

1.0 *Environmental Evaluation for Occupational RF Exposure -- Pursuant 47 CR2.1093(d)(2)*1.1 **General Information**

FCC ID: AZ489FT5793

Device category: Portable Radio

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Test method: Measurement

The test results included herein demonstrates that the highest level SAR measurements are well within the FCC limit of 1.6 W/kg, per the requirements of 47 CFR 2.1093(d)(2).

1.2 **Antenna Description**

Antenna type: monopole (x) dipole () Helix (x) Patch () Other ()
1/4 wave whip when extended and 1/4 wave helix when retracted

Antenna Location on Device: Left () Right (x) Top (x) Bottom () Front () Back ()

Antenna Dimensions:	Length (extended)	11.5 cm
	Diameter (at middle of antenna)	0.2 cm
	Diameter (at base of antenna)	0.5 cm

Antenna configuration: Fixed () Retractable (x) External () Other ()

Antenna Gain: 1.15 (dBi) Extended Antenna Gain: 0.65 (dBi) Retracted

1.3 **Test Signal**

Test signal source: Test mode (x) Base Station () Simulator () Other ()

Signal Modulation: C.W. () TDMA (x) Other ()

1.4 **Output Power**

Output power measurement conditions: Free Space radiated ()
SAR test configuration ()
Conducted (x)

Output power measured with: Power meter (x)
Base Station Simulator ()
Spectrum Analyzer ()

Output power measured at: 813.5625 MHz, 16.667 % Duty Factor

Maximum power measured before SAR with fully charged battery: 588 mW (Pulse Average)
Max. power measured after SAR: 588 mW, after 20 mins of SAR test, No Battery changes

1.5 **Test Position**

The following describes the three test positions used to perform SAR measurements on the portable radio:

1. Head - The portable radio is positioned in a normal operating position by aligning the axis of the radio with a line from the center of the ear to the corner of the lips, center the listening area of the radio over the ear canal. Next, position the radio as close as possible to the phantom, preferably with three points of contact with the phantom to allow for best coupling to the simulated tissue. Radios with retractable antennas will be tested in both conditions of antenna extended and antenna retracted into radio housing.

2. Face - The portable radio is positioned in the right hand of a full body phantom and the radio's normal speaking area is aligned with the center of the phantom's mouth. SAR measurements were performed with the radio antenna extended and retracted.

3. Abdomen - The portable radio antenna is positioned 2.5 cm beneath the abdomen of the full body phantom with the back of the radio facing the abdomen, the keypad/display facing the floor and the antenna is made to be as parallel as possible to the phantom. SAR measurements were performed with the radio antenna extended and retracted.

Reference figures: 1, 2, and 3 for portable radio antenna orientation and distances relative to phantoms.

1.6 Measurement Uncertainty

The table below list an estimate of the possible errors that are associated with the measurement system.

	ERROR (%)
a) Measurement of the conductivity of tissue simulant	+/- 3
b) Temperature rise calibration of probe	+/- 5
c) Measurement of thermal capacity of tissue simulant	+/- 5
d) Accuracy of a repeatable radio position	+/- 1
e) Probe isotropic response	+/- 12

Statistically it's unlikely that any of the errors are correlated thus, it's reasonable to use a Root -Sum - Squared calculation to estimate the total system error of +/- 14.3%.

1.7 Measurement System and Phantom Description

Description of Measurement System and Performance:

The measurement system used to evaluate the portable radio SAR consist of a small diameter Isotropic electric field probe, multiple axis probe positioning system, differential amplifiers, High impedance cables connecting the probes to the differential amplifiers and the amplifier output To a computer, DX FLEXWARE software version 3.56, robotics arm with its extension, a custom probe holder, and supporting equipment to calibrate the probe and characterize the simulated tissue material. The measurement system has sensitivity of 10 micro-Watt/g. Linear response up to 20 mW/g. The system is calibrated using thermal measurements of SAR in muscle and brain simulated tissue at the frequency band of interest.

Description of Positioning System and Performance:

The Intelledex Microsmooth Model 660 six-axis robotics arm is used to position a small diameter Isotropic electric field probe inside a human shaped phantom with a solution that mimics the electrical characteristics of human brain or muscle tissue. Communication with the robot is by a hand held controller and over an RS-232 link. Reference Intelledex MicroSmooth 660 Operation Manual. The positioning system performance is based on a 1 mm positioning repeatability.

Overall System Performance Verification Procedure:

Established procedures within the Motorola Worldwide LMPS EME Lab are routinely followed to verify the overall system performance. They consist of calibrating the electric field probe together with the system instrumentation for each frequency band of interest and measuring the simulated tissue conductivity and dielectric constant to ensure that they are within established specs.

RF Susceptibility Verification Results:

No change is produced in the voltage offsets of the measurement system instrumentation amplifiers as a result of positioning a transmitting radio around the amplifiers and cables or when the transmitting radio is moved around the lab. The radio used to cause RF interference to the measurement system is made to transmit in the same band and with comparable output power as the radio to be tested by the measurement system. The measurement system immunity to unwanted RF exposure is accomplished by providing the probe leads that connect to the instrumentation amplifiers with shielded EMI cables, enclosing the instrumentation amplifiers in a shielded housing, connecting the instrumentation amplifiers to the computer equipment with high impedance cables, using RF absorbing cones throughout the lab to minimize reflections, providing

enough distance between the computer equipment, positioning system and probe to eliminate unwanted coupling.

System Verification Results:

Overall system results are verified by performing SAR measurements with a reference radio, at the frequency band of interest, and then comparing the results to previously measured data using the same reference radio.

Description of phantom:

Human shaped, solid shell device made of Fiberglas and mounted on a non metallic base or stand. The phantoms used in the Motorola LMPS EME Lab are the half body or torso (left and right ear version, no arms) and a laydown full body (6 feet tall).

Phantom Types:	Full body (x)
	Abdomen Thickness: 0.15 cm
	Face Thickness: 0.15 cm
	Torso (x)
	Torso's Head: Left Ear (x) Right Ear (x)
	Left Ear Thickness: 0.5 cm
	Cheek Thickness: 0.15 cm

1.8 Simulated Tissue Properties

Type of simulated tissue used:	Muscle (x) [Full Body]	Brain (x) [Torso]
Simulated tissue composition (% by weight) for :	Muscle (x)	Brain (x)
%	Di-Water: 53.50 %	Di-Water: 43.75
	Sugar: 44.25 %	Sugar: 54.00 %
	Salt: 1.15 %	Salt: 1.15 %
	HEC: 1.00 %	HEC: 1.00 %
	Dowicil 75: 0.10 %	Dowicil 75: 0.10 %

Note: HEC (HYDROXYETHYL CELLULOSE) is a gelling agent and Dowicil 75 is anti-bacterial compound.

Characterization of Simulated tissue materials and ambient conditions:

Simulated tissue prepared for SAR measurements are measured at room temperature and verified to be in spec prior to actual SAR measurements by filling a coaxial slotted line with the tissue and probing the amplitude and phase changes versus distance in the simulated tissue. A HP8753D Network Analyzer is used to perform the measurements.

Simulated tissue dielectric constant:	Muscle: 51.1	Brain: 42.8
Simulated tissue conductivity:	Muscle: 1.06 S/m	Brain: 0.94 S/m
Simulated tissue density:	1.25 g/cubic-cm	

Note: Simulated tissue dielectric constant and conductivity have been rounded off to one and two significant digits after the decimal point respectively, to take into account the tissue measurement uncertainty.

1.9 Electric Field Probe Descriptions and Calibration

Electric Field Probe Description and Performance

The electric field probe is a three channel device used to measure RF electric fields. The probe Sensors consist of three mutually orthogonal dipoles, each 2.5 mm in length. Located at the center of each of the three dipoles is a Schottky diode detector. For each channel of the probe, the dipole and two high impedance lines are vapor deposited on a quartz substrate. The three substrates are mounted on a non conductive RF transparent support which has a I-beam cross section. Along the support are three pairs of high impedance lines which connect the substrate to a single output connector. The probe is enclosed in a protective sleeve to avoid contact with the corrosive elements

of the simulated tissue. The total length of the probe is approximately 25 cm. The electric field probe

is isotropic and its performance is such that no significant field perturbation from the probe occurs during measurements.

Probe type: Electric Field (x) Magnetic () Other ()

Probe S/N: P040

Electric Field Probe Calibration Procedure:

The SAR measurement system is calibrated as a single unit and is performed in two steps.

- 1) Correlation of the measured free space electric field and the measured electric field in the medium to temperature rise in a dielectric medium.
 - a. A RF transparent thermistor based temperature probe (Vitek Electrothermia Monitor #101) and an isotropic electric field probe are placed side by side in a planar phantom while both are exposed to RF energy from a half wave dipole antenna located below the phantom.
 - b. The location (hot spot) of maximum electric field concentration on the phantom's surface is determined. Then the electric field probe is moved sideways so that the temperature probe, while affixed to the electric field probe, is placed at the previous location of the electric field probe. Temperature changes for 30 second exposures at the same RF power levels used for the electric field measurements are recorded.
 - c. The conversion factor, which scales the electric field in terms of the thermally derived SAR, is determined.
- 2) Determination of free space electric field from amplified probe outputs in a test RF (TEM cell) field.
 - a. A RF signal generator is connected to the input of a TEM cell manufactured by IFI (Instruments For Industries) and the output of the cell to a RF HP 437B power meter. The RF signal generator is adjusted so that the power density inside the cell is 1 mW/sq-cm. For the IFI model CC-110, the corresponding power level is 271 mW.
 - b. The probe is inserted through the side aperture of the TEM cell with the positioning system and the tip of the probe, where the probe detectors are located, is lowered 3.5 inches inside

the volumetric center of the cell. Once the prescribed probe position inside the cell is achieved, it must be maintained during the measurements.

- c. The probe is rotated 360 degrees on its axis while the RF power level from the signal generator is maintained constant throughout the calibration.
- d. Software indicators will show the maximum measured value on each of the three channels while the probe is being rotated through 360 degrees. The maximum measured values are referred to as amplifier settings and they are the factors necessary to adjust each channel of the measurement system so its indicated output can then be equated to the RF field.

Media and Frequency for E-Field Probe Calibration

Media: Air

Frequency: 835 MHz

Media: Simulated Muscle and Brain tissue

Frequency: 835 MHz

Probe Offset: 3 mm

Probe Isotropic Response: +/- 12% deviation from isotropy in tissue located in flat phantom.

E-Field Probe Calibration Factor:

Muscle: 0.928 mW/g

Brain: 0.644 mW/g

Probe Initial Thermal Derived SAR Calibration Date: 1/6/99; Next Due Date: 1/5/2000

Probe Free Space Calibration Date Prior to SAR Measurement: 1/13/99.

1.10 SAR Measurement Parameters, Procedures and Results:

SAR test frequency: 813.5625 MHz

Description of coarse scan region:

A coarse scan of the radio was performed to determine the hot spot location with the radio positioned in the abdominal test position, described in the contour plot for run # 99011807_AREA.VLT.

Coarse Scan Area (highest measured SAR): $x = 9$ cm, $y = 5$ cm, $z = 0$ cm Scan resolution 1 cm

Description of fine scan region:

Subsequent to and based on the above coarse scan regions, a finer scan region centered around the peak SAR location was scanned, to determine the one gram average SAR.

Fine Scan Area (highest measured SAR): $x = 1$ cm, $y = 2$ cm, $z = 0$ cm Scan resolution: 0.25 cm

Note: The 0,0 location of the scan area is chosen to be at the radio antenna interface.

SAR distribution of worst case test results: Reference the description for scaling up the SAR based on the measured 1-gram averaged peak SAR as well as table 1 on the following page for variation of antenna position relative to the phantom.

Identification of peak SAR location:

Reference the contour plot (run # 99011807_AREA.VLT) for the highest measured peak SAR location on the radio.

Highest peak SAR (W/kg) and its test configuration:

- 1) Highest measured peak SAR = 0.43 mW/g and it occurs at the surface of the phantom when the radio is in the head position with the antenna retracted and operating in full duplex telephony mode. Reference the field attenuation (SAR scan) curve for run # 99011807_ZOOM.VLT.
- 2) Measured one-gram averaged peak SAR (W/kg):
The measured 1-gram averaged peak SAR = 0.3463 mW/g, however, will be rounded to 0.35 mW/g.

The above 1-gram averaged peak SAR was measured at the top of the band (820.9875 MHz). Reference run # 99011807_ZOOM.VLT.

Generally, radios are measured at the middle of the operating band in the LMPS EME Lab at Motorola and the calculated maximum 1 gram averaged SAR value is determined by scaling up the SAR by the same ratio as the maximum power delivered to the radio antenna connector under any conditions of permissible tuning, frequency, voltage and temperature. For this reason, the radio Maximum Calculated 1gram averaged SAR becomes:

$$\text{Maximum Calculated 1 gram Averaged SAR} = [(A / B) \times (C \times D)]$$

A = Maximum pulse average power delivered to the antenna connector under any conditions of permissible tuning, frequency, voltage and temperature.

B = Lowest pulse average power measured (top of the band 820.9875 MHz) at end of SAR.

C = Measured 1 gram averaged peak SAR

D = 2, to account for full duplex (3:1) telephony mode since SAR measurements were performed in 6:1 mode.

Maximum Calculated 1 gram averaged peak SAR = $[(0.75 \text{ W} / 0.65 \text{ W})] \times (0.3463 \text{ mW/g} \times 2) = 0.81 \text{ mW/g}$

Refer to table 1 for other SAR test positions and measured 1-gram averaged SAR values.

Table 1**MESURED SAR MATRIX**

RADIO	TRANSMIT	ANTENNA			
SERIAL NO.	BAND	POSITION	ABDOMEN (TELEPHONY)	FACE	HEAD (TELEPHONY)
831AYW6H85	MID	EXTENDED	0.2 @ 2.5 cm	0.08	0.30
831AYW6H85	MID	RETRACTED	< 0.2	0.10	0.32
831AYW6H85	TOP	RETRACTED	< 0.2	0.09	0.35

Measured SAR in the abdominal position was performed with the radio antenna 2.5 cm from the phantom's surface, per operating instructions supplied to the user.

Note: Measured 1-gram averaged SAR values in the table have been rounded off to two significant Digits after the decimal point, to take into account the probe's measurement uncertainty.

Description of procedures used to extrapolate SAR to phantom surface:

The highest local SAR occur at the surface of the phantom. There is a 3 mm probe offset from the physical end of the probe to the probe detectors. The probe offset make it necessary to extrapolate to the peak surface SAR from the SAR measured at a short distance from the surface.

At the measurement point on the phantom surface where the highest probe voltage is recorded (a.k.a. hot-spot), 11 probe voltage measurements are performed starting as close as possible to the phantom surface and every 0.5 cm thereafter along a path normal to the probe axis (+z - axis) for a distance of 5 cm. An exponential decay of the energy density with depth is calculated using the first three probe voltage measurements nearest the surface. The extrapolated peak surface voltage is calculated from the following relation:

$$\text{Peak Surface Voltage} = (V1) \times (\text{Exponential Decay})$$

where: V1 is the first voltage measurements along a path normal to the probe axis.

$$\text{Exponential Decay} = e\{\text{Ln}(\text{Slope}) \times (\text{Offset} / \text{Spacing})\}$$

$$\text{Slope} = [(V1/V2) + (V2/V3)] / 2$$

where: V1, V2 and V3 are the first, second and third voltage measurements along a path normal to probe axis, respectively. Reference the first three measured voltage values from run # 99011807_ZOOM.VLT.

Offset = Distance from center of probe dipoles to outside of probe case

Spacing = Distance between measurement points (in +z-axis)

The peak SAR, at the surface, is calculated as follows:

$$\text{Peak SAR (at surface)} = \text{Peak Surface Voltage} \times (\text{Probe Calibration Factor} / \text{Sensor Factor})$$

where: Sensor Factor = 10.8 mV/mW/sq-cm

Description of 1-gram average procedures, highest SAR gradient at peak location (W/kg/mm):

$$\text{1-gram avg SAR} = (\text{Peak Surface Voltage} + 1 \text{ cm Voltage})/2 \times \text{Probe Calibration Factor/Sensor Factor}$$

Peak Surface Voltage is described above and the 1 cm Voltage is an interpolated voltage, Representative of the voltage 1 cm above the surface of the phantom.

The derivative of the peak SAR is the gradient at the peak location.

$$\text{Gradient (at peak SAR location)} = [\text{Ln (slope)} \times \text{Peak SAR}] / \text{Spacing}$$

Gradient (at peak SAR location) is 0.019 W/Kg/mm. The calculation was determined using the Measured values from run # 99011807_ZOOM.VLT.

FIG. 1A HEAD POSITION - LEFT EAR

<====
(+x Axis)

====>
(-x Axis)



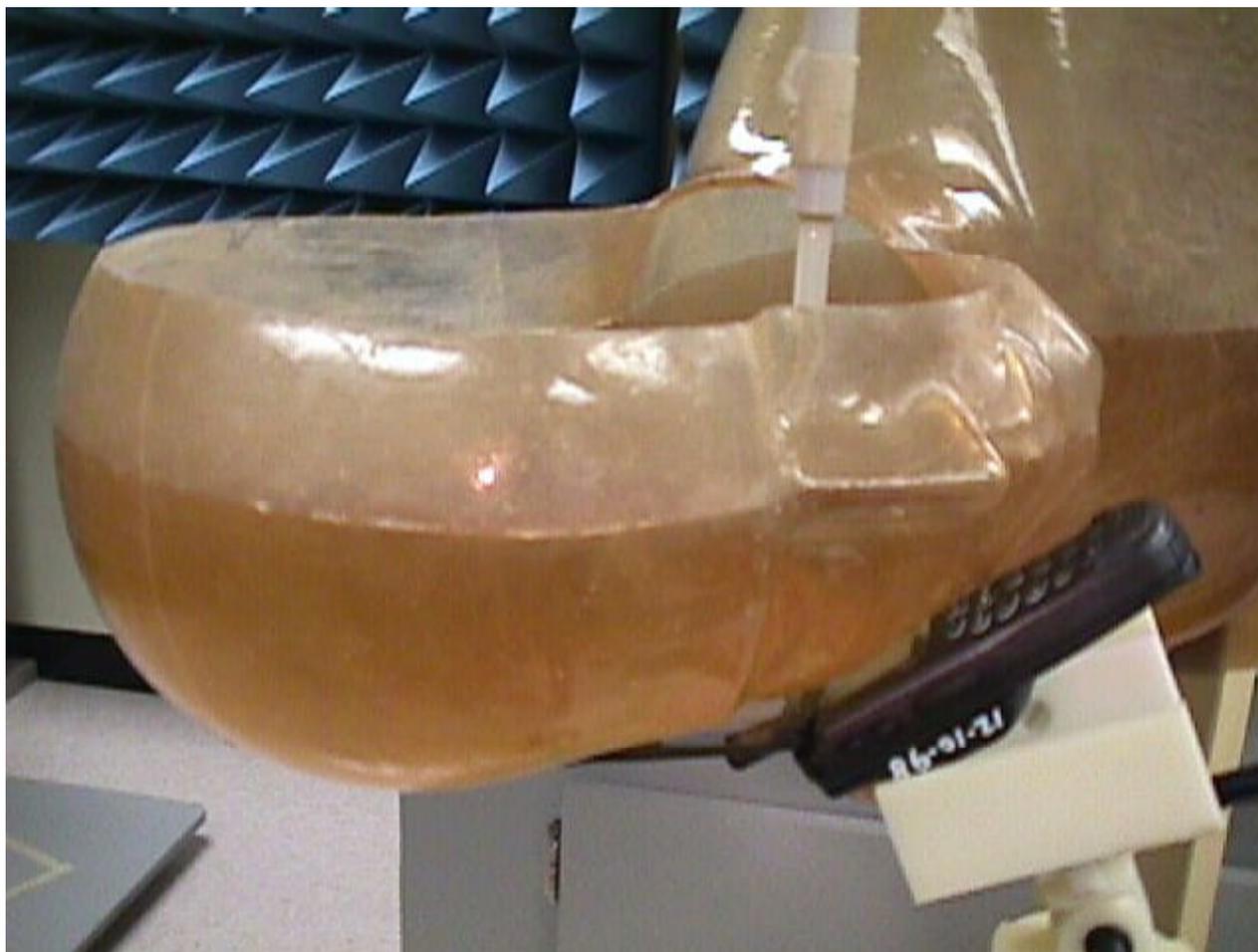
DIM A = Distance from surface of antenna base to phantom head = 14mm

DIM B = Distance from antenna surface tip to phantom head = 60mm

FIG. 1B HEAD POSITION - RIGHT EAR

<====
(+x Axis)

====>
(-x Axis)



DIM A = Distance from surface of antenna base to phantom head = 14mm

Legend: Torso filled with simulated brain tissue on non RF support fixture and radio affixed to head.

(+y) Axis is out of the page, toward viewer and (-y) Axis is into the page, away from viewer.

FIG. 2 FACIAL POSITION

<=====

(+x Axis)

=====>

(-x Axis)



DIM A = Distance from center of phantom's forehead to antenna surface when the antenna is in the retracted position = 70 mm

DIM B = Closest distance between phantom's chin and radio surface = 35 mm

Legend: Lay down full body phantom filled with simulated muscle tissue on non RF support fixture and radio in phantom's palm.

(+y) direction is out of the page, toward viewer and (-y) direction is into the page, away from viewer.

FIG. 3 ABDOMINAL POSITION

<== Toward Phantom's feet (+ x axis)

Toward phantom's head (-x axis) =



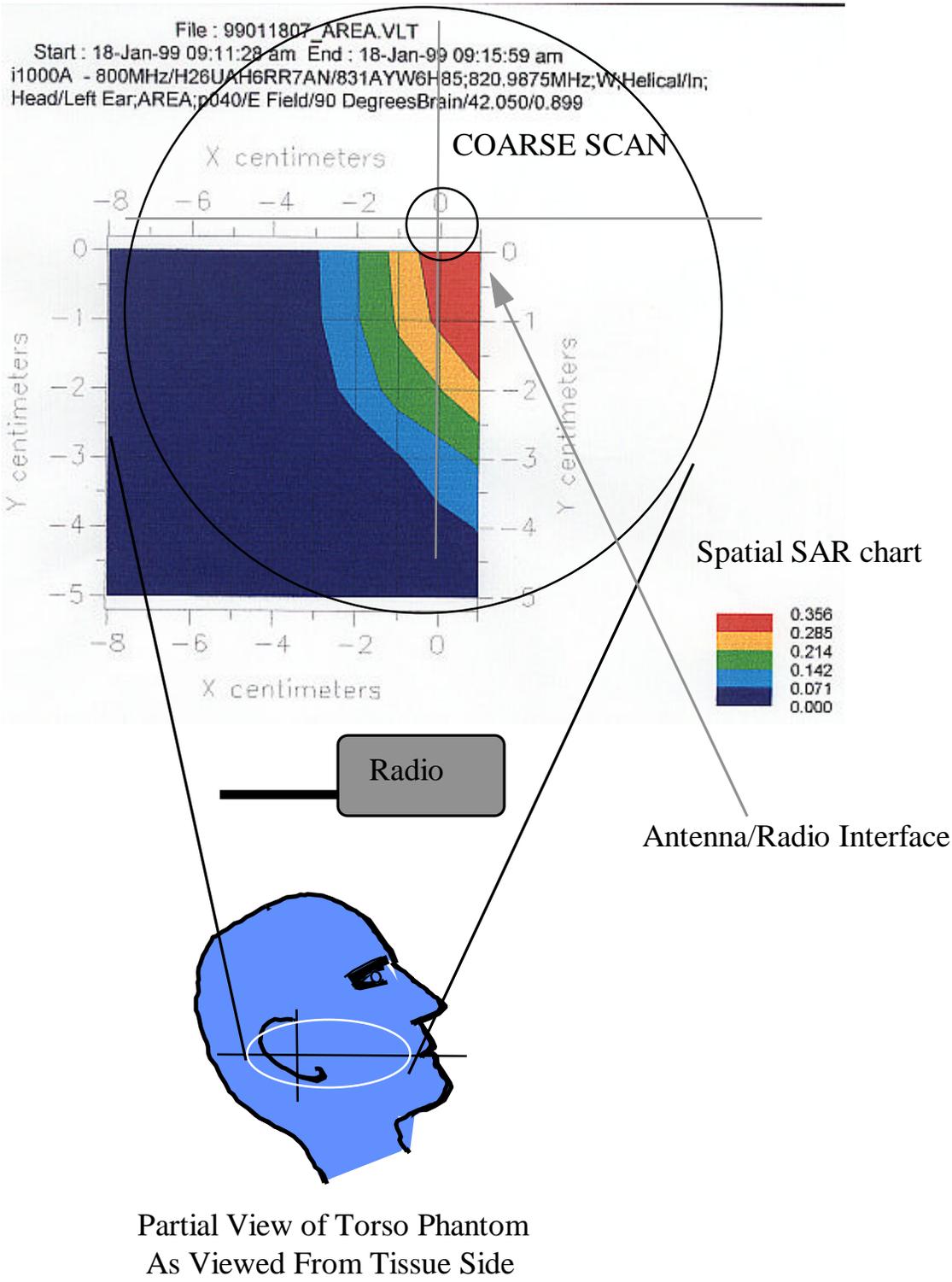
DIM A = Distance from surface of antenna base to phantom surface = 25 mm

DIM B = Distance from center of antenna surface to phantom surface = 26 mm

DIM C = Distance from surface of antenna tip to phantom surface = 25 mm

Legend: Lay down full body phantom filled with simulated muscle tissue on non RF support fixture and radio affixed to phantom's abdomen.

(x) axis is out of the page toward viewer and (y) axis is into the



File : 99011807_ZOOM.VLT

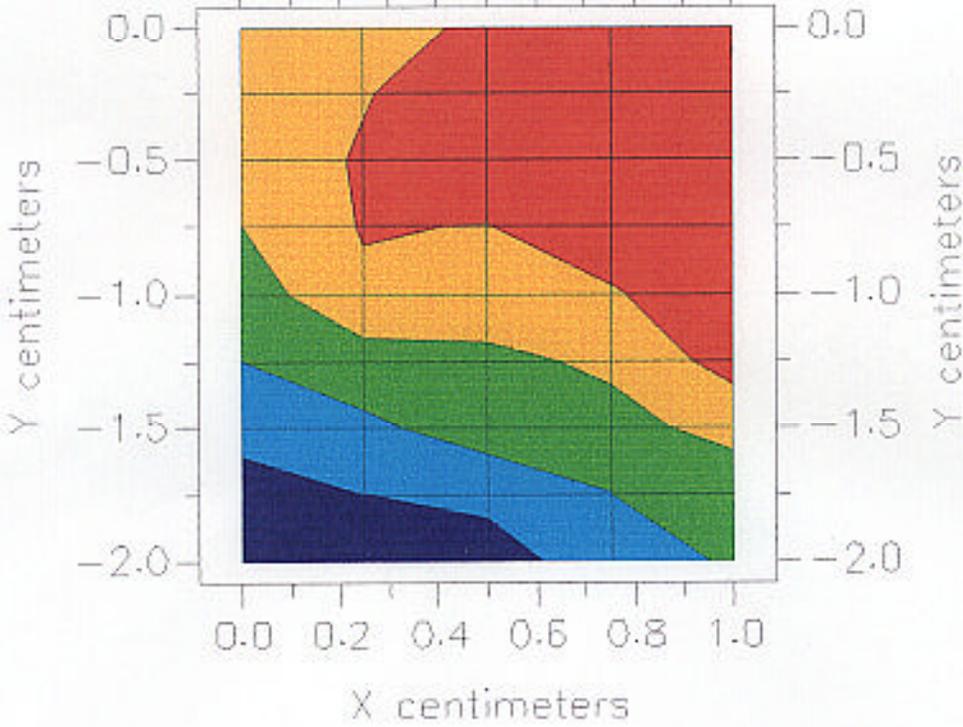
Start : 18-Jan-99 09:16:00 am End : 18-Jan-99 09:19:38 am

i1000A - 800MHz/H26UAH6RR7AN/831AYW6H85;820.9875MHz;W;Helical/In;
Head/Left Ear;ZOOM/SAR;p040/E Field/90 DegreesBrain/42.050/0.899

FINE SCAN

X centimeters

0.0 0.2 0.4 0.6 0.8 1.0



Spatial SAR chart

File : c:/idx3/SYSTEM/SARMEAS3/data/Normal/99011807_ZOOM.ULT
 Start : 18-Jan-99 09:16:00 am End : 18-Jan-99 09:19:38 am

Radio Type : Golden Eagle i1000A - 800MHz
 Model Number : H26UAH6RR7AN
 Serial Number : 831AYW6H85
 Frequency : 820.9875 MHz
 Peak Trans. Pwr : 0.750 W
 Start Trans. Pwr : 0.650 W
 Antenna Type : Helical
 Antenna Posn. : In
 Phantom Type : Head
 Phantom Posn. : Left Ear
 Scan Type : ZOOM/SAR
 Probe Name : p040
 Field Type : E Field
 Orientation : 90 Degrees

Mixture Type = Brain
 Mixture Dielectric Constant = 42.050
 Mixture Conductivity = 0.899

Comment :

Comment Line 1 Gain=10, Batt: NTN8614A, Ant: 8585760B01(Helical)Ant in
 Comment Line 2 No Belt clip connected to radio. 6:1, sample rates=5460/993
 Comment Line 3 Measurement taken w/ SAR Ver 3.56 & ROBOT27.ASC LOADED.

Robot : CGISS Robot

Probe Offset = 0.30 cm
 Sensor Factor = 0.0108
 Conversion Factor = 0.633

p040 Amplifier Channel Settings : 0.316 0.353 0.264

Max Location : X = 1.000, Y = -1.000, Z = 0.000 (cm) Value = 6.447

Measured Values (volts) =

6.352E-003	4.877E-003	4.070E-003	3.508E-003	2.994E-003	2.479E-003
1.979E-003	1.345E-003	8.913E-004	8.325E-004	8.934E-004	

Calc. Voltage @ Surface (Vs) = 0.0073

Voltage @ 1.00 cm (Ut) = 0.0046

Ave. Voltage (Vs+Ut)/2 = 0.0059

Ave. SAR over 1 g (mW/g) = 0.3463

SAR Scan
File : 99011807_ZOOM.VLT
Start : 18-Jan-99 09:16:00 am End : 18-Jan-99 09:19:38 am
Golden Eagle i1000A - 800MHz/H26UAH6RR7AN/831AYW6H85;820.9875MHz;W;Helical/In;
Head/Left Ear;ZOOM/SAR;p040/E Field/90 DegreesBrain/42.050/0.899

