Globalstar™

Globalstar User Terminal GSP-1610 Specific Absorption Rate (SAR) Report

80-98781-1 X1

QUALCOMM®

QUALCOMM Incorporated
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U.S.A.

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SIGNATURE PAGE

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CONTENTS

1 INTRODUCTION

This test report describes an environmental evaluation measurement of specific absorption rate (SAR) distribution in simulated human head tissues exposed to radio frequency (RF) radiation from a wireless portable device manufactured by QUALCOMM Inc. These measurements were performed for compliance with the rules and regulations of the U.S. Federal Communications Commission (FCC). The testing was performed between the 27th of April 1999 and the 28th of April 1999 in the QUALCOMM SAR Test Facility. The wireless device is described as follows;

EUT Type:	***Single Mode, Satellite/CDMA Portable User Terminal***
Trade Name:	***QUALCOMM Inc.***
Model:	***GSP1610***
Tx Frequency:	***1610 -1626.5 MHz (satellite mode)***
Rx Frequency:	***2483.5 - 2500 MHz (satellite mode)***
Max. Output Power:	***31 dBm EIRP (satellite mode)***
Modulation:	***CDMA (satellite mode)***
Antenna:	***Telescoping-revolving stacked quadrifilar helix for satellite mode.***
Trade Name / Model:	***QUALCOMM GSP 1610***
FCC Classification:	***Non-Broadcast Transmitter Held to Ear***
Application Type:	***Certification***
Serial Number:	***15908998914***
Place of Test:	***QUALCOMM Inc., San Diego, CA, USA***
Date of Test:	***April 28, 99***
FCC Rule Part:	***2.1093; ET Docket 96.326; part 25***

2 SAR TEST FACILITY

SAR tests were performed in the Qualcomm SAR Test Facility located at the following address:

Qualcomm Incorporated
Building AA.
10290 Campus Point Drive.
San Diego, CA 92121

3 APPLICABLE REGULATIONS

The Globalstar MES is designed to comply with the specific absorption rate SAR limits for distances within 20 cm of the transmitting elements of the MES, and with general public uncontrolled environment Maximum Permissible Exposure (MPE) limits at distances greater than 20 cm from the transmitting elements of the device, as required by Sections 1.1307 through 1.1310, 2.1091 and 2.1093 of the 47 C.F.R. (1997). These FCC RF safety limits, which are based on a hybrid combination of the SAR and MPE requirements from ANSI/IEEE C95.1-1992 and the National Council on Radiation Protection and Measurements (NCRP) report no. 86, are also consistent with the RF safety limits defined in the IRPA Guidelines on Protection Against Non-Ionizing Radiation which are reportedly in the process of being adopted in Europe, as codified in European Pre-Standard ENV 59166-2 approved by CENELEC (1994). This test report pertains specifically to the following limit from the Code of Federal Regulations 47:

> "Limits for General Population/Uncontrolled exposure: 0.08 W/kg as averaged over the whole-body and spatial peak SAR not exceeding 1.6 W/kg as averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube). Exceptions are the hands, wrists, feet and ankles where the spatial peak SAR shall not exceed 4 W/kg, as averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube)."

4 SAR TEST RESULTS SUMMARY

This device has been tested for localised specific absorption rate (SAR) for uncontrolled environment/general population exposure limits specified in ANSI/IEEE Std. C95.1 ~ 1992 and has been tested in accordance with the measurement procedures specified in ANSI/IEEE Std. C95.3 ~ 1992. Normal antenna operating positions were incorporated, with the device transmitting at frequencies consistent with normal usage of the device. For information only, the device was also tested with the antenna positioned in the incorrect orientation for both sides of the head. The device has been shown to be capable of compliance for localised specific absorption rate (SAR) for uncontrolled environment/general population exposure limits specified in ANSI/IEEE std. C95.1-1992

5 TECHNICAL DESCRIPTION

The test sample consisted of a Globalstar portable User Terminal (UT). This mode will only operate in the Globalstar Communications Network. The Globalstar mode is designed to transmit in the 1610 – 1626.5 MHz band at a maximum transmitter output power of 28 dBm and a peak antenna gain of 3.0 dBi, or a maximum EIRP of 31 dBm. The Globalstar transmitter utilises direct sequence spreading at a chip rate of 1.2288 MHz and OQPSK modulation. The transmitter is capable of variable rate transmission at 9600, 4800, and 2400 bps with associated changes in output power, but for the purpose of this test a pilot channel of constant rate was used to give a constant output power.

The GSP1610 is a portable user terminal. (Photo 1). The Globalstar mode employs a dual frequency stacked quadrifilar helix antenna that is deployed by the user by revolving out from the body of the user terminal and placing in one of the two click-retaining positions. One retaining click is felt when swinging the antenna to the left-ear position, another is felt when swinging the antenna to the right-ear position. Since either position is possible during use, both positions were tested; one position referred to as zenith because the antenna is aligned vertically, the other position referred to as horizontal because the antenna could be "accidentally" aligned with the horizon.

The user terminal antenna position mechanism interfaces with a switch that controls the point at which the transmitter becomes active. This mechanism automatically extends the antennas as it moves from the stored position and the switch is designed to activate and deactivate the Tx path at 95 degrees from the stored. At this point, the Tx elements of the antenna have been extended to within 0.5 inches of the fully extended position. This is still a significant distance above and away from the head (6.1 inch from centre of ear-piece to antenna feed point). Figure 1 on page 19 of this report details more clearly the combination of the switch and positioning mechanism with respect to the transmitter activation point and Tx antenna location above the head.

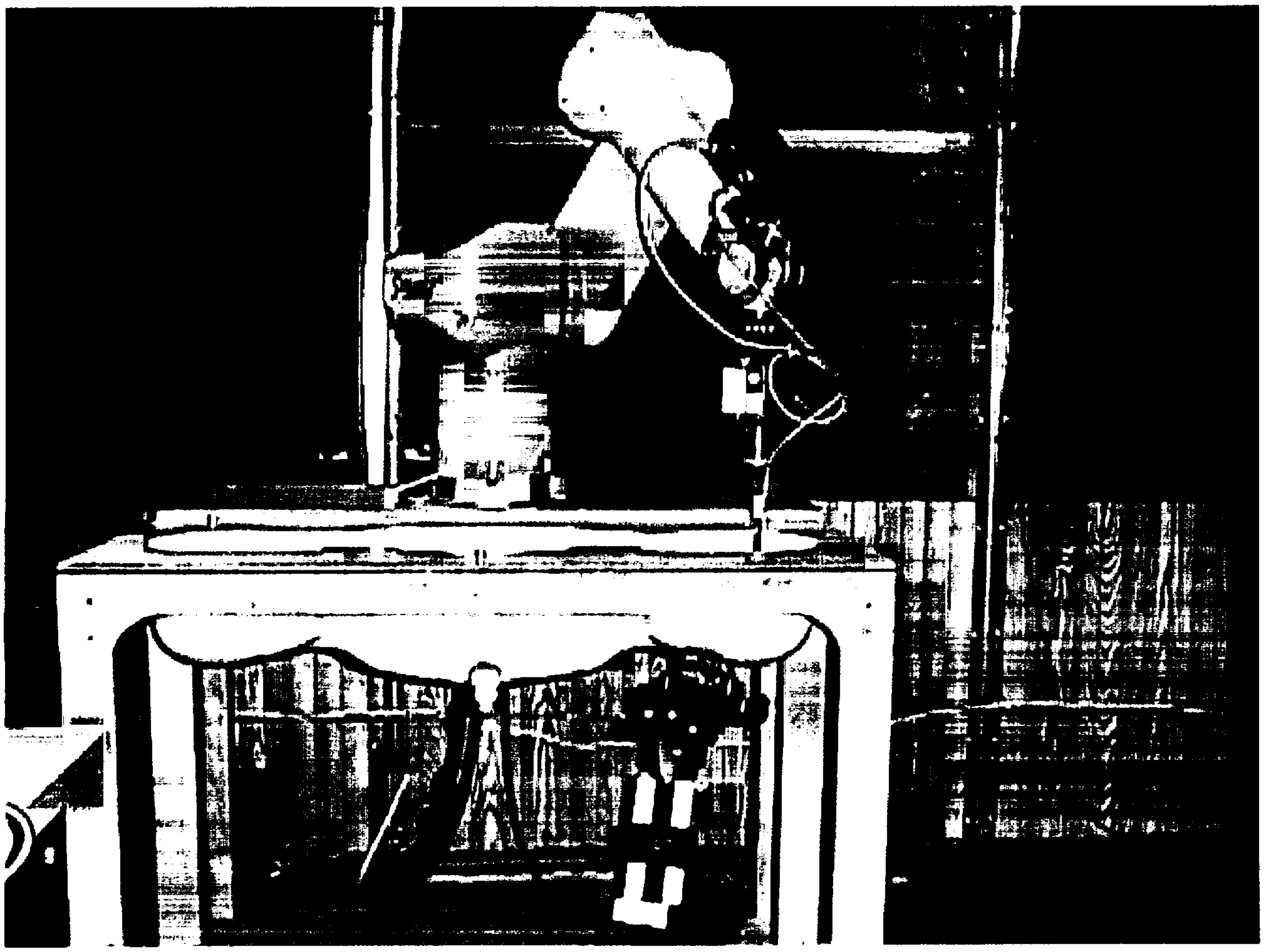
An Anritsu MT8803G Globalstar User Terminal Tester was used to simulate a Globalstar mode transmission. A high frequency helical antenna was connected to the Anritsu RF port and a radiated RF communications link was established between the GSP-1610 and the Anritsu. Having established a simulated over the air call, the Anritsu had the capability to control the transmit frequency and transmit power of the GSP-1610. The Anritsu was configured so the user terminal would transmit at maximum power. The user terminal's conducted power was measured at each frequency tested to ensure the correct maximum EIRP values.

5.1 DESCRIPTION OF QUALCOMM SAR TEST FACILITY

All tests were performed under the following environmental conditions:

Temperature Range:	15 - 35 Degrees C	(Actual 20 C)
Humidity Range:	25 - 75 %	(Actual 38 %)
Pressure:	860 - 1060 mbar	(Actual 1015 mB)

The SAR tests were performed using the following facilities (Photo 4 and Photo 5):



All Qualcomm dosimetry equipment is operated within a shielded screen room manufactured by Lindgren RF Enclosures to provide isolation from external EM fields. The E-field probes of the DASY3 system are capable of detecting signals as low as 5μW/g in the liquid dielectric, and so external fields are minimised by the screen room, leaving the user terminal as the dominate radiation source. The floor of the screen room is reflective, so four two-foot square ferrite panels are placed beneath the phantom area of the DASY system to minimise reflected energy that would otherwise re-enter the phantom and combine constructively or destructively with the desired fields. These ferrite panels provide roughly 12 to 13 dB of attenuation in the frequency range of 900 MHz, and 7 to 8 dB of attenuation in the frequency range of 1.9 GHz. Space beneath the DASY3 system limits the absorber type to ferrite tiles, although this attenuation combined with scattering of the energy is sufficient to bring the system validation within the acceptable tolerance.

DOSIMETRY SYSTEM The dosimetry equipment consists of a complete dasy3 v1.0 dosimetry system manufactured and calibrated by Schmid & Partner engineering ag of Zurich, Switzerland, it is currently a state of the art system and from our research, it appears to be the best available at this time. The dasy3 system consists of a six axis robot, a robot controller, a teach pendant, automation software on a pentium 200 MHz computer, data acquisition system, isotropic e-field□ probe, and validation kit.

E-FIELD PROBE This test was performed using an E-field probe with conversion factors determined by Schmid & Partner (s & p). The probe is the most important part of the system, so will be discussed in section 5.2.

Phantom The phantom was the so called "generic phantom" supplied by S & P, and consists of a left and right side head for simulating user terminal usage on both sides of the head. The phantom is constructed of fibreglass with 2 +/- 0.1 mm shell thickness. The shape of the shell is based on data from an anatomical study of a group of 33 men and 19 women to determine the maximum exposure in approximately 90% of all users. The Dasy system uses a homogeneous tissue phantom based on studies concerning energy absorption of the human head, and the different absorption rates between adults and children. These studies indicated that a homogeneous phantom should overestimate SAR by no more than 15% for 1 g averages and should not underestimate SAR. In similar studies, it was found that a typical ear thickness is approximately 4 mm, so a 2 mm rubber ring is attached to the phantom at the ear area. The combined total thickness is close to 4 mm.

LIQUID DIELECTRIC The tissue simulating liquid which fills the phantom is supplied by Schmid & partner. There are two separate formulas for the two frequencies 900 MHz and 1800 MHz. This is necessary because the water molecules raise the conductivity to approximately 1.65 +/- 10% at the 1800 MHz frequency, without the addition of salt, so no salt is needed. Before testing, the permittivity and conductivity were measured with an automated Hewlett Packard 85070b dielectric probe in conjunction with a hp 8752c network analyser to monitor permittivity change due to evaporation. The electromagnetic parameters of the liquid were maintained as shown in Table 1. The conductivity of average brain tissue for 1620 MHz is 1.065728 s/m according to the data from the FCC web page for tissue dielectric properties with internet address www.fcc.gov/fcc-bin/dilec.sh . The conductivity measured with the hp85070m dielectric probe system at 1620 MHz is 1.44 (for the liquid purchased from Schmid & partner). Since the liquid prepared by Schmid & partner has no salt or any conductive additive (the chemical/physical properties of the water, preservative, and sugar molecules alone provide too much conductivity), it is impossible to lower the conductivity to 1.07 s/m without a new formula with different ingredients. In other words we would have to locate an ingredient to replace the sugar/water/preservative ingredients with materials providing similar density, permittivity, and optical properties (for the optical surface detection) but having lower conductivity at 1620 MHz. It was determined that using the 1800 MHz fluid from Schmid & partner would overestimate the SAR by a small margin, and maintain maximum confidence. Although there are formulas readily available for both 900 MHz and 1800 MHz, there are none for 1620 MHz. A formula could be developed for this band but it was decided the error in permittivity and conductivity would be minimal if the 1800 MHz formula was used. Note that it was measured at 1620 MHz and the conductivity was approximately 35% higher than the value listed at the FCC web page for 1620 MHz average brain tissue.

Frequency	Permittivity	Conductivity	Density
900 MHz	41.5 +/- 5%	1.2 +/- 10% mho/m	1 g/cm^3
1620 MHz	43.2 +/- 5%	1.44 +/- 10% mho/m	1 g/cm^3
1800 MHz	42.0 +/- 5%	1.65 +/- 10% mho/m	1 g/cm^3

Table 1

Schmid & partner have supplied us with data that can be used to show the error in SAR caused by using higher conductivity. In general higher conductivity, *over estimates* measured SAR values. So by using a higher conductivity in the 1620 MHz band we were measuring SAR values higher than would exist in the human brain. This data is provided in Table 2.

Distance of radiator from liquid surface	Frequency MHz	*Avg. Volume gram*	*% Increase of SAR per % increase in conductivity*	*Relative. Permittivity*	*Conductivity of liquid s/m*	*Density of liquid g/cm³*
10 mm	900	1	+ 0 .62	41.5	0.85	1
10 mm	900	10	+ 0.39	41.5	0.85	1
15 mm	900	1	+ 0.63	41.5	0.85	1
15 mm	900	10	+ 0.39	41.5	0.85	1
30 mm	900	1	+0.63	41.5	0.85	1
30 mm	900	10	+0.39	41.5	0.85	1
10 mm	1500	1	+ 0.55	40.5	1.2	1
10 mm	1500	10	+ 0.27	40.5	1.2	1
15 mm	1500	1	+ 0.55	40.5	1.2	1
15 mm	1500	10	+ 0.27	40.5	1.2	1
30 mm	1500	1	+ 0.54	40.5	1.2	1
30 mm	1500	10	+ 0.26	40.5	1.2	1
10 mm	1800	1	+ 0.43	40.0	1.65	1
10 mm	1800	10	+ 0.13	40.0	1.65	1
15 mm	1800	1	+0. 42	40.0	1.65	1
15 mm	1800	10	+ 0.13	40.0	1.65	1
30 mm	1800	1	+ 0.41	40.0	1.65	1
30 mm	1800	10	+ 0.12	40.0	1.65	1

Table 2

These derivatives do not include 1620 MHz but the change in SAR with respect to conductivity appears to vary slowly with frequency. Using the value for 1500 MHz at a 10 mm separation we have as an approximation:

$$\% \text{ change in SAR} = \% \text{change in } \sigma \times 0.55 = \left\{ [1.44 - 1.06573] / 1.06573 \right\} \times 0.55 \times 100\%$$

% change in SAR = + 19.3%

Errors in this approximation include the frequency, distance of the currents to the surface of the phantom, and the slight difference in permittivity and conductivity of the liquid used in the s & p calculation. Actual overestimation likely to be smaller since the factor .55 appears to decrease with increasing frequency, and .55 is the value for 1500 MHz, not 1620 MHz. The e-field probe is calibrated by the manufacturer in brain simulating tissue at frequencies of 900 MHz, and 1.8 GHz, accurate to +/- 8%. Linearity is said by the manufacturer to be +/- .2 dB from 30 MHz to 3 GHz. Dynamic range is said by the manufacturer to be 5 µw/gm to > 100 mw/g. The probe contains 3 small dipoles positioned symmetrically on a triangular core to provide for isotropic detection of the field. Each dipole contains a diode at the feed point that converts the RF signal to dc, which is conducted down a high impedance line to the data acquisition system.

The data acquisition system amplifies the signals, and converts them to digital values so they may be sent to the computer. The inputs to the signal amplifiers are auto zeroed after every measurement to prevent charge build up on the lines, which could lead to errors.

5.2 SAR SYSTEM THEORY

The human body absorbs energy from a radiating cell phone by ionic motion and oscillation of polar molecules. The human head is in the near field of the device where polarisation and field intensity are very complex. Also the human head can cause large reflections and scattering, so it is more practical to measure the field absorbed inside the head, than to measure incident power before it enters the head. Inside the lossy brain tissue, the power per unit volume is given by

$$P_v = \tfrac{1}{2}\, j \bullet e^* = \tfrac{1}{2}\, \sigma \left| E \right|^2 \quad \mathrm{W/m^3}$$

Where j is current density

σ is conductivity of human tissue due to conductive and lossy displacement currents.

E is the electric field

But since SAR is the absorption of RF power per unit mass

$$P_g = \tfrac{1}{2}\, \sigma/p \left| E \right|^2 \mathrm{w/kg}$$

Where p is density of the tissue in kilograms per cubic meter.

In this equation, σ is a function of frequency, and so it must be measured at the frequency of the test. It is measured in terms of the real and imaginary components of the complex permittivity;

$$\varepsilon = \varepsilon_0 (\varepsilon' - j\varepsilon'')$$

$$\sigma = 2\pi f \times (8.854 \times 10^{-12}) \times \varepsilon''$$

Loss tangent $\equiv \tan\delta = \varepsilon''/\varepsilon'$

In order to measure the e field strength without distorting the field, the e field probe (shown here) is made as described by Schmid, egger, and kuster in [3].

E-field probe

A major concern is that secondary coupling of the EUT radiated fields to the feed lines of the probe are minimised. This is done by making the feed lines of high impedance "twin-line" transmission line, printed very close together. In the probe tip there are three orthogonal dipoles, electrically small to minimise field distortion from coupling. The electrically small dipoles have source impedance's of 5 to 8 mΩ due to their small size, the high resistive feed lines, and the distributed filters on the lines. This high impedance makes them less sensitive so a sophisticated data acquisition electronics (dae) box is needed to amplify, multiplex, and digitize the signals. The dae is installed on top of the robot arm. It also detects the proximity of the phantom surface with a fiber-optic cable. It provides for multiplexing between the three dipoles, and between 1x gain and 100x amplification, and it provides some filtering that will remove unwanted signals picked up by the probe. The dae also provides a fast digital link to the robot for stopping in the event of a touch detection. It samples the probe output for 2600 complete e field measurements per dipole, per second. These samples are used to determine the amplification needed, 1x or 100x, and the magnitude determines what diode compression correction factor should be used. These factors as well as sensitivity factors of the specific probe, which are stored in the program, are used to determine the actual field strength for the test point.

The substrate on which the dipoles are printed, has been shaped to align each dipole with the e-field *after* the field lines are distorted by the permittivity of the substrate. In other words, since the substrate and the liquid dielectric have differing permitivities, the e-field will diffract as it passes through the interface, and so the dipoles have been positioned to align with the fields *after* this distortion is accounted for.

The dipole elements in the probe are offset from the tip of the probe approximately 2.7 mm so unfortunately the field strength cannot be measured at the surface of the phantom, where it is likely to be maximum. The magnitude of the field at the surface must therefore be calculated with interpolation by using the data points stepped away from the surface and curve fitting. This is done automatically by the software.

6 TEST SAMPLE CALIBRATION

The wireless device was made to transmit maximum power that is allowed by the software in the device. The SAR test transmit power level (which is the maximum level the software is set to allow) is determined as follows; The device is placed in an anechoic chamber and the effective isotropic radiated power is measured when the device is transmitting its highest possible output power available from the power amplifier. The peak ERP is measured, at the angle of peak gain of the antenna. The conducted output power of the device is measured with an RF power meter using the RF connector on the device. The user terminal software is then programmed to adjust the power so that the maximum output power does not exceed 29.5 dBm EIRP.

7 CALIBRATION DATES OF TEST EQUIPMENT

All measurements were made with instruments whose operation and accuracy has been verified by a Calibration Laboratory with traceability to National standards. The calibration date for each measurement instrument is shown in Table 3.

EQUIPMENT MANUFACTURER & TYPE	SERIAL NO.	LAST CAL.	NEXT CAL.
Schmid & Partner Engineering AG Dosimetric E-field Probe:ET3DV5	1348	AUG 16, 1998	AUG, 1999
Schmid & Partner Engineering AG dipole	220	Jan, 1998	Jan, 2000
EQUIPMENT MANUFACTURER & TYPE	SERIAL NO.	LAST CAL.	NEXT CAL.
Schmid & Partner Engineering AG dipole validation kit : type D900V2	024	Jan, 1998	Jan, 2000
Schmid & Partner Engineering AG Data Acquisition Electronics : Model DAE3 V1	335	June 6, 1998	June 6, 2000
HP ESG-D3000A Digital Sig Gen		Aug 3, 1998	Aug 3 1999
HP 437B RF Power Meter	K59325	May 6, 1998	May 6, 1999
HP Vector Network Analyzer		Oct 10, 1998	Oct 10, 1999
HP 85070M Dielectric Probe System		Not Required	
Liquid Dielectric for 1800 MHz		Replaced every 3 months	
validation kit : type D1800V2		Not Required	

Table 3

8 SAR TEST SYSTEM VALIDATION

Before the test, the system was validated using a symmetric dipole designed to be impedance matched when pressed against a machined dielectric spacer, touching the phantom filled with the brain simulating fluid (photo 5). The separation distance between the validation dipole and the flat phantom is maintained at 10 mm from dipole centre to solution surface with a machined plastic spacer, manufactured for the validation kit. The measured permittivity and conductivity was entered into the DASY settings window (there are slight variations in the permittivity from day to day due to evaporation, although water is added to minimise the variation) A signal generator and a high power amplifier were used to generate a very stable one Watt continuous wave signal, which was checked with an HP RF power meter (calibrated to 1800 MHz) several times over a 30 minute period (to eliminate drift by reaching stable temperature), then input to the validation dipole. Then the DASY3 system was put through an automated validation cycle to determine if the correct SAR is measured. The correct SAR was determined by Schmid & Partner to be 39.9 mW/gm for the type D1800V2 dipole, and 9.44 mW/gm for the D900V2 dipole. These values measured indicate that the system is measuring correctly at these frequencies.

Since these validation dipoles are designed to validate at a specific frequency, we cannot validate the system at 1620 MHz. What is done is to validate at 1800 MHz and change the parameters of the liquid, probe, and device in the DASY software to compensate for the change in frequency. To change the conversion factors for the probe for the 1620 MHz Globalstar transmit frequency, the conversion factors for the probe are based on a linear interpolation from the conversion factors supplied for the probe at 1500 MHz and 1800MHz, which are 5.1 and 4.9 respectively. Interpolating these values gives 5.02. The parameters for this probe, S/N 1353, are included at the end of this report. Note that the frequency response for the electric field in a TEM cell is quite flat with changing frequency (page 6 of 8 in attached probe data). Although calibration of the probe was done at 1800 MHz and 900 MHz, this data indicate that the probe can be used safely at 1620 MHz with interpolated conversion factors.

If the validation result were to give a value high or low by more than 4%, the liquid is re-measured to check for evaporation, and other parameters are checked until this validation produces the correct SAR value. Parameters frequently checked if the validation gives erroneous SAR include diode compression factors, probe conversion factors, frequency settings for the probe, frequency, permittivity, and conductivity settings for the liquid. Placement of ferrite panels beneath phantom, drift in the signal generator, power meter calibration settings, stirring of the liquid dielectric, or the teaching of the robot the exact location of the phantom. This is the main validation test for the system configuration.

Over a period of several days, the robot loses the exact position of the phantom, this information is stored in memory and must be "re-taught" to the system. Before each day of measuring begins, the robot is sent to three test points on the phantom to determine if the exact position information has been lost. If so, the robot is manually sent to these three points and the computer is told to record the information from position sensors in the robot joints. This insures that the system can place the probe as close as possible to the phantom surface.

SAR SYSTEM SPECIFICATIONS

Data Acquisition

Processor: Pentium 200 MHz
Operating Sys: Windows
Software: DASY3 V1.0b Dec 97 edition, Schmid & Partners Eng. AG, Switzerland
Amplifier Gain: 10X or 100X depending on signal level
Surface Detection: Optical and Mechanical
Sample Rate: 7800 data sets per second
Isolation: Fiber Optics to computer, 100KΩ/m to probe tip

E-Field Probe

Offset tip to sensor center: 2.7 mm
Offset surface to probe tip: 1.8 +/- 0.2
Frequency: 30 MHz to 3.0 GHz
Dynamic Range: 5μW/g to 100 mW/g
Isotropy: +/- .15 dB (in brain liquid)

Phantom

Dielectric:	Homogeneous sugar/salt/cellulose liquid
Shell	2 mm +/- 0.2 mm polyester fiber glass
Ear:	2 mm rubber ring

Liquid Dielectric

Permittivity	42.5 @ 900 MHz, 41 @ 1800 MHz
Conductivity	0.85 S/m @ 900 MHz, 1.65 S/m @ 1800 MHz

9 SAR MEASUREMENT PROCEDURE

POWER LEVELS After calibration/validation of the SAR system, the test of the user terminal proceeds as follows.

The Globalstar user terminal transmits at a peak Effective Isotropic Radiated Power of 29.5 dBm EIRP to maintain a link to the satellite. The antenna was measured in an anechoic chamber and was found to have a directive gain of 3 dBi. The power amplifier could then be set to 26.5 dBm for normal operation, however when this power amplifier is set in the factory variations of as much as 1.5 dB are possible due to connector tolerances, etc.

PEAK EFFECTIVE ISOTROPIC RADIATED POWER = 29.5 dBm

ANTENNA GAIN (dBi) = 3 dBi

POWER REQUIRED (peak set in factory) = 26.5 dBm (conducted)

POSSIBLE VARIATION IN P.A. OUTPUT = 1.5 dB

POWER SETTINGS USED FOR SAR MEASUREMENT = 28.0 dBm @ 1611 MHz
27.8 dBm @ 1618 MHz
27.7 dBm @ 1625.5 MHz

POWER VERIFICATION The Globalstar mode radiates through a stacked quadrifilar helix antenna located in a telescoping/rotating structural radome of the user terminal. For safety and improved coverage, the radiating element is furthest or highest from the head at the tip of the rotating support radome. There are two flexible coaxial cables leading from the antenna to the GSP-1610 RF circuitry board. These cables provide the transmit and received signal paths for the Globalstar UT. To measure power, a directional coupler is connected between the transmit antenna cable and the transmit connector on the circuit board. The conducted power test set-up is shown in Photo 15. An HP 437B RF power meter is then connected to the –10dB coupling port of the directional coupler. The insertion loss through the coupling port and the and short cable used to connect to the UT was measured and found to be 10.9dB. The loss of the flexible coaxial cables is included with the gain of the antenna, which is typically 3 dBi. The Anritsu Globalstar User Terminal is used to establish a Globalstar mode call at the desired test frequency. The Anritsu is configured to program the user terminal to transmit at maximum power. The power is then measured from the directional coupler. The power level is entered in the comment section of the DASY system test file, so that it is printed on the SAR graphic plot included in this report.

COARSE GRID The possible locations for the Globalstar user terminal antenna form a circle centred on the user's ear. The 5 x 5 x 7 point fine scan that the DASY system measures over the "hot spot" generally follows the position of the antenna from the top of the head to the back of the head as it is rotated. Because of this, the coarse grid setting is adjusted to cover the entire head (left or right) so that there is no chance of the "hot spot" falling outside of the coarse scan. The resolution of the course scan was Dx = 20 mm, Dy = 20 mm, and Dz = 10 mm.

DEVICE POSITIONING The user terminal was tested in several positions (Photo 7 through Photo 11), but the primary test position was that described by Supplement C of OET Bulletin 65 from the Office of Engineering & Technology, of the FCC. The procedure places the surface of the user terminal in contact with the phantom, but also places the transmit antenna 1.85 inches or more above the head of the user (see figure 1). The two angles, "tilt angle" and "inclination angle" are depicted in figure 1 and figure 2. The distance to the radiating portion of the antenna greatly reduces the SAR levels, which is why the levels measured are unusually low. In photo 12, it can be seen that the radiating section of the Globalstar antenna is 1.85 inches or more from the user's head when the ear-speaker is near the user's ear. This is because the radiating portion of the antenna is in the top portion of the telescoping tube, putting it as far as possible from the user's head (see figure 1). Even if used incorrectly as shown in photos 13 & 14 the radiating portion of the antenna is maintained a safe distance from the user's head. Additionally the radiation pattern of the transmitting antenna was designed to be pseudo Omni-directional above the horizon, with minimum radiation below the horizon, since it must link with a satellite. This also has a great reducing effect on the SAR. As such, in the normal position the SAR values measured were very low.

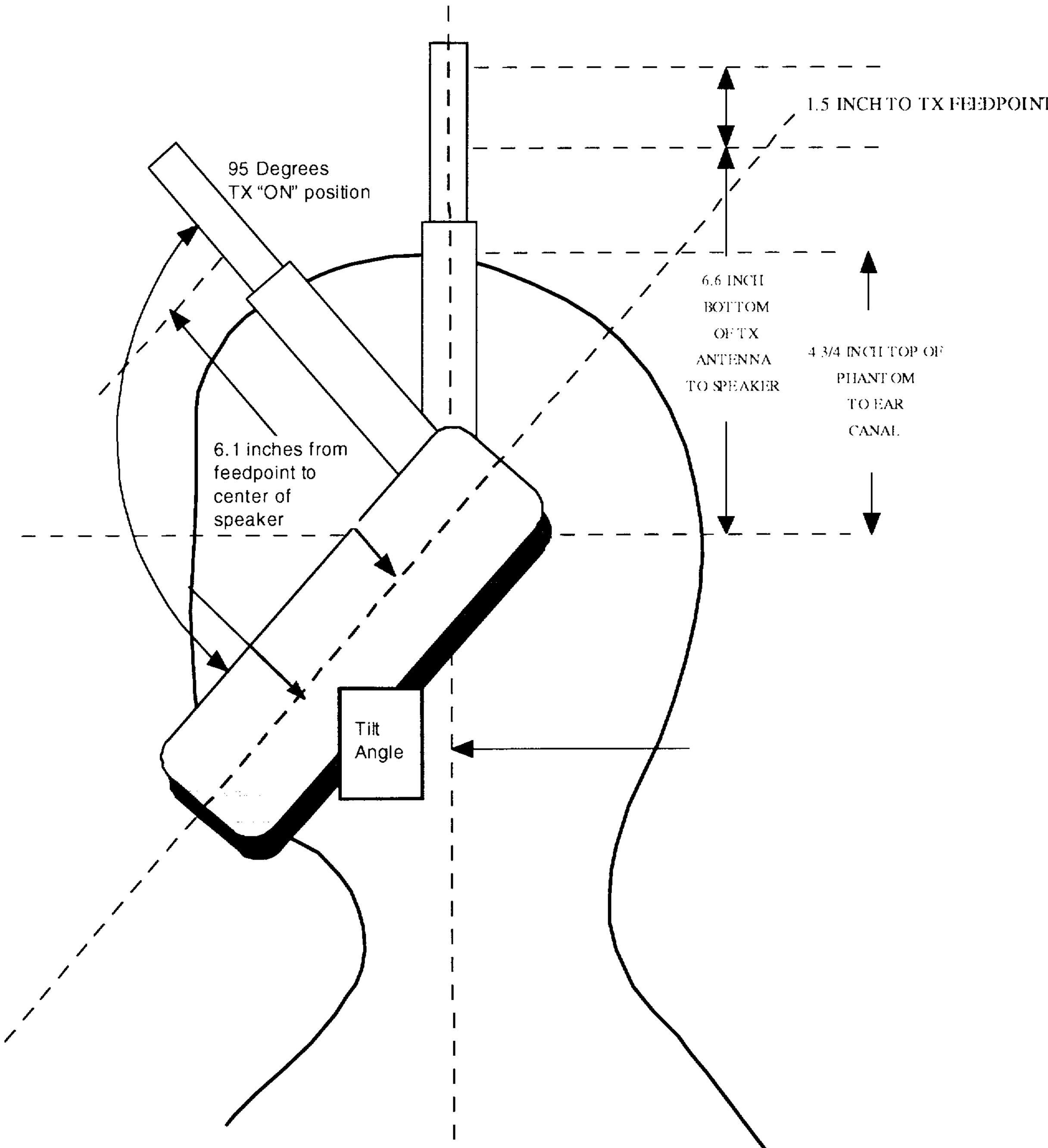


Figure 1 – Antenna Positions Relative to User's Head

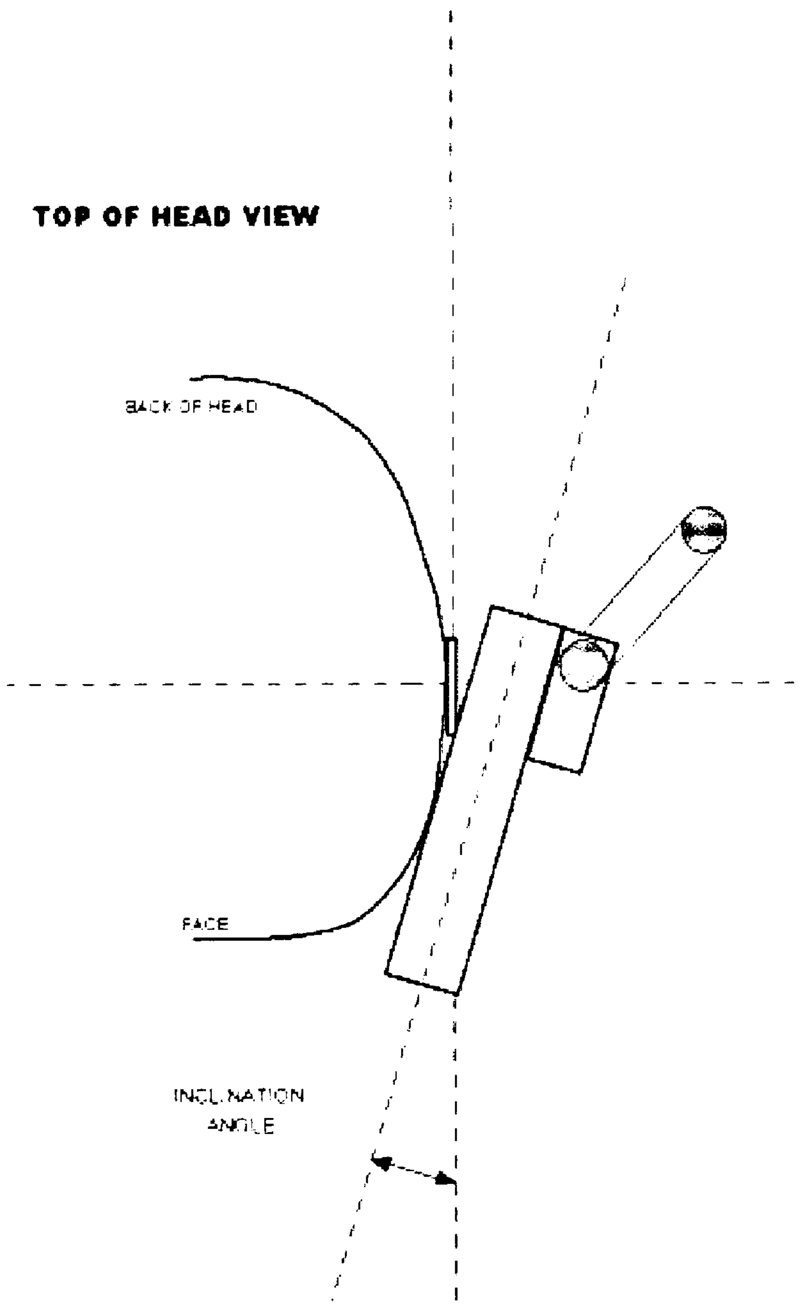


Figure 2 – Top view of User's Head with UT

CREST FACTOR To compensate for probe diode compression with strong signals, the DASY3 system software utilizes the crest factor (the ratio of peak to RMS signal level) of the measured waveform to scale a second order correction term in the output voltage from the probes. The correction factor is applied using the following built-in equation to each (x, y, z) probe channel:

Channel signal voltage = input signal + [(input signal)^2 * crest factor / diode compression point]

Both the crest factor and the diode compression point are DASY3 system input parameters; the latter probe specific, the former waveform specific. For small measured signals, the crest factor selected is immaterial, but the system requires that one be specified. For a TDMA waveform, the crest factor is simply the inverse of the duty cycle (a factor of 8 for GSM signals). For CDMA waveforms, the crest factor is difficult to predict and must be measured; the Globalstar CDMA waveform crest factor is **3**. This Crest factor was measured using a Gigatronics 8542 C Power meter with a power sensor model 80601 A.

CUBE EVALUATION The explanation of the fine scan, or cube evaluation is given in the manual for the DASY system by Schmid & Partners, and is repeated here.

> The spatial peak SAR value for 1 and 10 g is evaluated after the cube measurements have been done. The algorithm that finds the maximal averaged volume is divided into three different stages.
>
> (1)The data between the dipole center of the probe and the surface of the phantom is extrapolated. This data cannot be measured because the dipoles are 2.7 mm away from the actual tip of the E-field dosimetry probe. The distance between the surface and the lowest measuring point is approximately 1 mm, so they can never be placed in the field at the surface of the phantom. The extrapolation is based on a least square algorithm [W. Gander, Computermathematik, p. 168 – 180]. Through the points in all z-axis polynomials of order four are calculated. This polynomial is then used to evaluate the points between the surface and the probe tip. The points calculated from the surface, have a distance of 1 mm from one another.
>
> (2)The maximal interpolated value is searched with a 3d-spline. The 3d-spline is composed of three one-dimensional splines with the "Not a knot" condition [W.Gander, Computermathematik, p.141 – 150] (x, y, and z direction) [Numerical Recipes in C, Second Edition, p.123ff]. Around this maximum, the SAR values averaged over the spatial volumes (1g or 10g) are computed using the 3d spline interpolation algorithm. If the volume cannot be evaluated (i.e., if part of the grid was cut off by the boundary

of the measurement area) the evaluation will be started on the corners of the bottom plane of the cube.

(3) All neighboring volumes are evaluated until no neighboring volume with a higher average value is found. For the volume, averaging the size of the cube is first calculated. The volume is then integrated with the trapezoidal logarithm. 1000 points (10 x 10 x 10) are interpolated to calculate the average.

Typically, the maximum SAR values occur on the outer boundary of the liquid nearest the radiation source, at the fluid-phantom shell interface. The extrapolation of this maximum will indicate that the maximum is outside of the measurable area. When this occurs the DASY system writes the comment "maximum outside" on the SAR plots. This is not an indication of a bad measurement, but indicates that the maximum was extrapolated since it was physically impossible to measure.

10 SAR MEASUREMENT UNCERTAINTY

The possible errors included in this measurement arise from device positioning uncertainty, device manufacturing uncertainty, liquid dielectric permittivity uncertainty, liquid dielectric conductivity uncertainty, uncertainty due to disturbance of the fields by the probe.
These will be discussed as they are of much importance to the final dosimetric assessment. Every attempt is made to reduce uncertainty, as well as to test for worst case SAR. These uncertainties are likely to be pessimistic, but they should be considered when comparing data taken from one lab to another. Thomas Schmid of Schmid and Partners has performed a study of SAR repeatability due to many different uncertainties, this is likely the most complete study of the topic so it is referred to here.

Device positioning; this uncertainty is due to different operators positioning the device on the phantom differently, it depends on the operators, the device design, the phantom, and the device holder. Repeatability for some devices in Schmid's study was as poor as +/- 30% for the "touch" position. For the "intended use" position the repeatability was approximately +/- 5%, depending on the device tested, overall a figure of +/- 6% was taken as typical device positioning uncertainty. One operator is used at the QUALCOMM lab, trained to place the user terminal as close as possible to phantom, and the test is performed after the position of maximum SAR is determined. This minimises device positioning error. Typically the user terminal is clamped in the holder in the horizontal position, and a short wooden dowel is placed in a small hole where the center of the ear speaker resides. This wooden dowel allows the operator to line up the speaker with the ear canal. Once aligned, the toothpick is removed, and the user terminal is raised up until it touches the phantom on the ear. Then the cradle is rocked so the user terminal rocks toward the chin of the phantom, touching as closely as possible without depressing the keypad. This puts the user terminal as close as possible to the phantom, allowing maximum SAR to be measured, for most positions. In the event that this may not produce maximum SAR, the user terminal is placed in several other positions and a coarse scan is run for each position. The DASY system has a command called "move to max" which allows the probe to be sent to the point of max field intensity found with the coarse scan. This gives a visual indication of where the maximum surface currents may be, and allows the operator to position this point of the user terminal as close as possible to the phantom.

Liquid dielectric permittivity and conductivity; The average permittivity of a typical human head was determined by Dr. Gabriel and has been listed by the FCC (OET bulletin 65 supplement C) as 46.1 at 835 MHz and 43.4 at 1800 MHz. The liquid purchased from Schmid & Partner measures approximately 42 at 1900 MHz and 43.2 at 1620 MHz. The lower permittivity generally gives a slightly higher SAR value, so these values were used for the test. Since SAR is defined as the time rate of absorption per unit of weight, only the macroscopic simulation of the tissue's permittivity, permeability, and conductivity are required. These electrical properties are obtained with a liquid that uses sugar to raise the permittivity, salt to raise the conductivity, and cellulose to hold the two in suspension. The QUALCOMM lab purchases the dielectric from Schmid and Partners so that maximum accuracy of permittivity and conductivity is insured, by eliminating any possibility of liquid preparation errors, i.e. lumps in cellulose, excess viscosity causing excess bubbles, etc After receiving the liquid it is measured with an HP 85070A dielectric probe kit. The achievable accuracy of this device is +/- 5% for the permittivity and +/- 10% for the conductivity. The permittivity and conductivity match with those claimed by Schmid & Partners. The liquid is also measured at the beginning of each SAR measurement day, to check for evaporation.

FIELD DISTURBANCES Errors due to disturbance of the fields by the probe; because the polarizations of the fields are unknown, the near field probe must measure all polarizations without disturbing them by being present. Three orthogonal dipoles are located at the tip of a special dielectric support, with diodes at the feed points sensitive to fields as small as 5 microWatt/gm. To prevent secondary coupling of the fields to the feed lines, the lines are high resistance printed lines with distributed filters integrated in the lines, after the diode. Much research has been put into these probe designs, so their uncertainty is considered minimized. There are other uncertainties, such as laboratory set-up uncertainty, the reader should refer to attachment 10 of the March 1998 minutes of the IEEE standards coordinating committee, by Thomas Schmid. Mr. Schmid's preliminary uncertainty figure is –12% to +52% for the SAR measurement. As stated before this is possible, but believed to be pessimistic because many of the sources of uncertainty have been reduced or eliminated, at considerable expense. All practical precautionary measures are taken to reduce these errors in the QUALCOMM Inc. SAR lab.

Surface Detection The location of the antenna feedpoint for the Globalstar user terminal is above the user's head for the intended mode of operation. This causes a very low-level peak in the SAR to be found at the top of the user's head. This area of the phantom as situated in the DASY3 system is a vertical surface, and as a result the dosimetry probe during measurement is parallel to this surface. As a result of this the optical detection, which is designed for surfaces perpendicular to the dosimetry probe, does not function. The immediate surface of the liquid dielectric cannot be measured due to limitations of the systems optical and mechanical surface detection. The border of the phantom was moved approximately 10 mm further from the surface to prevent the system from shutting down. Because the SAR values are extremely far from the limit of 1.6 mW/g (the highest measured being .0246 mW/g) the error caused by this limitation of the system is acceptable. In other words it is likely the SAR increases closer to the edge of the liquid, but it is impossible for it to increase by a factor of 49 in 10 mm. Even if this could occur, that data point would be averaged with low levels that surround the peak, which were the measured levels, and the averaging process would bring the SAR below the 1.6 mW/g limit. At the time of this writing the DASY3 system does not have the capability to use surface detection in this area of the phantom.

11 TEST DATA SUMMARY

The device that was tested is the final production model. No more design changes are to be made which will effect SAR. The device represents the frozen design of the GSP1610.

The SAR values measured for the Globalstar UT in Globalstar mode are extremely low due to the design of the Globalstar antenna. In some cases, the levels measured are near the bottom of the dynamic range of the DASY systems measurement capability. Some of the values when examined with respect to neighboring frequencies values appear to be inconsistent. This occurs because at levels this low more accuracy is needed, and the system is more greatly effected by the many causes of error. Some of this error is due to static, slight settling of the liquid during measurement, device positioning, and other smaller sources of error. This does not indicate faults with the measurements, it is a result of the difficulty of measuring extremely small SAR levels. Since the levels are far below the limits, these variations are of lesser concern.

TEMPERATURE (°C)	20 C
RELATIVE HUMIDITY	38%
Atmospheric PRESSURE	1015 mB

Mixture Type:	Water/Sugar/cellulose/Salt
Dielectric Constant:	40.30
Conductivity:	1.52 +/- 10% mho/m
Closest Distance between E-Probe & Phone Antenna:	1.85 Inch (intended use position)

ANSI/IEEE C95.1 1992 – SAFETY LIMIT Spatial Peak (Brain) Uncontrolled Exposure/General Population	1.6 W/kg (mW/g)

FREQ. MHZ	CONDUCTED POWER (dBm)	HEAD SIDE	ANTENNA POSITION INCLINATION°/TILT°	1 GRAM AVG. SAR (mW/g)	10 g AVG. SAR (mW/g)
1611 (ch 4)	31.2	Left	Zenith/vertical 20° / 65°	0.0084	0.0040
1618 (ch 250)	31.2	Left	Zenith/vertical 20° / 65°	0.0092	0.0043
1625.5 (ch 496)	31.2	Left	Zenith/vertical 20° / 65°	0.0025	0.0006
1611 (ch 4)	31.2	Left	Horizontal 20° / 65°	0.0085	0.0047
1618 (ch 250)	31.2	Left	Horizontal 20° / 65°	0.0093	0.0046
1625.5 (ch 496)	31.2	Left	Horizontal 20° / 65°	0.0068	0.0025
1611 (ch 4)	31.2	Right	Zenith/vertical 20° / 65°	0.0217	0.0132
1618 (ch 250)	31.2	Right	Zenith/vertical 20° / 65°	0.0246	0.0120
1625.5 (ch 496)	31.2	Right	Zenith/vertical 20° / 65°	0.0185	0.0103
1611 (ch 4)	31.2	Right	Horizontal 20° / 65°	0.0078	0.0038
1618 (ch 250)	31.2	Right	Horizontal 20° / 65°	0.0097	0.0044
1625.5 (ch 496)	31.2	Right	Horizontal 20° / 65°	0.0081	0.004

References

[1] Klaus Meier, Voker Hombach, Ralf Kastle, Roger Yew-Siow Tay, and Neils Kuster "The dependence of Electromagnetic Energy Absorption upon Human-Head Modeling at 1800 MHz" IEEE Transactions on Microwave Theory and Techniques, Vol. 45 No 11, November 1997

[2] Volker Hombach, Klaus Meier, Michael Burkhardt, Eberhard Kuhn, and Neils Kuster "The Dependence of EM Energy Absorption Upon Human Head Modeling at 900 MHz" " IEEE Transactions on Microwave Theory and Techniques, Vol. 44 No 10, October 1996

[3] Thomas Schmid, Oliver Egger, Niels Kuster "Automated E-Field Scanning System for Dosimetric Assessments" IEEE Transactions on Microwave Theory and Techniques, Vol 44, No 1, January 1996

[4] Niels Kuster, Q. Balzano, and J.C. Lin "Mobile Communications Safety" Chapman & Hall, First edition
1997

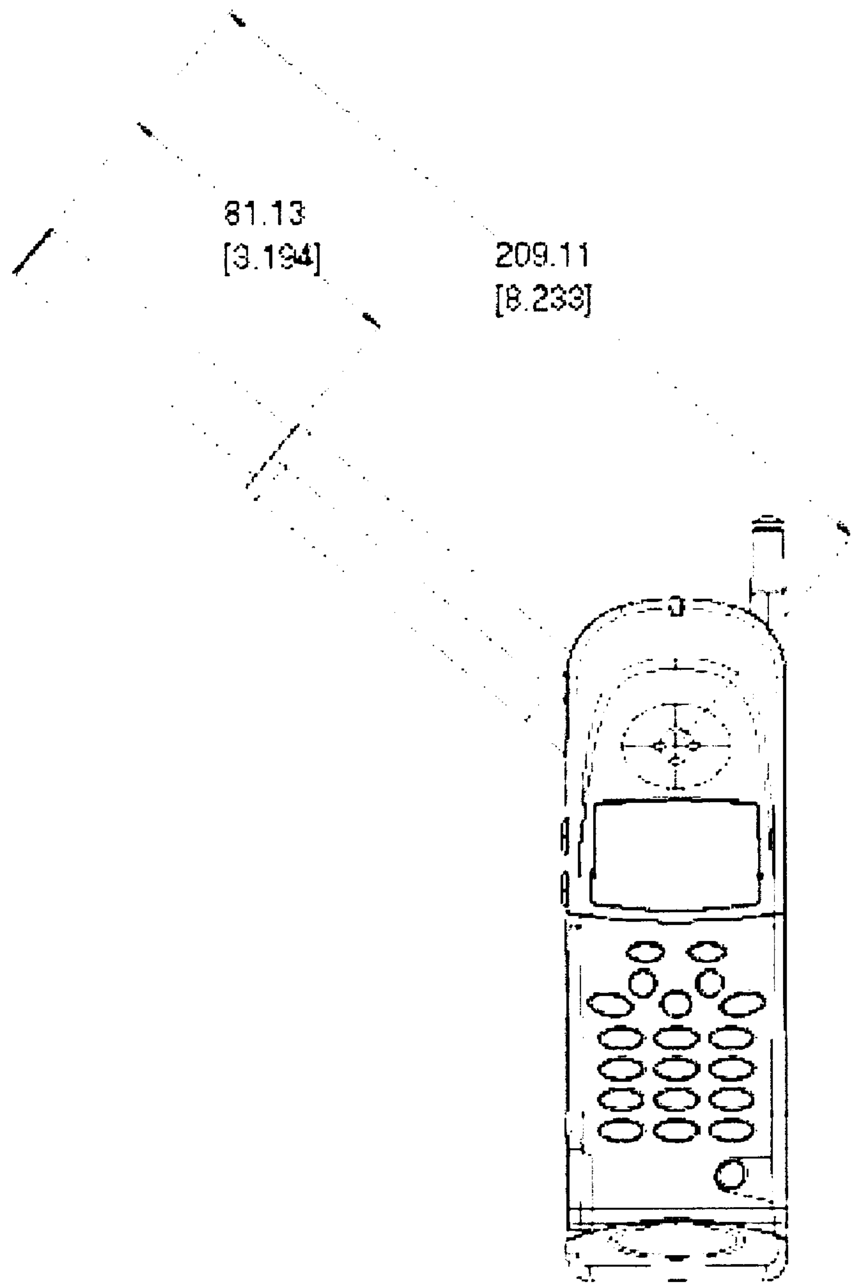


Figure 3 – Front View of GSP 1610 with Antenna Positions

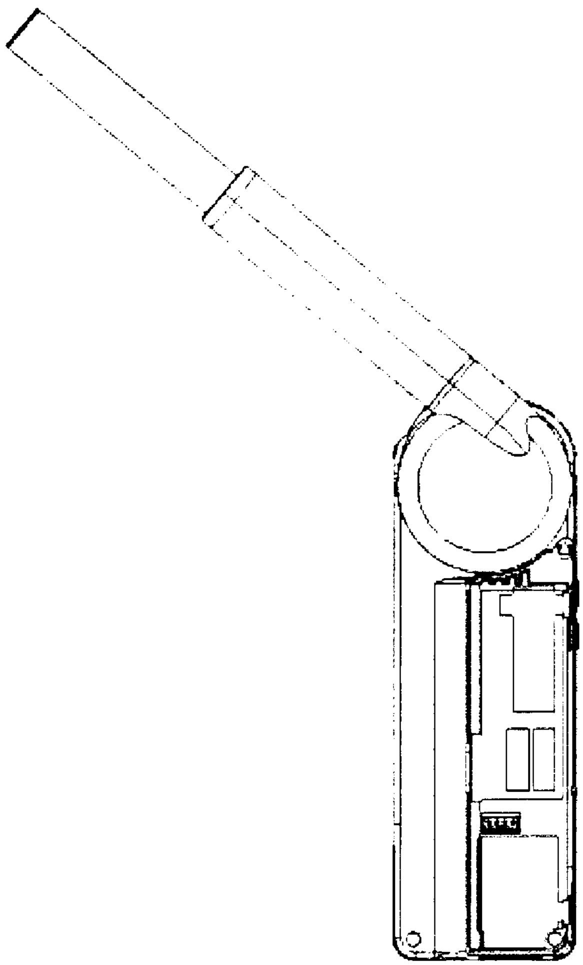


Figure 4 – Rear View of GSP 1610

"Operator:DWS"
"Title:Globalstar"
"Time:09:41:21"
"Date:04/28/99"
"Comments:Brain simulation fluid validation"

"Program=3601"
"Sweep mode=2050"
"Number of points=201"
"Start Frequency=300000.000000"
"Stop Frequency=3000000000.000000"
"Data Sensitivity=1"

"frequency"	"e'"	"e''"	"data sens"
300000.000000	170.90986	48.791891	2340.571424
15298500.000000	63.740743	8.836968	123.207863
30297000.000000	62.466054	6.039898	63.503472
45295500.000000	61.263035	5.929836	43.343346
60294000.000000	61.048611	5.878613	32.701833
75292500.000000	61.029134	5.607809	26.213449
90291000.000000	60.313972	5.790843	22.139401
105289500.000000	59.833090	6.179863	19.161240
120288000.000000	59.671446	6.411802	16.837120
135286500.000000	59.134478	6.738531	15.126632
150285000.000000	58.819826	7.005840	13.708553
165283500.000000	58.499890	7.376319	12.552687
180282000.000000	58.109266	7.501792	11.601108
195280500.000000	58.060631	7.632137	10.734082
210279000.000000	57.585688	7.902615	10.067387
225277500.000000	57.355810	8.164765	9.451249
240276000.000000	57.151154	8.249411	8.906121
255274500.000000	56.910297	8.592269	8.435564
270273000.000000	56.638080	8.776441	8.020040
285271500.000000	56.297970	9.031830	7.659571
300270000.000000	56.068358	9.187640	7.320232
315268500.000000	55.862227	9.435827	7.012637
330267000.000000	55.699490	9.599348	6.727042
345265500.000000	55.341272	9.902991	6.491960
360264000.000000	55.084183	9.969226	6.261923
375262500.000000	54.784579	10.215900	6.058781
390261000.000000	54.566072	10.326544	5.861018
405259500.000000	54.325557	10.542163	5.682617
420258000.000000	54.156439	10.687905	5.509153

435256500.000000	53.875663	10.884635	5.359947
450255000.000000	53.717294	11.024251	5.208608
465253500.000000	53.455502	11.179806	5.077347
480252000.000000	53.288009	11.270896	4.945024
495250500.000000	53.044547	11.368925	4.827934
510249000.000000	52.853511	11.463137	4.713514
525247500.000000	52.643949	11.659757	4.609553
540246000.000000	52.549588	11.876464	4.502593
555244500.000000	52.211727	11.977226	4.419523
570243000.000000	52.059129	12.099367	4.326786
585241500.000000	51.844661	12.187077	4.243348
600240000.000000	51.591886	12.374211	4.169414
615238500.000000	51.344915	12.478654	4.097489
630237000.000000	51.147181	12.552443	4.025003
645235500.000000	50.965923	12.700616	3.956444
660234000.000000	50.806112	12.823440	3.889239
675232500.000000	50.630556	12.883216	3.825162
690231000.000000	50.371050	13.024244	3.771836
705229500.000000	50.294970	13.083791	3.706441
720228000.000000	50.062940	13.214212	3.656315
735226500.000000	49.891385	13.265212	3.602740
750225000.000000	49.659635	13.338244	3.556113
765223500.000000	49.536626	13.447927	3.504992
780222000.000000	49.330352	13.535830	3.461180
795220500.000000	49.164493	13.608592	3.416285
810219000.000000	49.027026	13.733532	3.372514
825217500.000000	48.826246	13.791715	3.333256
840216000.000000	48.635699	13.876540	3.295548
855214500.000000	48.476465	13.974490	3.257688
870213000.000000	48.291204	14.038860	3.222275
885211500.000000	48.147819	14.107422	3.185735
900210000.000000	48.009503	14.177419	3.150304
915208500.000000	47.869859	14.231700	3.115939
930207000.000000	47.681232	14.297986	3.086104
945205500.000000	47.521401	14.376752	3.055958
960204000.000000	47.331525	14.437620	3.028360
975202500.000000	47.232424	14.505452	2.996537
990201000.000000	46.998463	14.559440	2.973509
1005199500.000000	46.878055	14.647028	2.945460
1020198000.000000	46.708491	14.725551	2.921076
1035196500.000000	46.579297	14.760934	2.894250
1050195000.000000	46.459332	14.845003	2.868899
1065193500.000000	46.279572	14.891381	2.846984

1080192000.000000	46.086563	14.969513	2.827351
1095190500.000000	45.989434	14.990992	2.801687
1110189000.000000	45.820644	15.008636	2.780757
1125187500.000000	45.689838	15.069708	2.759411
1140186000.000000	45.540775	15.130063	2.739769
1155184500.000000	45.415030	15.180397	2.719257
1170183000.000000	45.305392	15.280664	2.699696
1185181500.000000	45.146859	15.300472	2.681544
1200180000.000000	44.986989	15.329936	2.664276
1215178500.000000	44.884846	15.393977	2.645260
1230177000.000000	44.725669	15.432295	2.629289
1245175500.000000	44.544325	15.442536	2.614356
1260174000.000000	44.440822	15.515469	2.597262
1275172500.000000	44.306733	15.559962	2.581629
1290171000.000000	44.202254	15.606321	2.564952
1305169500.000000	44.091526	15.644374	2.548883
1320168000.000000	43.947017	15.687666	2.535190
1335166500.000000	43.812101	15.715878	2.521051
1350165000.000000	43.679934	15.777136	2.508020
1365163500.000000	43.528933	15.803777	2.495517
1380162000.000000	43.419253	15.873541	2.482346
1395160500.000000	43.315298	15.893156	2.468007
1410159000.000000	43.173197	15.914550	2.456063
1425157500.000000	43.061465	15.964941	2.443658
1440156000.000000	42.906503	15.991396	2.433218
1455154500.000000	42.775522	15.992632	2.421233
1470153000.000000	42.644857	16.033967	2.410599
1485151500.000000	42.526777	16.083686	2.399870
1500150000.000000	42.425540	16.090264	2.387480
1515148500.000000	42.322750	16.119463	2.376071
1530147000.000000	42.217470	16.129983	2.364601
1545145500.000000	42.076414	16.143581	2.355299
1560144000.000000	41.991347	16.189733	2.344337
1575142500.000000	41.872300	16.203861	2.334504
1590141000.000000	41.791219	16.218528	2.323065
1605139500.000000	41.683266	16.275725	2.314368
1620138000.000000	41.572958	16.291290	2.304931
1635136500.000000	41.462237	16.311502	2.295886
1650135000.000000	41.368928	16.356079	2.286891
1665133500.000000	41.266597	16.389911	2.278291
1680132000.000000	41.148596	16.407272	2.270241
1695130500.000000	41.035279	16.449297	2.262862
1710129000.000000	40.918074	16.478227	2.255537

1725127500.000000	40.823355	16.495128	2.246999
1740126000.000000	40.720559	16.498380	2.238684
1755124500.000000	40.586780	16.514715	2.232435
1770123000.000000	40.532978	16.536044	2.222662
1785121500.000000	40.400328	16.554145	2.216796
1800120000.000000	40.302410	16.555848	2.208987
1815118500.000000	40.186790	16.575796	2.202727
1830117000.000000	40.112198	16.590803	2.194546
1845115500.000000	40.020856	16.620044	2.187751
1860114000.000000	39.949615	16.631480	2.179671
1875112500.000000	39.856718	16.678976	2.173828
1890111000.000000	39.754133	16.696063	2.167745
1905109500.000000	39.678041	16.740890	2.161374
1920108000.000000	39.558528	16.736826	2.155803
1935106500.000000	39.478333	16.761385	2.149362
1950105000.000000	39.361253	16.776760	2.144546
1965103500.000000	39.275698	16.803634	2.138734
1980102000.000000	39.177298	16.848847	2.134217
1995100500.000000	39.076044	16.866544	2.129171
2010099000.000000	38.967409	16.878141	2.124431
2025097500.000000	38.871726	16.873488	2.118736
2040096000.000000	38.788553	16.879820	2.112915
2055094500.000000	38.677702	16.899565	2.108923
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2100090000.000000	38.416178	16.936204	2.093724
2115088500.000000	38.308364	16.902508	2.088471
2130087000.000000	38.239027	16.944183	2.083842
2145085500.000000	38.149845	16.962011	2.079531
2160084000.000000	38.049821	16.918166	2.073941
2175082500.000000	37.991317	16.940444	2.068574
2190081000.000000	37.891326	16.992237	2.066154
2205079500.000000	37.824411	16.975491	2.060200
2220078000.000000	37.718441	16.987193	2.057032
2235076500.000000	37.645750	16.993970	2.052286
2250075000.000000	37.543980	16.993545	2.048754
2265073500.000000	37.472057	17.016184	2.044677
2280072000.000000	37.410800	17.014919	2.039461
2295070500.000000	37.334153	17.025596	2.035425
2310069000.000000	37.259928	17.021233	2.030900
2325067500.000000	37.192020	17.038893	2.026881
2340066000.000000	37.106857	17.061467	2.023906
2355064500.000000	37.045660	17.098616	2.020402

2370063000.000000	36.950200	17.082626	2.016845
2385061500.000000	36.890182	17.100898	2.012865
2400060000.000000	36.821711	17.120629	2.009408
2415058500.000000	36.722832	17.149839	2.007730
2430057000.000000	36.651370	17.134422	2.003443
2445055500.000000	36.576502	17.153399	2.000510
2460054000.000000	36.525895	17.180064	1.996820
2475052500.000000	36.453012	17.171441	1.993060
2490051000.000000	36.370290	17.188007	1.990653
2505049500.000000	36.298480	17.216623	1.988235
2520048000.000000	36.203331	17.219767	1.986107
2535046500.000000	36.151336	17.287501	1.984259
2550045000.000000	36.083518	17.307384	1.981618
2565043500.000000	36.007479	17.293240	1.978276
2580042000.000000	35.917051	17.269454	1.975323
2595040500.000000	35.845879	17.314079	1.973881
2610039000.000000	35.785803	17.328870	1.971012
2625037500.000000	35.685140	17.401180	1.971998
2640036000.000000	35.603919	17.398910	1.969652
2655034500.000000	35.533412	17.421995	1.967749
2670033000.000000	35.478960	17.367866	1.962535
2685031500.000000	35.410107	17.399696	1.960983
2700030000.000000	35.297525	17.375300	1.959535
2715028500.000000	35.237908	17.471892	1.959956
2730027000.000000	35.152858	17.468018	1.958119
2745025500.000000	35.079065	17.462917	1.955779
2760024000.000000	35.013578	17.446689	1.952731
2775022500.000000	34.962763	17.420783	1.948736
2790021000.000000	34.905771	17.438433	1.946607
2805019500.000000	34.796567	17.430228	1.945981
2820018000.000000	34.737628	17.494050	1.945706
2835016500.000000	34.656311	17.512994	1.944918
2850015000.000000	34.590807	17.501090	1.942367
2865013500.000000	34.534788	17.476930	1.938995
2880012000.000000	34.461542	17.462846	1.936809
2895010500.000000	34.397752	17.502878	1.936203
2910009000.000000	34.335359	17.539831	1.935491
2925007500.000000	34.240067	17.555091	1.935535
2940006000.000000	34.170006	17.557918	1.934042
2955004500.000000	34.126152	17.568457	1.931695
2970003000.000000	34.043499	17.504713	1.928421
2985001500.000000	34.024895	17.526855	1.925457
3000000000.000000	33.916180	17.535064	1.926093

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DASY

Dipole Validation Kit

Type: D900V2

Serial: 024

Manufactured: December 1997
Calibrated: January 1998

1. Measurement Conditions

The measurements were performed in the flat section of the new generic twin phantom (shell thickness 2mm) filled with brain simulating sugar solution of the following electrical parameters at 900 MHz:

Relative Dielectricity	**42.3**	± 5%
Conductivity	**0.85 mho/m**	± 5%

The DASY3 System (Software version 1.0a) with a dosimetric E-field probe ET3DV4 (SN:1302, Conversion factor 5.5) was used for the measurements.

The dipole was mounted on the small tripod so that the dipole feedpoint was positioned below the centre marking of the flat phantom section and the dipole was oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 15mm from dipole centre to the solution surface. The included distance holder was used during measurements for accurate distance positioning.

The coarse grid with a grid spacing of 15mm was aligned with the dipole. The 5x5x7 fine cube was chosen for cube integration. Probe isotropy errors were cancelled by measuring the SAR with normal and 90° turned probe orientations and averaging. The dipole input power (forward power) was 250mW ± 3 %. The results are normalised to 1W input power.

2. SAR Measurement

Standard SAR-measurements were performed with the phantom according to the measurement conditions described in section 1. The results have been normalised to a dipole input power of 1W (forward power). The resulting averaged SAR-values are:

averaged over 1 cm^3 (1 g) of tissue:	**9.44 mW/g**
averaged over 10 cm^3 (10 g) of tissue:	**6.16 mW/g**

Note: If the liquid parameters for validation are slightly different from the ones used for initial calibration, the SAR-values will be different as well. The estimated sensitivities of SAR-values and penetration depths to the liquid parameters are listed in the DASY Application Note 4: 'SAR Sensitivities'.

3. Dipole Impedance and return loss

The impedance was measured at the SMA-connector with a network analyser and numerically transformed to the dipole feedpoint. The transformation parameters from the SMA-connector to the dipole feedpoint are:

Electrical delay:	**1.397 ns**	(one direction)
Transmission factor:	**0.988**	(voltage transmission, one direction)

The dipole was positioned at the flat phantom sections according to section 1 and the distance holder was in place during impedance measurements.

Feedpoint impedance at 900 MHz:	Re{Z} = **50.2 Ω**
	Im {Z} = **-0.0 Ω**
Return Loss at 900 MHz	**- 54.9 dB**

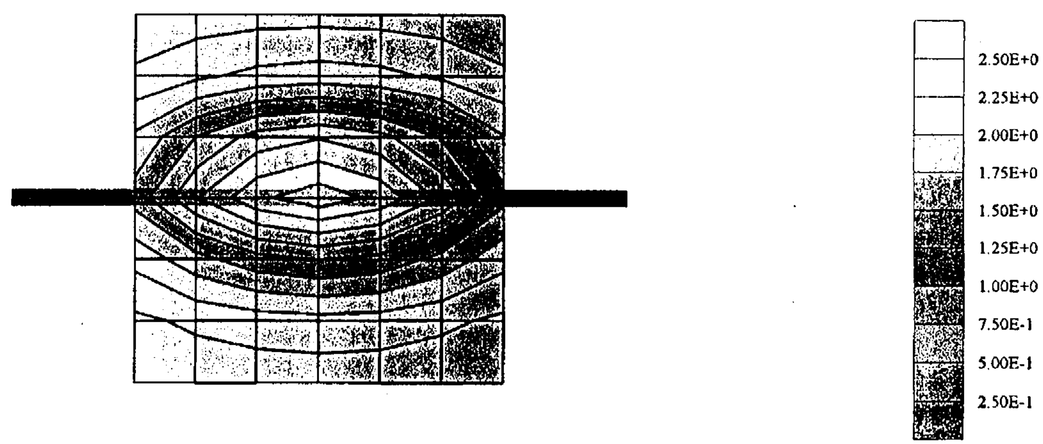
4. Handling

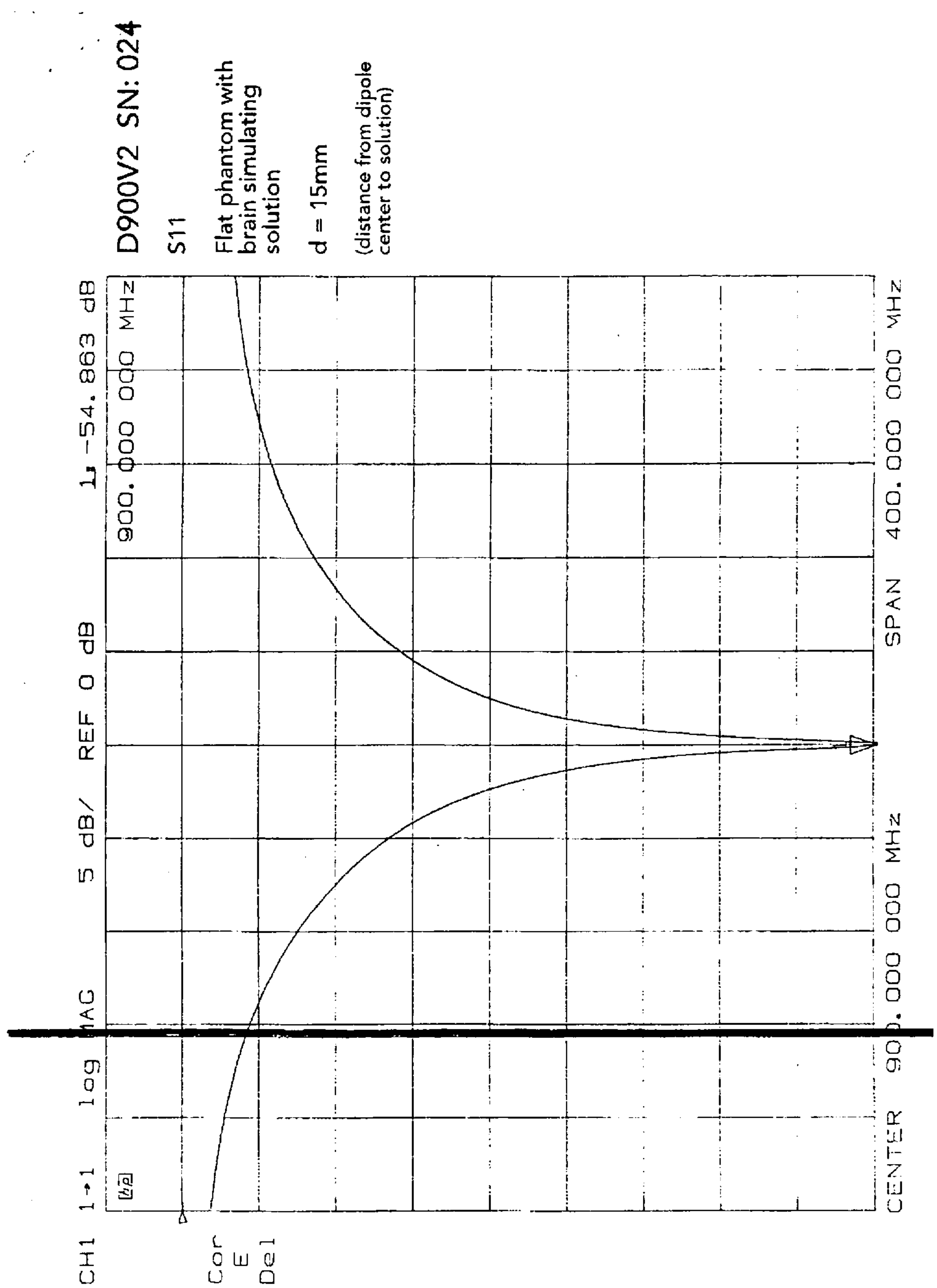
The dipole is made of standard semirigid coaxial cable. The centre conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals.

Do not apply excessive force to the dipole arms, because they might bend. If the dipole arms have to be bent back, take care to release stress to the soldered connections near the feedpoint; they might come off.

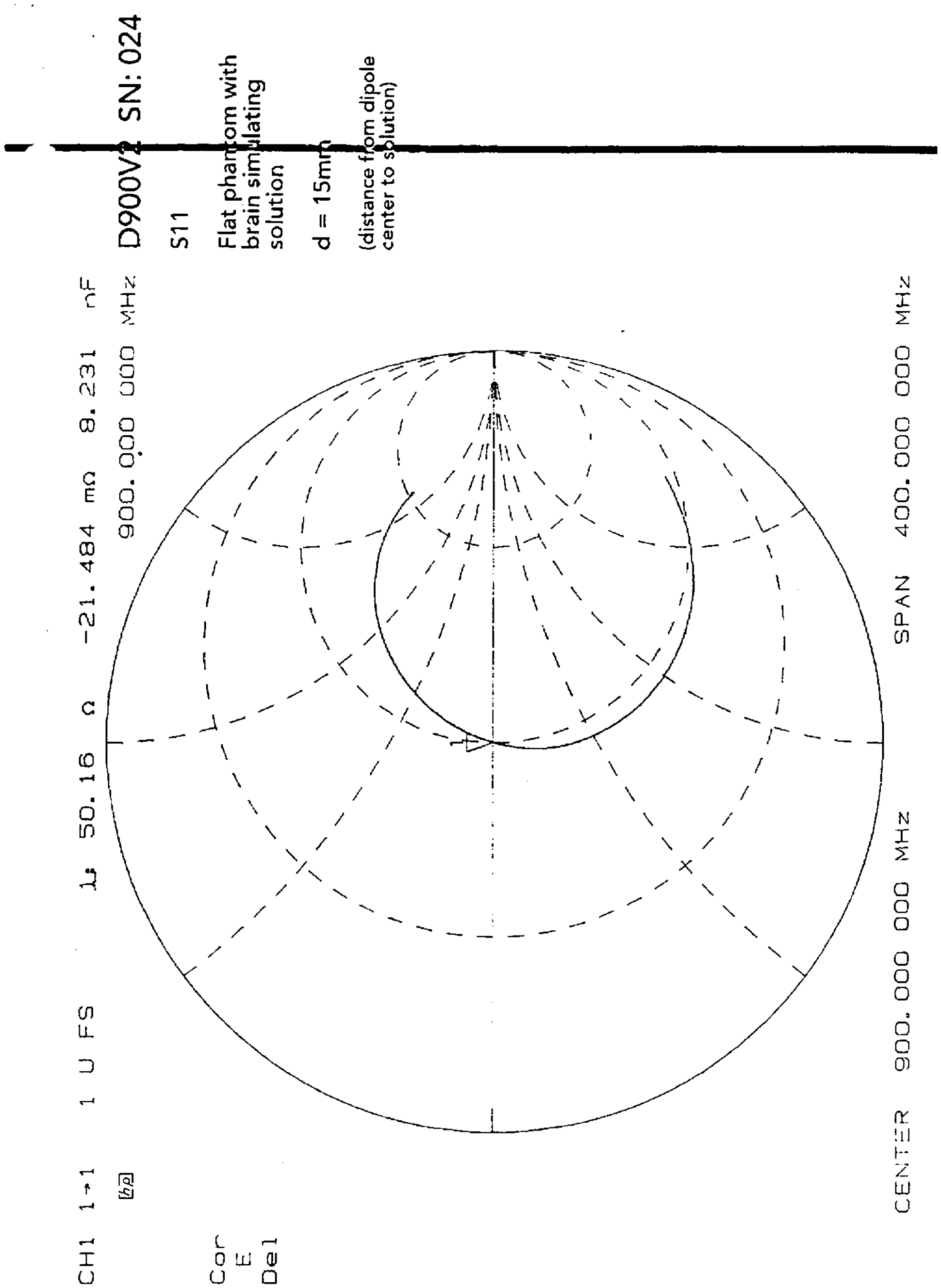
After prolonged use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

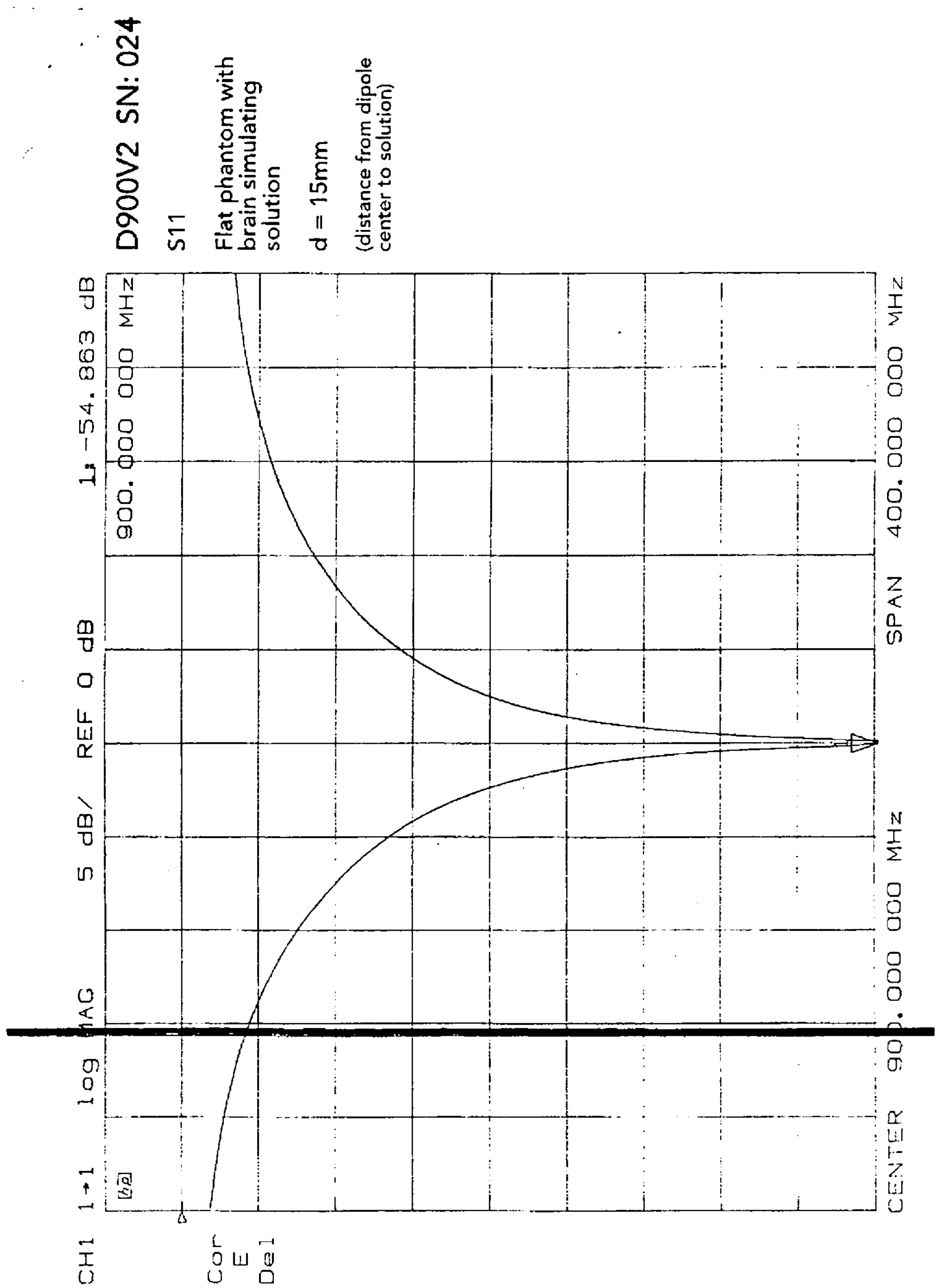
Validation Dipole D900V2 SN:024, d = 15mm
Frequency: 900 [MHz]; Antanna Input Power: 250 [mW]
Generic Twin Phantom; Flat Section; Grid Spacing: Dx = 15.0, Dy = 15.0, Dz = 10 0 [mm]
Probe: ET3DV5 - SN1302 DAE3; ConvF(5.40,5.40,5.40); Crest factor: 1.0; }: σ = 0.85 [mho/m] ε_r = 42.3 ρ = 1.00 [g/cm³]
Cubes (2): Peak: 3 58 [mW/g] ± 0.06 dB, SAR (1g): 2.36 [mW/g] ± 0.05 dB, SAR (10g): 1.54 [mW/g] ± 0.04 dB, (Worst-case extrapolation)
Penetration depth. 13.1 (12.1, 14.4) [mm]
Powerdrift: 0 03 dB





D900V2 SN: 024
S11
Flat phantom with brain simulating solution
d = 15mm
(distance from dipole center to solution)
CH1 1→1 log MAG 5 dB/ REF 0 dB 1_ -54.863 dB
900.000 000 MHz
Cor
E
Del
CENTER 900.000 000 MHz
SPAN 400.000 000 MHz


D900V2 SN: 024
S11
Flat phantom with brain simulating solution
d = 15mm
(distance from dipole center to solution)
CH1 1→1 1 U FS 1: 50.16 Ω -21.484 mΩ 8.231 nF
900.000 000 MHz
Cor
E
Del
CENTER 900.000 000 MHz SPAN 400.000 000 MHz



D900V2 SN: 024
S11
Flat phantom with brain simulating solution
d = 15mm
(distance from dipole center to solution)
CH1 1→1 log MAG 5 dB/ REF 0 dB 1: -54.863 dB
900.000 000 MHz
CENTER 900.000 000 MHz SPAN 400.000 000 MHz
Cor
E
Del

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Probe ET3DV5

SN:1348

Manufactured: August 1998
Calibrated: August 1998

Calibrated for System DASY3

ET3DV5 SN:1348

Introduction

The performance of all probes is measured before delivery. This includes an assessment of the characteristic parameters, receiving patterns as a function of frequency, frequency response and relative accuracy. Furthermore, each probe is tested in use according to a dosimetric assessment protocol. The sensitivity parameters (NormX, NormY, NormZ), the diode compression parameter (DCP) and the conversion factor (ConvF) of the probe and some of the measurement diagrams are given in the following.

The performance of the individual probes varies slightly due to tolerances arising from the manufacturing process. Since the lines are highly resistive (several MOhms), the offset and noise problem is greatly increased if signals in the low µV range are measured. Accurate measurement below 10 µW/g are possible if the following precautions are taken: 1) check the current grounding with the *multimeter*[1], i.e., low noise levels, 2) compensate the current *offset*[1], 3) use long integration time (approx. 10 seconds), 4) *calibrate*[1] before each measurement, 5) persons should avoid moving around the lab while measuring.

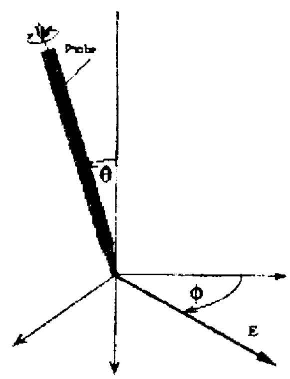


Fig. 1: Due to the field distortion caused by the supporting material, the probe has two characteristic directions, referred to as angle φ and θ.

Since the field distortion caused by the supporting material and the sheath is quite high in the θ direction, the receiving pattern is poor in air. However, the distortion in tissue equivalent material is much less because of its high dielectricity. In addition, the fields induced in the phantoms by dipole structures close to the body are dominently parallel to the surface. Thus, the error due to non-isotropy is much better than 1 dB for dosimetric assessments.

The probes are calibrated in the TEM cell ifi 110 although the field distribution in the cell is not very uniform and the frequency response is not very flat. To ensure consistency, a strict protocol is followed. The conversion factor (ConF) between this calibration and the measurement in the tissue simulation solution is performed by comparison with temperature measurements and computer simulations. This conversion factor is only valid for the specified tissue simulating liquids at the specified frequencies. If measurements have to be performed in solutions with other electrical properties or at other frequencies, the conversion factor has to be assessed by the same procedure.

As the probes have been constructed with printed resistive lines on ceramic substrates (thick film technique), the probe is very delicate with respect to mechanical shocks.

Attention:

Do not drop the probe or let the probe collide with any solid object. Never let the robot move without first activating the emergency stop feature (i.e., without first turning the data acquisition electronics on).

[1] Feature of the DASY2 Software Tool

ET3DV5 SN:1348

DASY3 - Parameters of Probe: ET3DV5 SN:1348

Sensitivity in Free Space

NormX	**1.38**	$\mu V/(V/m)^2$
NormY	**1.72**	$\mu V/(V/m)^2$
NormZ	**1.92**	$\mu V/(V/m)^2$

Diode Compression

DCP X	**94**	mV
DCP Y	**94**	mV
DCP Z	**94**	mV

Sensitivity in Tissue Simulating Liquid

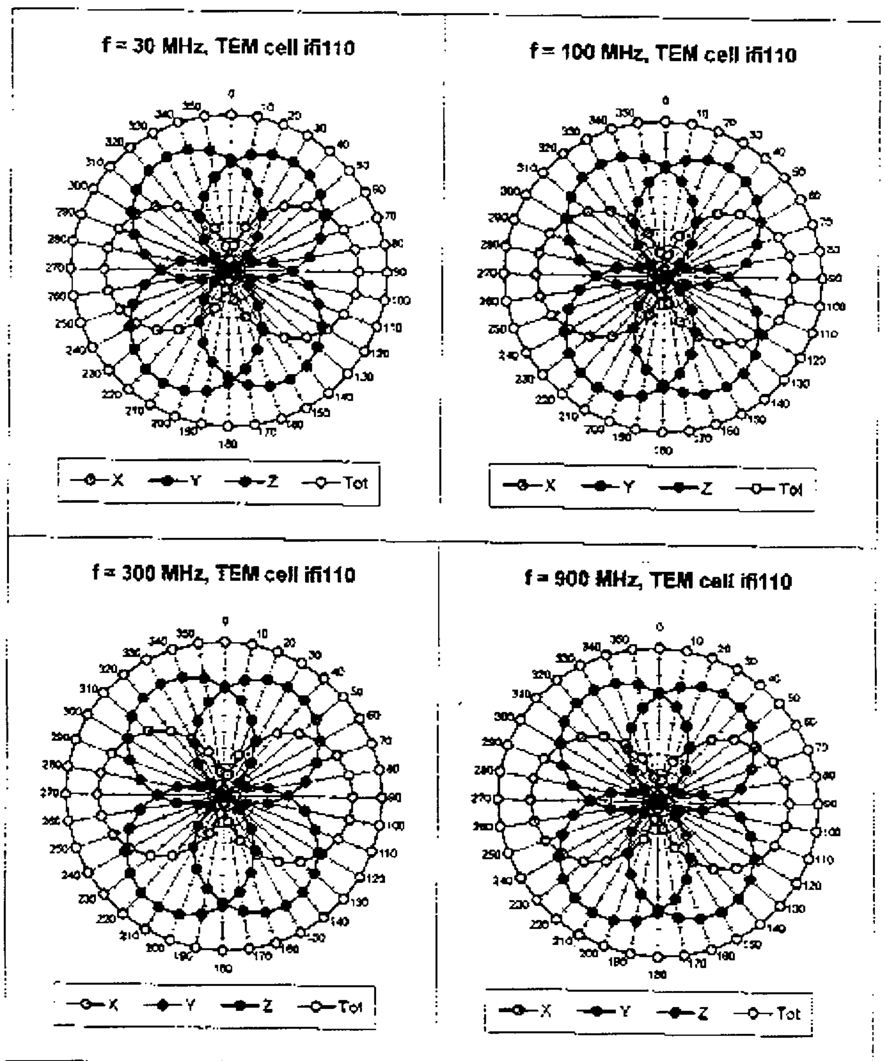
450 MHz	ConvF X	**6.4**	extrapolated	ε_r = 48 ± 5%
	ConvF Y	**6.4**	extrapolated	σ = 0.50 ± 10% mho/m
	ConvF Z	**6.4**	extrapolated	(brain tissue simulating liquid)
900 MHz	ConvF X	**5.9**	± 10%	ε_r = 42.5 ± 5%
	ConvF Y	**5.9**	± 10%	σ = 0.86 ± 10% mho/m
	ConvF Z	**5.9**	± 10%	(brain tissue simulating liquid)
1500 MHz	ConvF X	**5.3**	interpolated	ε_r = 41 ± 5%
	ConvF Y	**5.3**	interpolated	σ = 1.32 ± 10% mho/m
	ConvF Z	**5.3**	interpolated	(brain tissue simulating liquid)
1800 MHz	ConvF X	**5.0**	± 10%	ε_r = 40.5 ± 5%
	ConvF Y	**5.0**	± 10%	σ = 1.69 ± 10% mho/m
	ConvF Z	**5.0**	± 10%	(brain tissue simulating liquid)

Sensor Offset

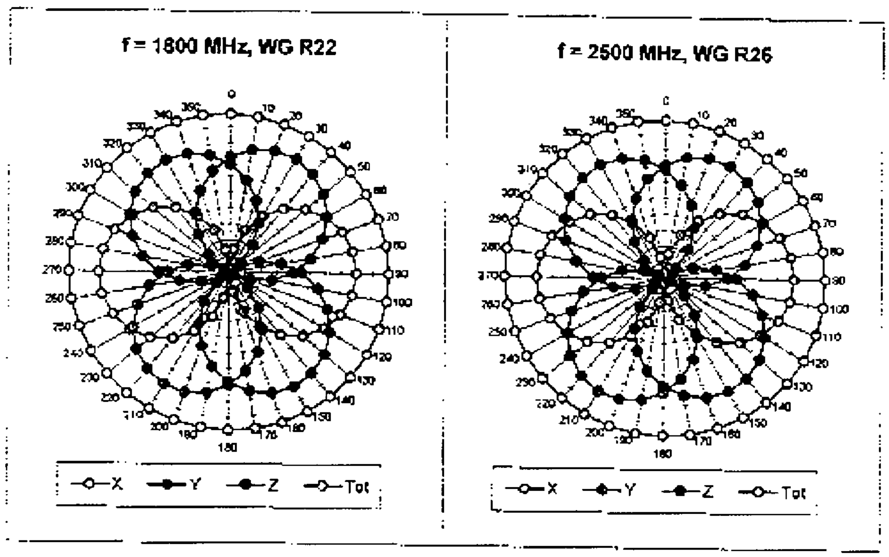
Probe Tip to Sensor Center	**2.7**	mm
Surface to Probe Tip	**1.9 ± 0.2**	mm

ET3DV5 SN:1348

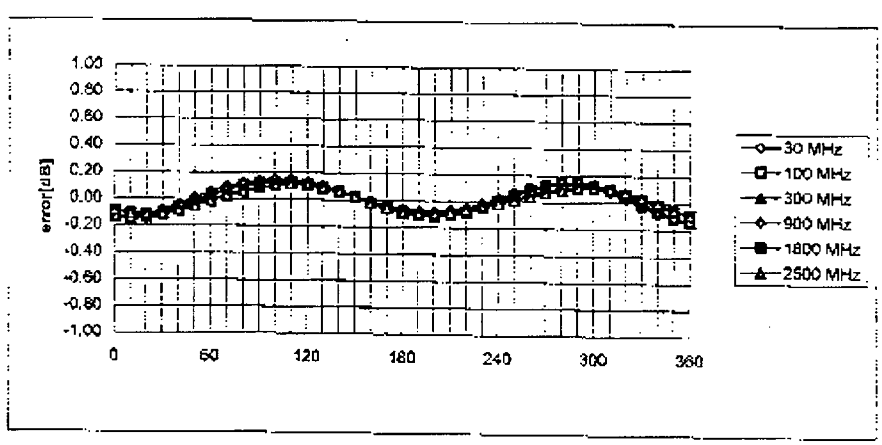
Receiving Pattern (ϕ), $\theta = 0°$



ET3DV5 SN:1348



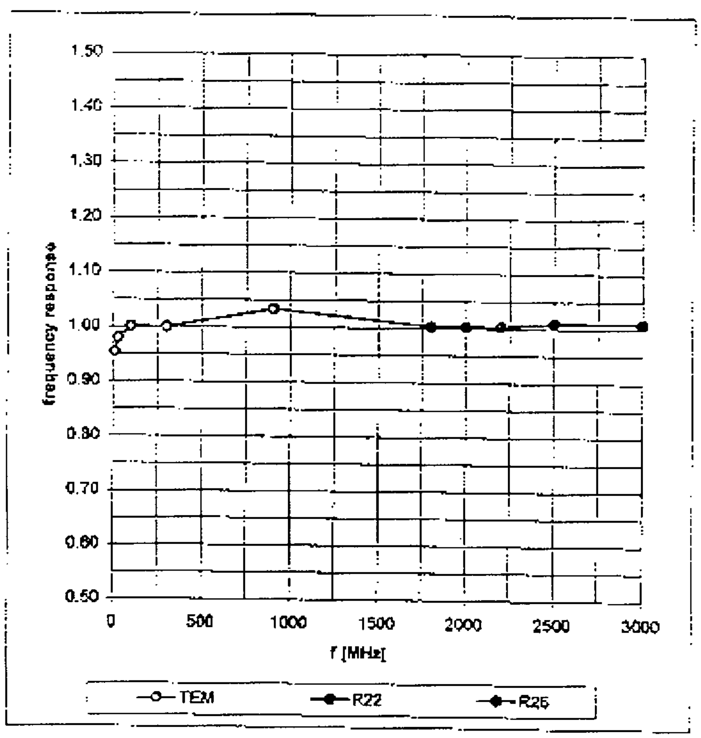
Isotropy Error (ϕ), θ = 0°



ET3DV5 SN:1348

Frequency Response of E-Field

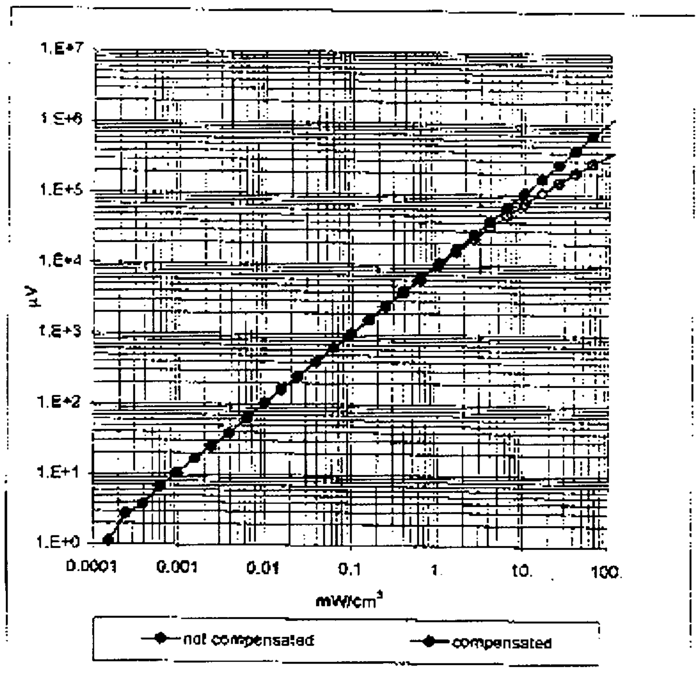
(TEM-Cell:ifi110, Waveguide R22, R26)

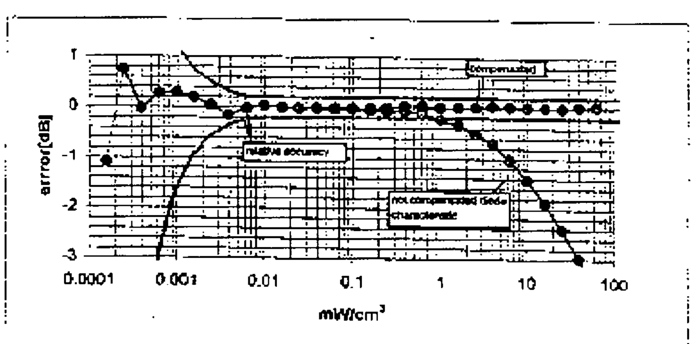


ET3DV5 SN:1348

Dynamic Range f(SAR_{brain})

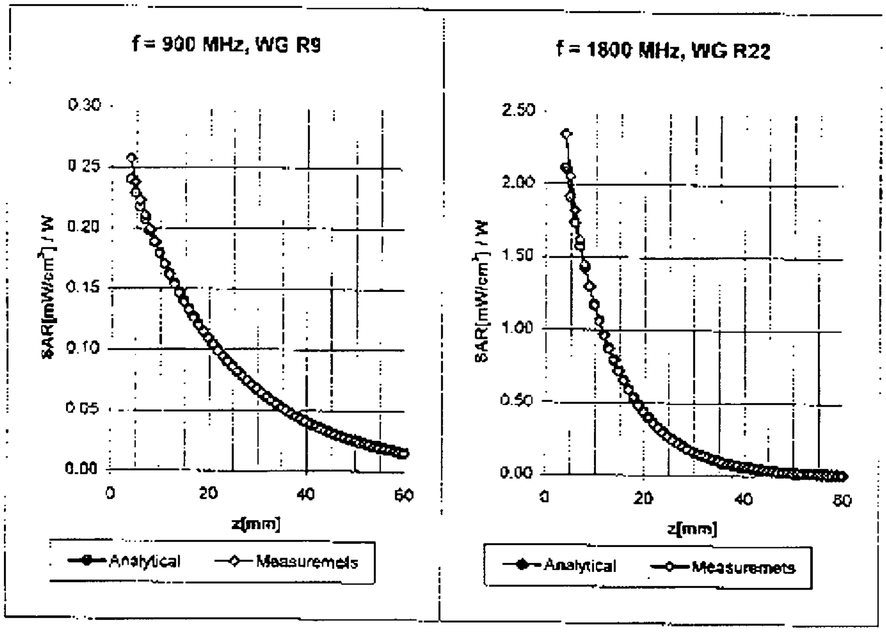
(TEM-Cell:ifi110)





ET3DV5 SN:1348

Conversion Factor Assessment



Receiving Pattern (ϕ)

(in brain tissue, z = 5 mm)