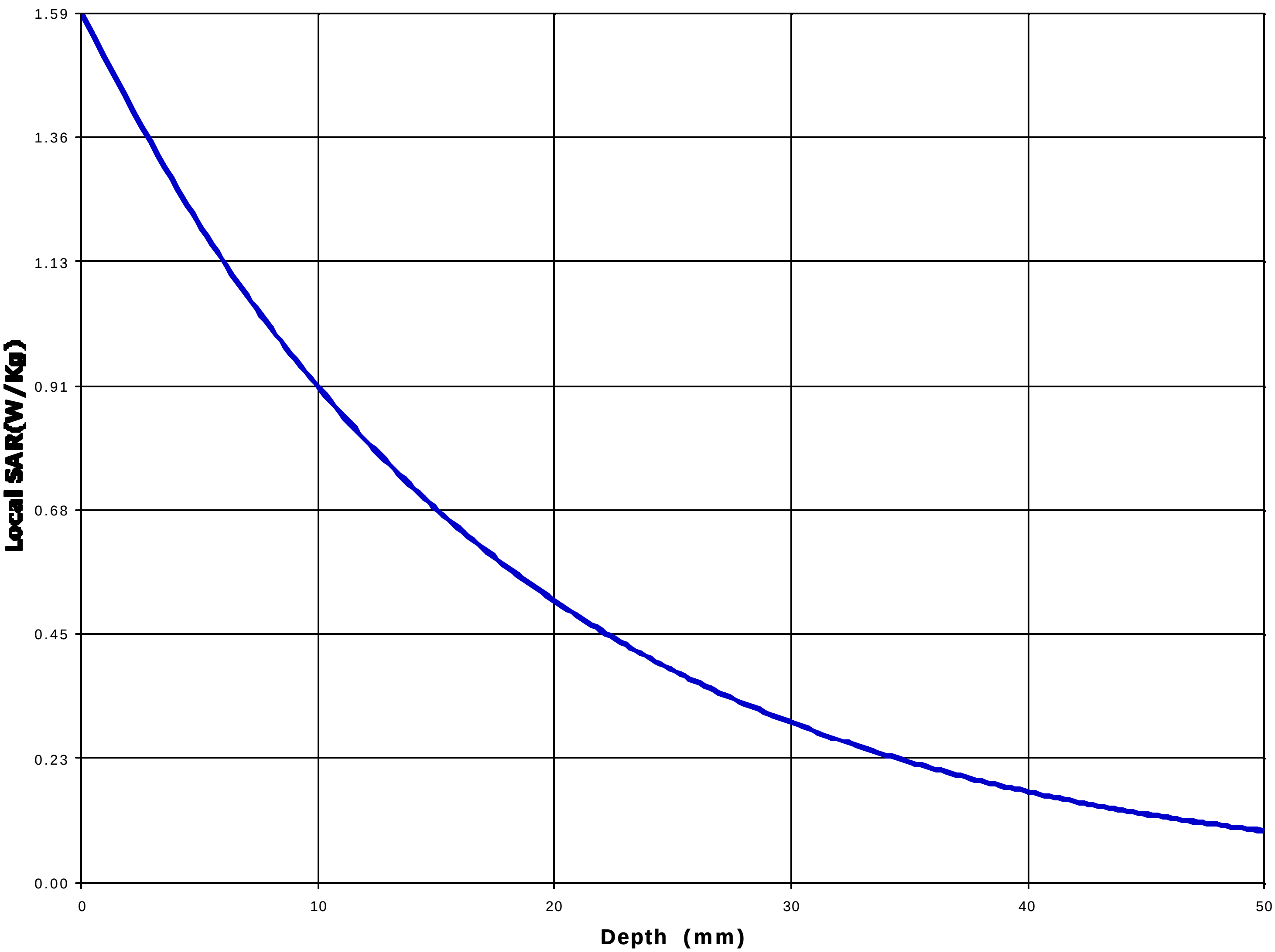

21.91
18.78
15.65
12.52
9.39
6.26
3.13



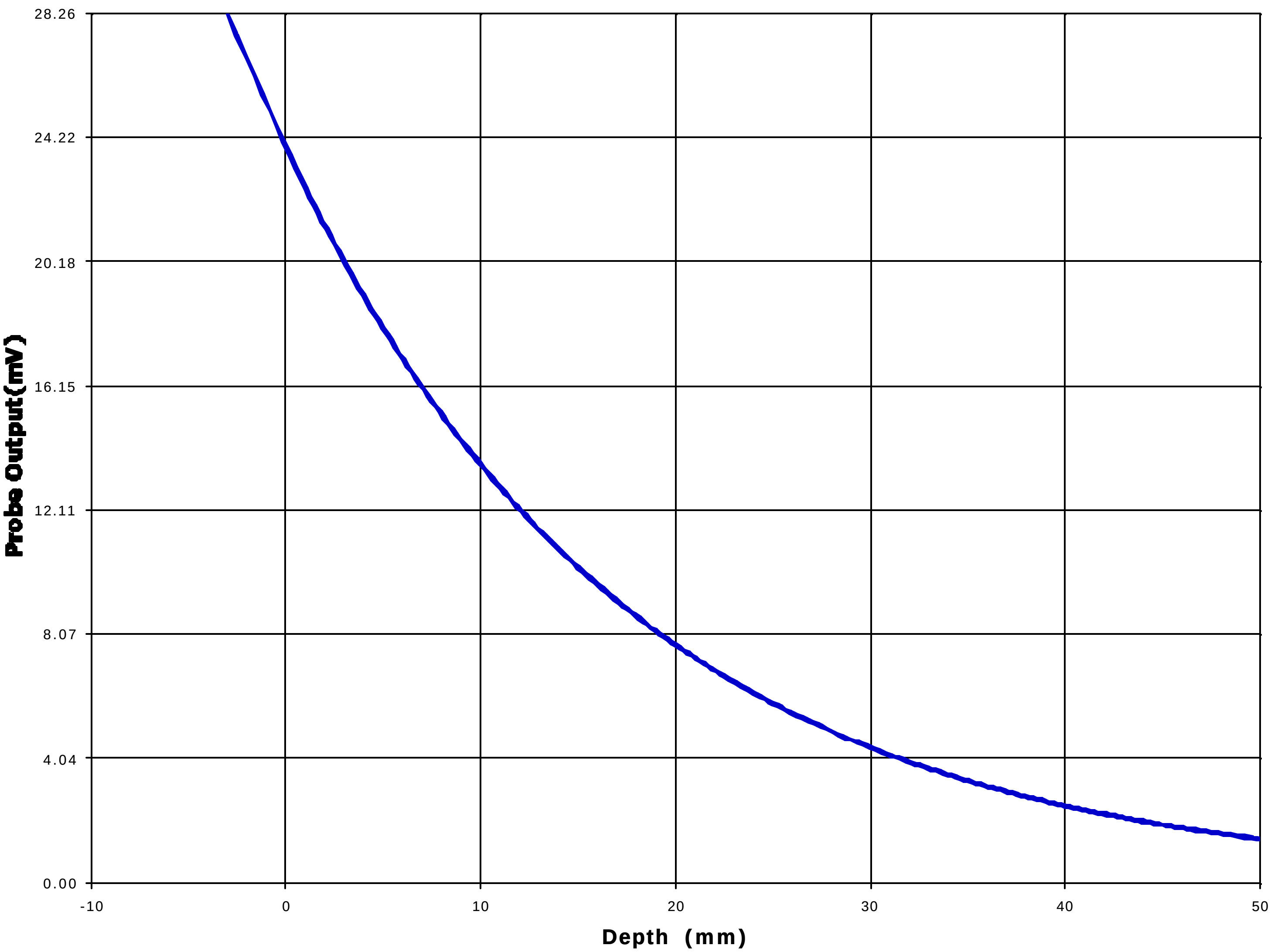
50
40
30
20
10
0
-10
-20
-30
-40
-50
Y Axis (mm)
-20
-10
0
10
20
X Axis (mm)
21.91
18.78
15.65
12.52
9.39
6.26
3.13



-30
-35
-40
-45
-50
Y Axis (mm)
0
5
10
15
20
X Axis (mm)
21.91
18.78
15.65
12.52
9.39
6.26
3.13



1.59
1.36
1.13
0.91
0.68
0.45
0.23
0.00
Local SAR(W/Kg)
0
10
20
30
40
50
Depth (mm)



28.26
24.22
20.18
16.15
12.11
8.07
4.04
0.00
Probe Output(mV)
-10
0
10
20
30
40
50
Depth (mm)

Test Information

Date : 6/6/00
Time : 3:29:26 PM

Product	: Cellular Phone	**Test**	: SAR
Manufacturer	: Maxon	**Frequency (MHz)**	: 849
Model Number	: MX-1111	**Nominal Output Power (W)**	: 0.5
Serial Number	: AR10601011005000042	**Antenna Type**	: Helix
FCC ID Number	: F3JMX1111	**Signal**	: AMPS

Phantom	: Head - Left Ear	**Dielectric Constant**	: 44.4
Simulated Tissue	: Brain	**Conductivity**	: 0.76

Probe	: E	**Antenna Position**	: FIX
Probe Offset (mm)	: 3.00	**Measured Power (dBm) (conducted)**	: 23.6
Sensor Factor (mV)	: 10.8		
Conversion Factor	: 0.61	**Cable Insertion Loss (dB)**	: 0.7
Calibrated Date	: 3/24/99	**Compensated Power (dBm)**	: 24.3

Amplifier Setting :

Channel 1 : 0.0045 Channel 2 : 0.0039 Channel 3 : 0.0031

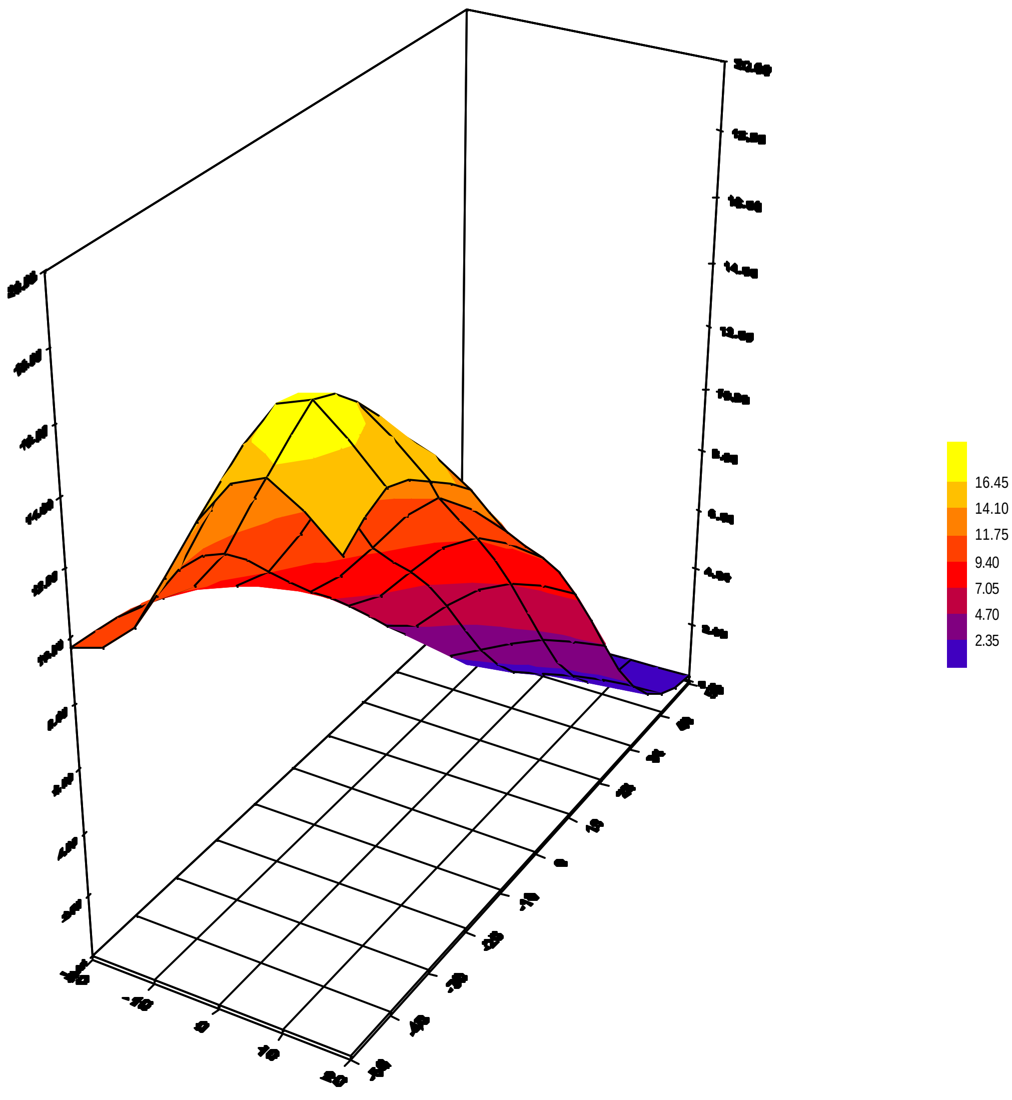
Location of Maximum Field :

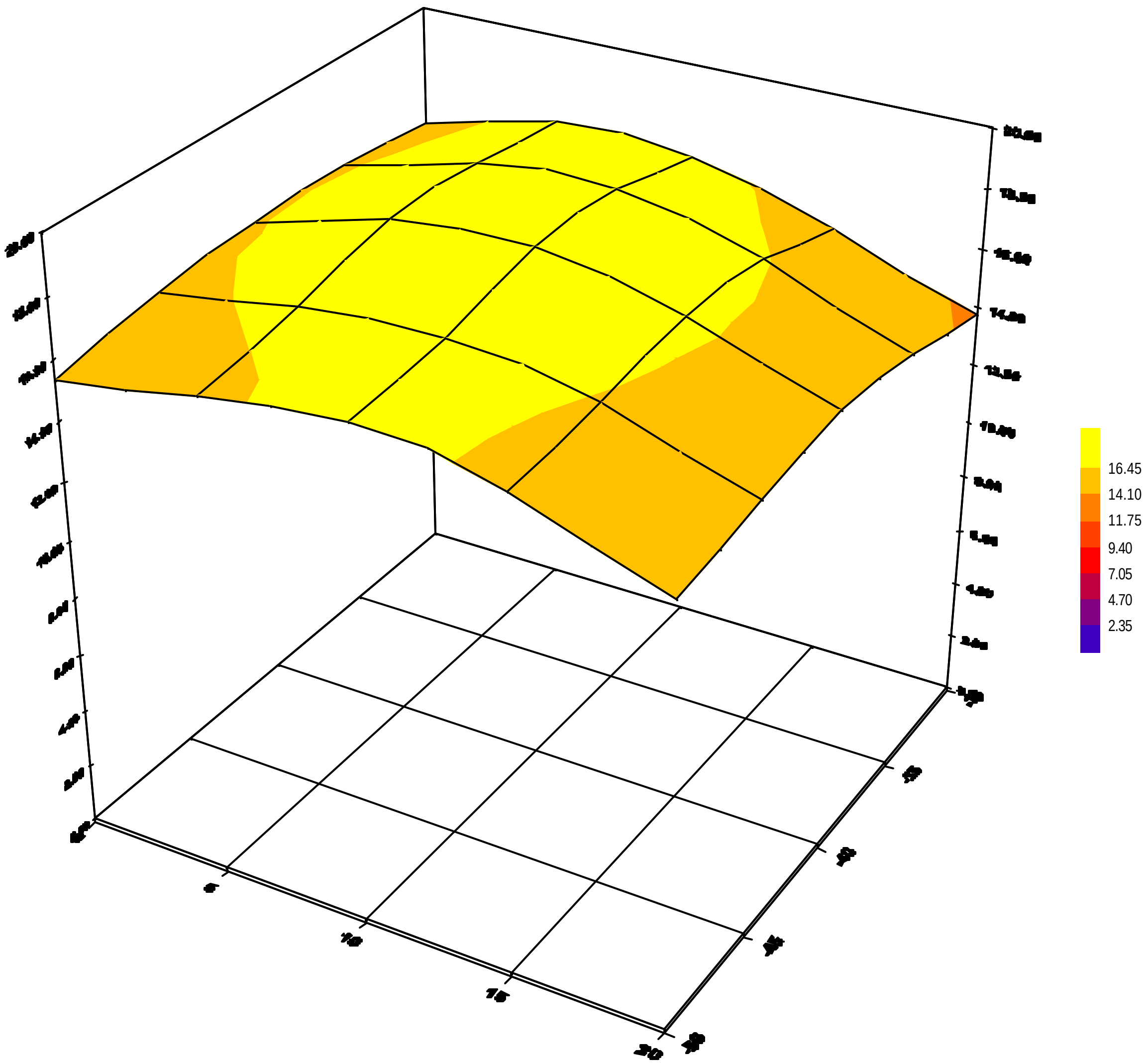
X = 10 Y = -40

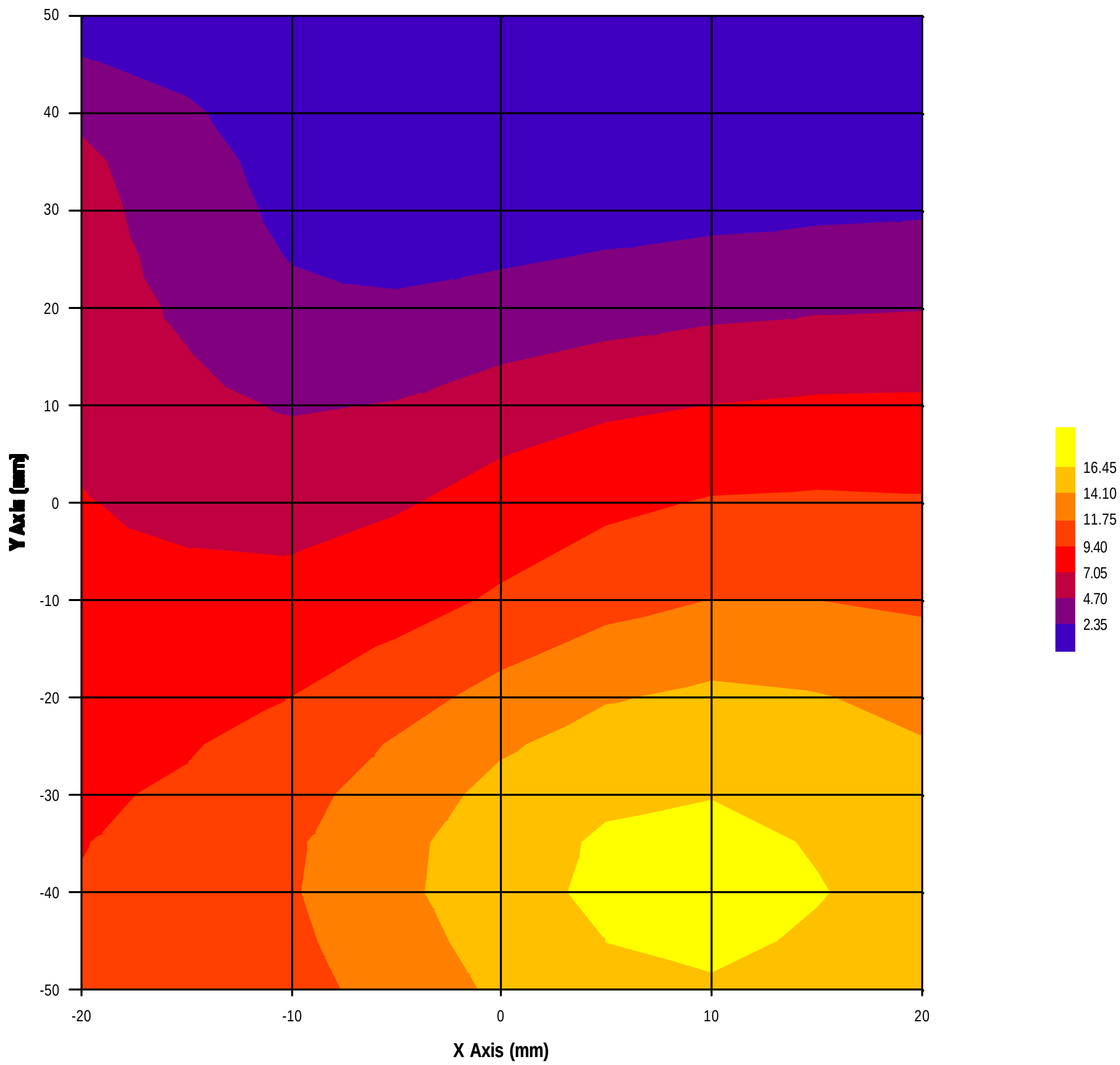
Measured Values (mV) :

17.85	16.30	15.04	14.18	13.44	12.83
12.23	11.65	11.12	10.61	10.14	

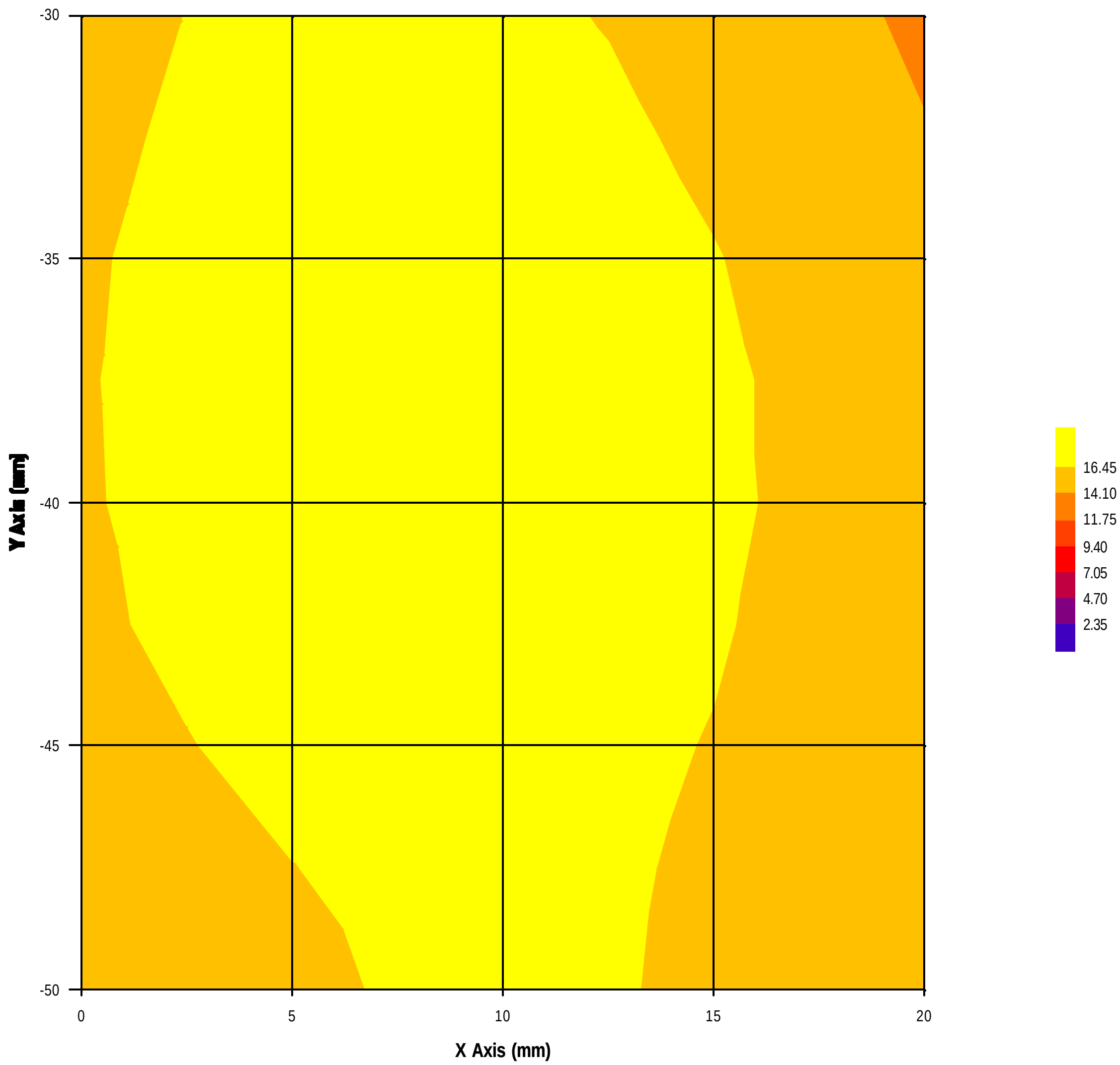
Peak Voltage (mV) : 20.88 **1 Cm Voltage (mV)** : 11.45 **SAR (W/Kg)** : 0.89


16.45
14.10
11.75
9.40
7.05
4.70
2.35

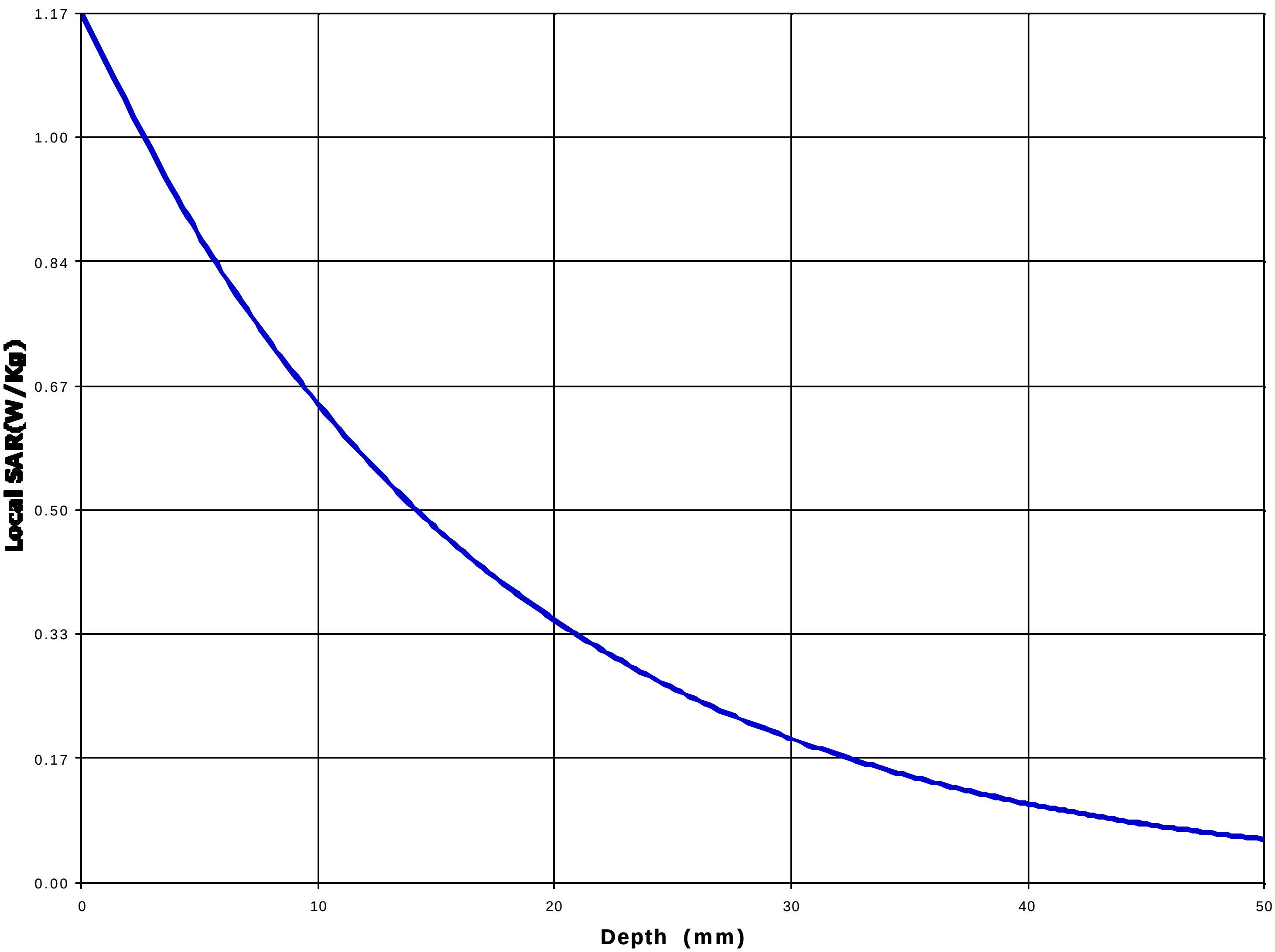

16.45
14.10
11.75
9.40
7.05
4.70
2.35



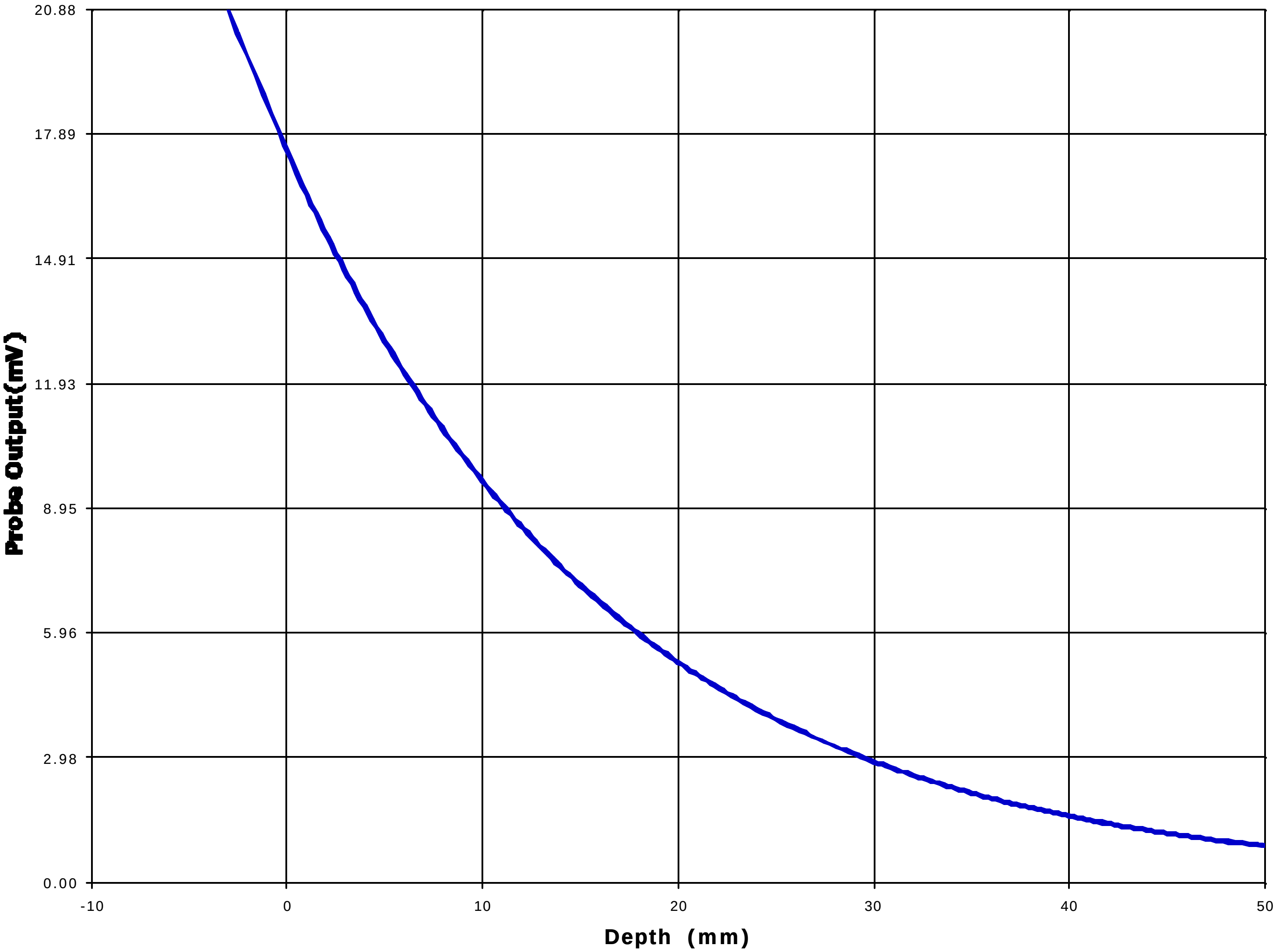
50
40
30
20
10
0
-10
-20
-30
-40
-50
-20
-10
0
10
20
X Axis (mm)
Y Axis (mm)
16.45
14.10
11.75
9.40
7.05
4.70
2.35



-30
-35
-40
-45
-50
Y Axis (mm)
0
5
10
15
20
X Axis (mm)
16.45
14.10
11.75
9.40
7.05
4.70
2.35



1.17
1.00
0.84
0.67
0.50
0.33
0.17
0.00
0
10
20
30
40
50
Local SAR(W/Kg)
Depth (mm)


20.88
17.89
14.91
11.93
8.95
5.96
2.98
0.00
-10
0
10
20
30
40
50
Probe Output(mV)
Depth (mm)

ANNEX B: TISSUE CALIBRATION

Ultratech Lab.

Date: 4/26/00

Frequency: 835 MHz

Composition					
Tap Water(%)	DI Water(%)	Sugar(%)	Salt(%)	HEC(%)	Bactericide(%)
43.74	0	56.25	0	0.01	0

Mixture: Brain ('Brain' or 'Muscle')

# of Points: 11

Point Dist: 1 cm.

Room Temp 25

Point	Amplitude	Phase	
1	-22.33	81.87	
2	-23.79	14.26	
3	-25.92	-52.06	
4	-27.82	-118.53	
5	-29.80	174.19	
6	-31.70	105.31	
7	-33.47	37.00	
8	-35.33	-31.22	
9	-36.95	-98.10	
10	-38.72	-168.71	
11	-40.46	122.83	

-49.9	
-51.6	
-53.5	-1.837727273
-55.3	-20.45454545
-56.9	-67.88881818
	151.5910909

Omega:	5246459731	rad/sec
Epsilon 0:	8.85E-14	F/m
mu:	1.26E-08	H/m
alpha avg:	-0.211576171	Np/cm
beta avg:	-1.184883403	rad/cm

Results:		**Target**	**Low Limit**	**High Limit**	**% Off Target**
D. Const:	**44.4**	46.1	43.781496	48.3900743	-3.77
Cond:	**0.76**	0.74	0.7058491	0.78014895	2.33