5.6.3.2. Determination of Conversion Factor (γ) in the simulated tissue

The sensitivity of the probe in the dielectric media compared to its sensitivity in the air, is different. Conversion Factor (γ) is defined to determine the degree of the enhancement of sensitivity in the different dielectric media and relate it to its sensitivity in the air.

$$PO_{tot\_tissue} \equiv PO_{tot\_air} \times \gamma$$

Thus,

$$\left|E_{tissue}\right|^2 = \frac{PO_{tot\_tissue}}{\eta_{E2}} \times \frac{1}{\gamma} \quad \text{,and} \quad SAR_{tissue} = \frac{\sigma \times \frac{PO_{tot\_tissue}}{\eta_{E2}} \times \frac{1}{\gamma}}{\rho}$$

where,

$\|E_{tissue}\|^2$	RMS E-field level [$(V/m)^2$] induced within the exposed tissue
PO_{tot_tissue}	Probe voltage output measured in the simulated tissue [mV]
PO_{tot_air}	Probe voltage output measured in the air (Z_{air} = 377[Ω]) [mV]
η_{E2}	Sensor Factor to the $\|E\|^2$, an arbitrary value 10.8/3,770 [mV/$(V/m)^2$]
γ	Conversion factor; ratio of sensor response in air to response in the dielectric media

The conversion factor (γ) can be used to scale the E-field in terms of the thermally-derived SAR. It is the quotient of SAR_t, the SAR determined from temperature measurements in the flat phantom, and PO_{tot_tissue}, the E-field prove output voltage obtained at the same location in the phantom

$$SAR_t = SAR_{tissue}$$

$$\frac{c \cdot \Delta T}{\Delta t} = \frac{\sigma_{@cal} \times \left|E_{tissue}\right|^2}{\rho} = \frac{\sigma_{@cal} \times \frac{PO_{tot\_tissue}}{\eta_{E2}} \times \frac{1}{\gamma}}{\rho}$$

Thus,

$$\gamma = \frac{\sigma_{@cal}}{\eta_{E2} \times \rho} \times \frac{PO_{tot\_tissue}}{SAR_t} = \frac{\sigma_{@cal} \times 3{,}770}{10.8 \times c \times \rho} \times \frac{PO_{tot\_tissue}}{\Delta T / \Delta t} \qquad \text{(Eq. 3)}$$

where,

γ	Conversion factor; ratio of sensor response in air to response in the dielectric media
SAR_t	Thermally-derived SAR [W/Kg] (Eq. 1)
$\|E_{tissue}\|^2$	RMS E-field level [$(V/m)^2$] induced within the exposed tissue
PO_{tot_tissue}	Probe voltage output measured in the simulated tissue [mV]
η_{E2}	Sensor Factor to the $\|E\|^2$, an intermediately constant, 10.8/3,770 [$mV/(V/m)^2$]
c	Specific heat capacity of the simulated tissue [J/Kg/ ^oC]
$\sigma_{@cal}$	Conductivity of the simulated tissue during the calibration procedure [S/m]
ρ	Actual mass density of the simulated tissue [Kg/m^3]
$\Delta T/\Delta t$	Initial rate of tissue heating, before thermal diffusion takes place [^oC /sec]

The temperature E-field correlation is illustrated below (for simulated brain tissue) for an example in which the thermal quantities were,

RF power input = 0.5 [W]
ΔT = 0.0163 [^oC] (from thermistor-base temperature probe)
$\sigma_{@cal}$ = 0.97 [S/m]
ρ = 1,200 [Kg/m^3]
c = 2,700 [J/Kg/^oC]
Δt = 30 [sec]

The resulting SAR_t was (Eq. 1)

$$SAR_t = \frac{2{,}700 \times 0.0163}{30} = 1.467 \text{ [W/Kg]}$$

In this case the output of the E-field probe when at the same position as the thermistor probe was

PO_{tot_tissue} = 28.5 [mV]

The calculation of conversion factor (γ) from (Eq. 3) follows:

$$\gamma = \frac{0.97}{\frac{10.8}{3{,}770} \times 1{,}200} \times \frac{28.5}{1.467} = 5.482$$

5.6.4. Data Acquisition Methodology

5.6.4.1. E-Field Measurement

The probe calibration must be current before starting measurements. Instrumentation amplifier batteries must be charged. This can be monitored by observing DC offset voltages. A daily log of the DC offset voltages should be kept for this purpose.

Measurements in the phantom are automatically calculated for each location by summation of the three dipole outputs. Because each dipole produces an output voltage proportional to the square of the electric field component along the dipole, the sum of dipole voltages represents the RMS values for the total electric field. Thus, taking into consideration the amplifier settings and the DC offset voltages, the total electric field strength at a measurement location is as follows. See Appendix C. PO_{tot} is labeled by the software as measure of values (voltages). The SAR for calculations that are derived from the measure of values are discussed below.

At each measurement point, the program records the output of the three channels:

$$PO_1 = (V_1 - DC_1) \times AS_1 \equiv |E_1|^2 \times \eta_{E2}$$
$$PO_2 = (V_2 - DC_2) \times AS_2 \equiv |E_2|^2 \times \eta_{E2}$$
$$PO_3 = (V_3 - DC_3) \times AS_3 \equiv |E_3|^2 \times \eta_{E2}$$

$$PO_{tot} \equiv |E|^2 \times \eta_{E2} = \left(|E_1|^2 + |E_2|^2 + |E_3|^2\right) \times \eta_{E2} = |E_1|^2 \times \eta_{E2} + |E_2|^2 \times \eta_{E2} + |E_3|^2 \times \eta_{E2}$$
$$\equiv PO_1 + PO_2 + PO_3$$

Where,

V_i	Actual raw reading of channel i at a measurement point
DC_i	Ambient DC offset of channel i at a measurement point
AS_i	Amplifier setting of channel i
η_{E2}	Sensor Factor to the $\|E\|^2$, an arbitrary value 10.8/3,770 [mV/(V/m)^2]
PO_i	Probe output of channel i at a measurement point [mV]
PO_{tot}	Total probe output at a measurement point [mV]

5.6.4.2. Sensitivity(ζ) of probe in the simulated tissue

The sensitivy(ζ) of the probe in the simulated tissue is rendered in terms of Sensor Enhancement Factor in the simulated tissue.

$$\zeta = \frac{\sigma_{@meas}}{\eta_{E2} \times \rho \times \gamma} = \frac{\sigma_{@meas}}{\frac{10.8}{3,770} \times 1,000 \times \gamma} = \frac{3,770 \times \sigma_{@meas}}{10,800 \times \gamma} \qquad \text{(Eq. 5)}$$

Where,

ζ	Sensitivity of the probe in the simulated tissue [W/Kg/mV]
γ	Conversion factor; ratio of sensor response in air to response in the dielectric media
η_{E2}	Sensor Factor to the $\|E\|^2$, an arbitrary value 10.8/3,770 [mV/(V/m)^2]
$\sigma_{@meas}$	Conductivity of the simulated tissue during the measurement [S/m]
ρ	Mass density of the simulated tissue [Kg/m^3]; 1,000 [Kg/m3] is conventionally chosen.

Therefore, SAR can be yielded from

$$SAR = \zeta \times PO_{tot\_tissue} \quad \text{(Eq. 6)}$$

Where,

ζ	Sensitivity of the probe in the simulated tissue [W/Kg/mV]
PO_{tot_tissue}	Probe voltage output measured in the simulated tissue [mV]

To continue the example illustrated above,

$\sigma_{@meas}$ = 0.99 [S/m]
PO_{tot_tissue} = 11.5 [mV]

$$\zeta = \frac{3{,}770 \times \sigma_{@meas}}{10{,}800 \times \eta} = \frac{3{,}770 \times 0.99}{10{,}800 \times 5.482} = 0.063 \text{ [W/Kg/mV]}$$

SAR = $\zeta \times PO_{tot\_tissue}$ = 0.063 × 11.5 = 0.725 [W/Kg]

5.6.4.3. SAR Measurement

The goal of the measurement process is to scan the phantom over a selected area in order to find the region of highest levels of RF energy and then to obtain a single value for the peak spatial-average of SAR over a volume that would contain one gram (in the shape of a cube) of biological tissue. The test procedure, of course, measures SAR in the simulated tissue.

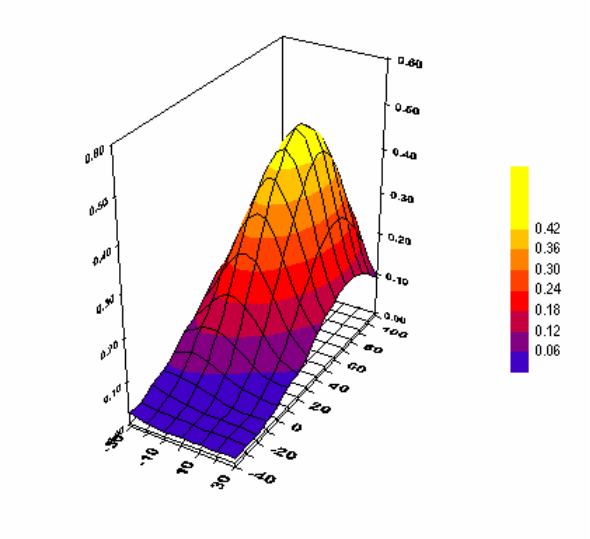


Figure 5.6.4.3.a. Area scan

The software request the user to move the probe to locations at two extreme corners of a rectangle that encloses the area to be scanned. An arbitrary origin and the spatial resolution for the scan are also specified. Under program control, the scan is performed automatically by the robot-guided probe.

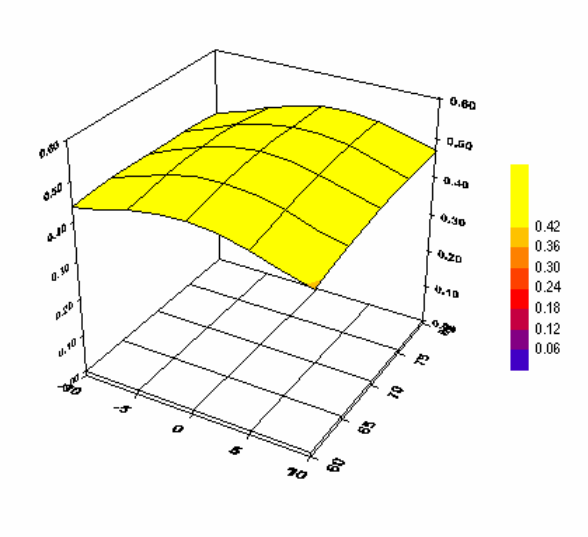


Figure 5.6.4.3.b. Zoom Scan

The fine resolution volume scan region is centered at the peak SAR locations determined by the interpolated (cubic spline) data from the area scan measurements. The number of measurement point required in a zoom scan is defined to provide an accurate one-gram averaged SAR in terms of both the number of points ($PT_X \times PT_Y \times PT_Z$) and the size ($SZ_X$[mm] × SZ_Y[mm] × SZ_Z[mm]) of the cubic. For one-gram SAR, (5 × 5 × 7) and (32[mm] × 32[mm] × 30[mm]) is preferred to select below 1 GHz. The zoom scan region extends in each direction for at least 1.5 times the linear dimensions of 1- or 10-gram cube of tissue from each peak. The zoom scan spatial resolution is interpolated down to SAR values on a 1mm grid by using the tri-linear interpolation algorithm.

The peak field values near the surface of a homogeneous phantom are usually not measurable because the sensors in a field probe are located at 2-4 mm behind the tip of the probe and the measurement point is defined at the geometric center of the sensors where the calibration is defined. These SAR values are computed by extrapolating the closest measured points to the surface of the phantom to determine the highest one-gram averaged SAR. The extrapolation coefficients are determined with a multi-order curve-fitting algorithm. Generally the 4-th order polynomial least-square fit is sufficient to extrapolate to the surface if the number of the valid measurements, that are non-zero, along the probe axis is greater than 4.

The interpolated and extrapolated SAR values from the zoom scan measurements are integrated in the shape of 1- or 10-gram cube then traversed to determine the highest peak spatial-average SAR in the zoom scan region.

This peak spatial-averaged SAR is reported as SAR [W/kg] for compliance.

5.6.4.4. Data Extrapolation and boundary effect

The distance from the center of the sensor (diode) to the end of the protective tube is called the 'probe offset' or 'sensor offset'. To compensate we use a multi-order polynomial least-square curve fitting to obtain the peak surface value from the voltages measured at the distance from the inner surface of the phantom. The field is measured as close as possible to the phantom's surface and every pre-defined separation distance (1 [mm] to 5 [mm]) along the probe axis (z) for a distance of at least 50 mm until they are not measurable. The appropriate curve is obtained from all the points measured and used to define an exponential decay of the energy density versus depth.

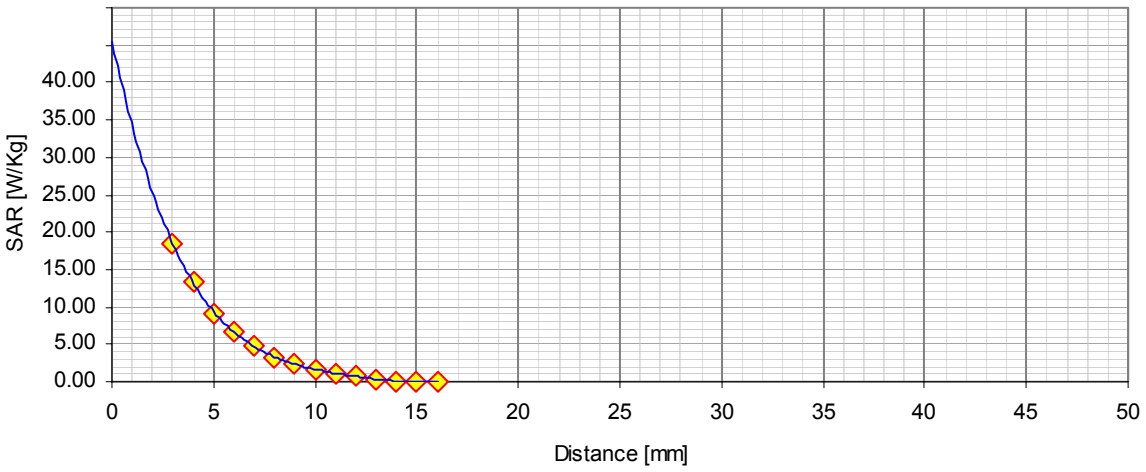


Figure 5.6.4.4. Exponential decay of the energy density versus depth

Boundary effects arise when the tip of an electric field probe approaches the interface between two dielectric media. Under these conditions, the external field is strongly perturbed by the superposition of a scattered field from the probe. The effect of the boundary on the peak spatial-average SAR values strongly depends on the probe dimensions, especially the diameter of the tip of the probe. It is known that the error due to boundary effects is very small if the distance between the probe tip and the surface is greater than half the probe diameter. Therefore the first one or two measurements at the vicinity to the phantom surface are excluded for evaluating the exponential decay curve in order to compensate for the boundary effect.

5.6.5. Determining the Heat Capacity of Simulated Tissue

5.6.5.1. Instruments and Materials

- Calibrated differential thermometer (Vitek or BAT-8 or equivalent)
- Two identical 500 ml containers

- A thermally insulated vessel (thick styrofoam, with a form fitting hole for one container)
- Hot and cold tap water
- Solution under test
- Hot plate
- Temperature vs. time (chart recorder, or data loger)

5.6.5.2. Method

Heat can be propagated by conduction, convection and radiation. In the case of liquids heated from below, gravity convection is the main and predominant heating mechanism of the fluid mass.

Obtain two containers that can be rapidly heated (e.g. glass or suitable plastic). Fill one container with 250 ml of water, the other with the same mass of simulated tissue. The initial temperature of the water should be the same as that of the simulated tissue ($\pm$1°C). Since we are dealing with heating by electromagnetic sources at ambient temperature, it is essential that we eliminate the chance of any direct infrared heating of the temperature sensor. To ensure this, position the tip of the sensor 2 mm from the bottom of the center of the container. Turn on the heat source and wait at least 5 minutes for its temperature to stabilize. Record the initial temperature of the water. Place the container of water 5 mm above the center of the hot plate and monitor the temperature increase.

After 30 seconds of heating, the water temperature should have increased by at least 5 °C. Record the time and temperature. Remove the container from the heat source and place it in the thermally insulated vessel. Stir the liquid thoroughly and record the steady state temperature 1-2 minutes after stirring.

Repeat the above procedure using the container of simulated tissue. Ensure that the container is placed on the same area of the hot plate, is heated for the identical length of time, and the steady state temperature is recorded after the identical time interval.

Since the heat capacity of water is C_w = 1,000 [cal/Kg/°C] or 4,189 [J/Kg/°C] with excellent approximation (~1%) in the temperature range of interest, the heat capacity (C_s) of the solution is given by:

$$C_s = C_w \cdot \frac{\Delta T_w}{\Delta T_s}$$

where ΔT_w is the temperature increase of water and ΔT_s the temperature increase of the solution. The ration of the values, $\Delta T_w / \Delta T_s$, should be the same (within the sensitivity of the thermometer) at the end of the heating and stirring. This ensures that the liquids have been uniformly heated.

5.6.5.3. Rationale

$$C \cdot \Delta T = Heat\_Flow \cdot Time = Total\_Heating\_Energy$$

If the heat flow, sample mass, and absorption (heat transfer) are the same for both liquids, then:

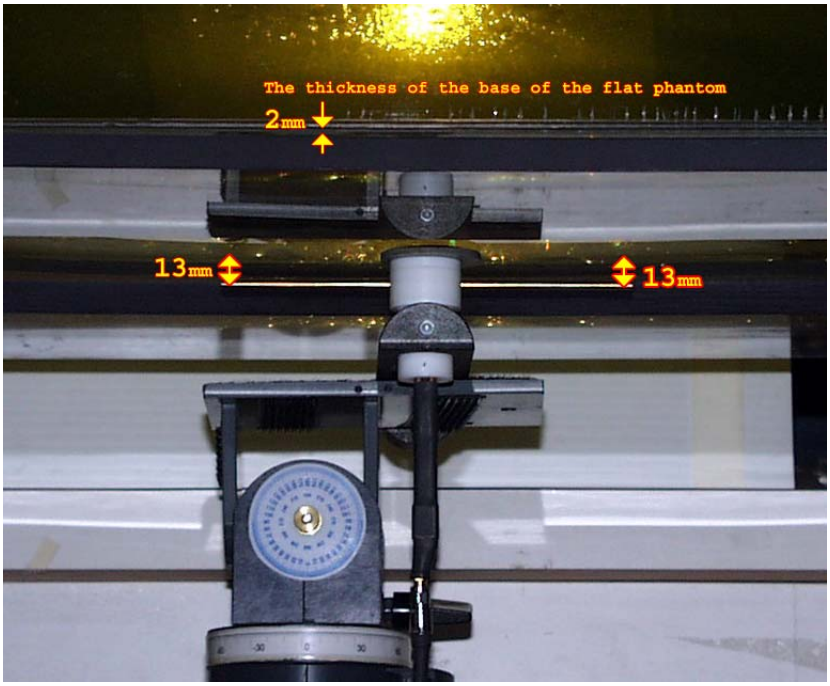
$$C_w \cdot \Delta T_w = C_s \cdot \Delta T_s$$

The heat flow and total heating are kept constant by using the same source for the same amount of time. If the heat transfer mechanisms for the woe liquids are about the same, with insignificant differences in convective and conductive characteristics, then any differences in temperature increase are a direct measure of the specific heat capacity, C.

5.7. SAR MEASUREMENT SYSTEM VERIFICATION

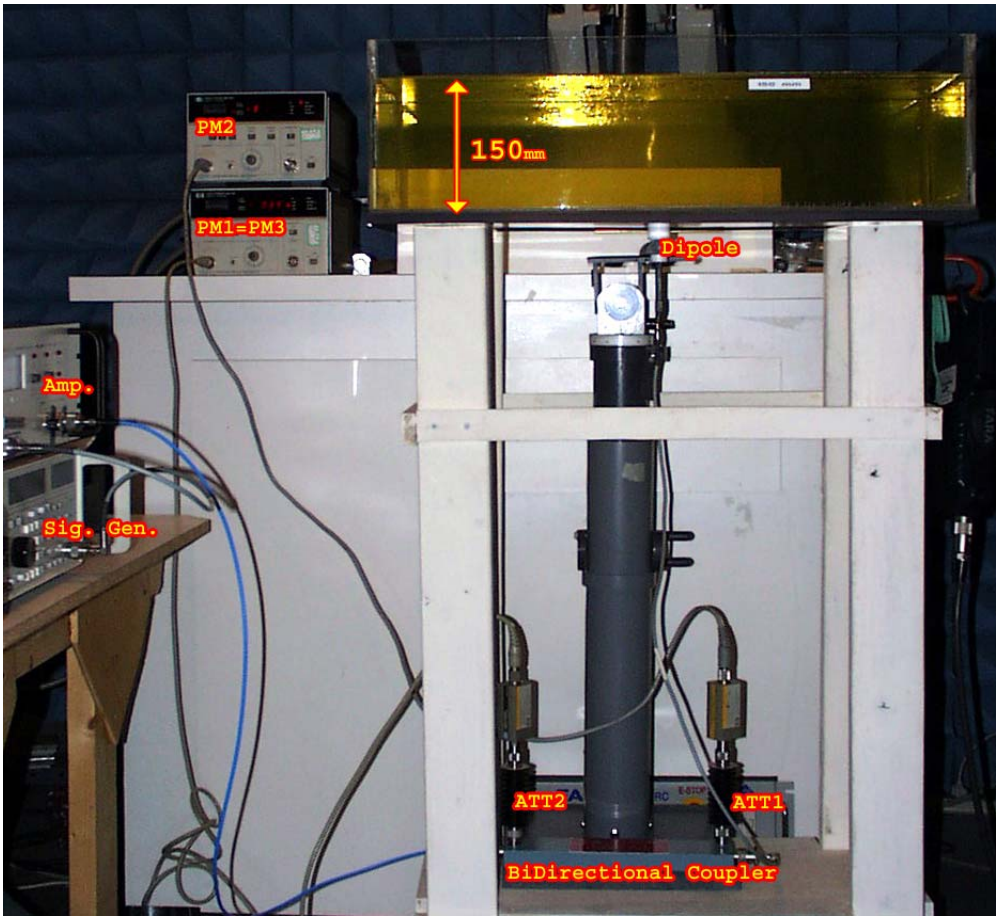
5.7.1. Standard Source

A half-wave dipole is positioned below the bottom of the phantom and centered with its axis parallel to the longest side of the phantom. The distance between the liquid filled phantom bottom surface and the center of the dipole axis, *s*, is chosen as specified IEEE 1528 at the specific test frequency (i.e. 15 mm at 835 MHz). A low loss and low dielectric constant spacer is used to establish the correct distance between the top surface of the dipole and the bottom surface of the phantom.



5.7.2. Standard Source Input Power Measurement

The system validation is performed as shown below or in Figure 7.1 in IEEE 1528.



First the power meter PM1 (including attenuator Att1) is connected to the cable to measure the forward power at the location of the dipole connector (X). The signal generator is adjusted for the desired forward power at the dipole connector (taking into account the attenuation of Att1) as read by power meter PM2. After connecting the cable to the dipole, the signal generator is readjusted for the same reading at power meter PM2. If the signal generator does not allow adjustment in 0.01dB steps, the remaining difference at PM2 must be taken into consideration. PM3 records the reflected power from the dipole to ensure that the value is not changed from the previous value. The reflected power was verified to be at least 20dB below the forward power.

5.7.3. System Validation Procedure

A complete 1g-averaged SAR measurement is performed. The measured 1g-averaged SAR value is normalized to a forward power of 1W to a half-wave dipole and compared with the reference SAR value for the reference dipole and flat phantom shown in columns 2 and 3 of Table 7.1 in IEEE 1528.

5.8. POWER MEASUREMENT

Whenever 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 at the time of testing. A difference in output power would determine a need for battery replacement and to repeat the SAR test.

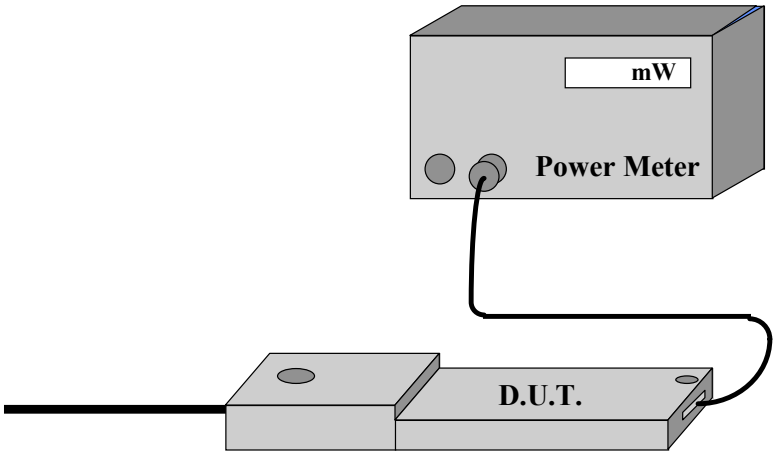


Figure 5.8. Measured Power + Cable and Switching Mechanism Loss

5.9. POSITIONING OF D.U.T.

The clear SAM phantom shell have been previously marked with a highly visible grid with a defined centre line, so it 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.

For HAND HELD devices (push-to-talk), or any other type of wireless transmitters postioned in front of the face, the D.U.T. will be positioned 2.5cm distance from a flat phantom to simulate the frontal facial position in use. All body-worn operating configurations are tested using a flat phantom. The length and width of the phantom is at least twice the corresponding dimensions of the test device, including its antenna.

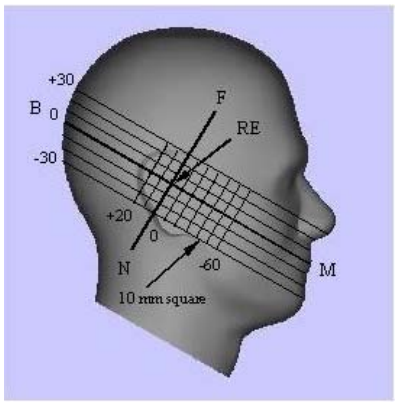


Figure 5.9.a. Side view of the phantom showing relevant marking

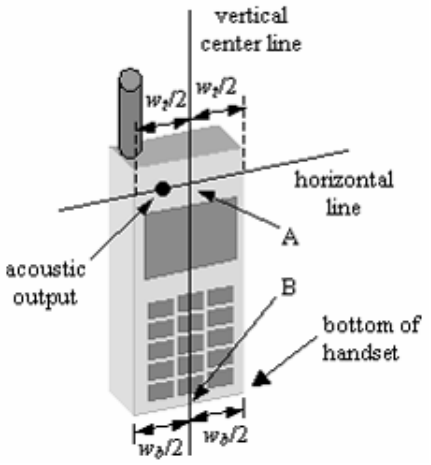


Figure 5.9.b. Handset vertical and horizontal reference lines – fixed case

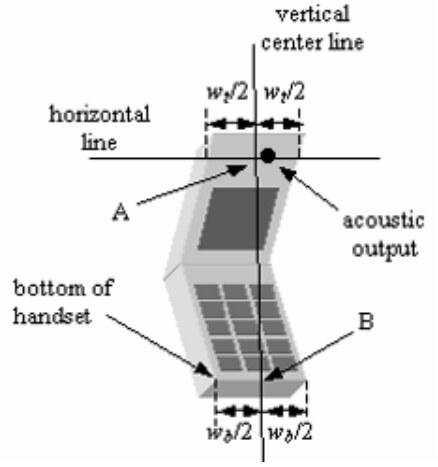


Figure 5.9.c. Handset vertical and horizontal reference lines – "clam-shell"

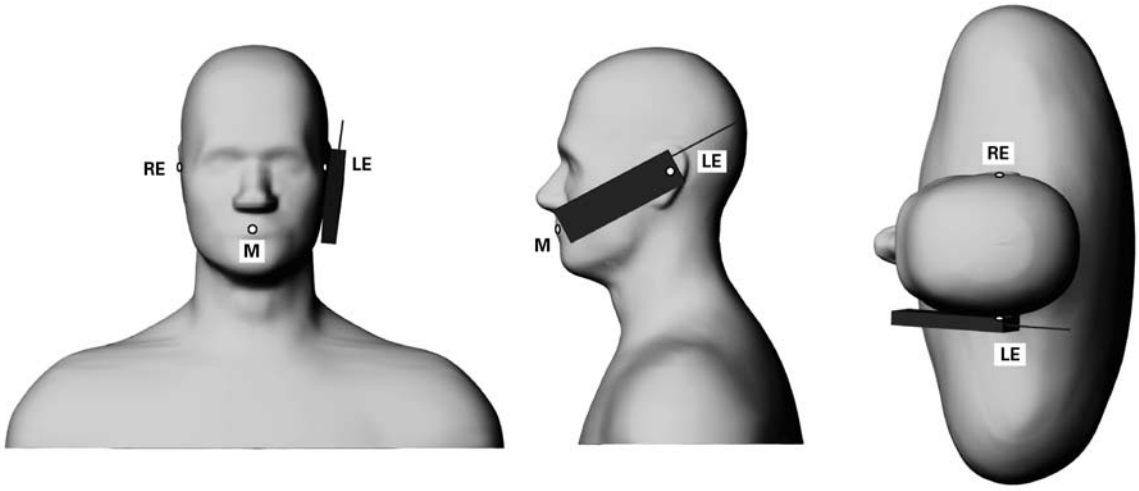


Figure 5.9.d. Phone position 1, "cheek" or "touch" position. The reference points for the right ear (RE), left ear (LE) and mouth (M), which define the reference plane for phone positioning, are indicated. The shoulders are shown for illustration purposes only.

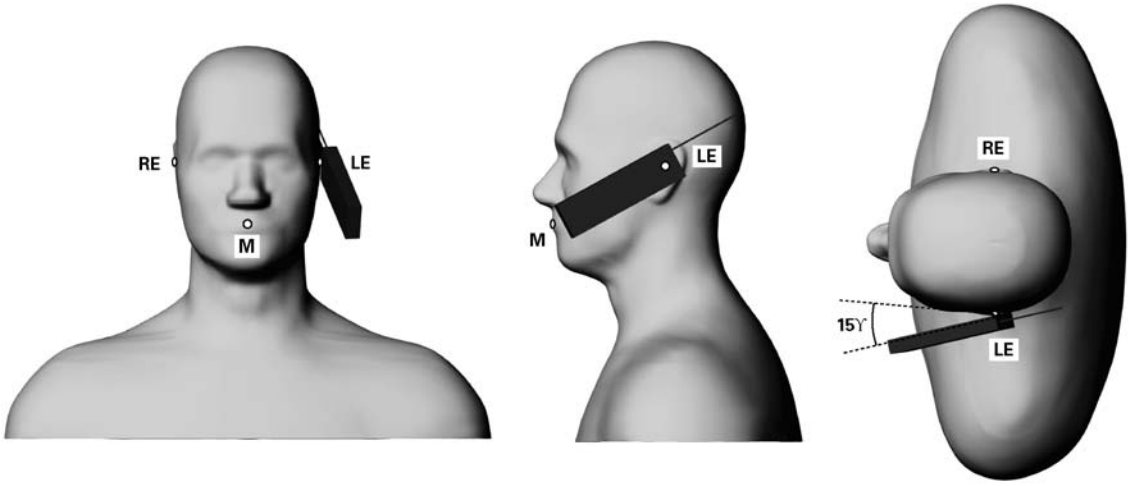


Figure 5.9.e. Phone position 2, "tilted position." The reference points for the right ear (RE), left ear (LE) and mouth (M), which define the reference plane for phone positioning, are indicated. The shoulders are shown for illustration purposes only.

5.10. SAR MEASUREMENT UNCERTAINTY

This uncertainty analysis covers the 3D-EMC Laboratory test procedure for Specific Absorption Rate (SAR) associated with wireless telephones and similar devices.

Standards Covered Are:

WGMTE 96/4 - Secretary SC211/B

FCC 96-326, ET Docket No. 93-62

Industry Canada RSS 102

ACA Radiocommunications (Electromagnetic Radiation – Human Exposure) Amendment Standard 2000 (No. 1)

The laboratory test procedure, and this uncertainty analysis, may be used to cover all standards above. It is based on test equipment and procedures specified by 3D-EMC Laboratories, Inc. located in Ft. Lauderdale, Florida.

5.10.1. Measurement Uncertainty

5.10.1.1. Measurement Uncertainty evaluation for handset SAR test

a	*b*	*c*	*d*	*e = f(d,k)*	*F*	*g*	*h = c x f / e*	*i = c x g / e*	*k*
Uncertainty Component	**Sec.**	**Tol. (± %)**	**Prob. Dist.**	**Div.**	**c_i (1-g)**	**c_i (10-g)**	**1-g u_i (±%)**	**10-g u_i (±%)**	**v_i**
Measurement System									
Probe Calibration	E1.1	3.0	N	1	1	1	3.0	3.0	∞
Axial Isotropy	E1.2	5.0	R	√3	0.7	0.7	2.0	2.0	∞
Hemispherical Isotropy	E1.2	8.0	R	√3	1	1	4.6	4.6	∞
Boundary Effect	E1.3	10.0	R	√3	1	1	5.8	5.8	∞
Linearity	E1.4	4.2	R	√3	1	1	2.4	2.4	∞
System Detection Limits	E1.5	2.0	R	√3	1	1	1.2	1.2	∞
Readout Electronics	E1.6	1.0	N	1	1	1	1.0	1.0	∞
Response Time	E1.7	1.5	R	√3	1	1	0.9	0.9	∞
Integration Time	E1.8	2.0	R	√3	1	1	1.2	1.2	∞
RF Ambient Conditions	E5.1	3.0	R	√3	1	1	1.7	1.7	∞
Probe Positioner Mechanical Tolerance	E5.2	1.0	R	√3	1	1	0.6	0.6	∞
Probe Positioning with respect to Phantom Shell	E5.3	3.0	R	√3	1	1	1.7	1.7	∞
Extrapolation, interpolation and Integration Algorithms for Max. SAR Evaluation	E4.2	3.5	R	√3	1	1	2.0	2.0	∞
Test sample Related									
Test Sample Positioning	E3.2.1	7.5	N	1	1	1	7.5	7.5	*11*
Device Holder Uncertainty	E3.1.1	6.5	N	1	1	1	6.5	6.5	*8*
Output Power Variation - SAR drift measurement	5.6.2	5.0	R	√3	1	1	2.9	2.9	∞
Phantom and Tissue Parameters									
Phantom Uncertainty (shape and thickness tolerances)	E2.1	4.0	R	√3	1	1	2.3	2.3	∞
Liquid Conductivity Target - tolerance	E2.2	5.0	R	√3	0.7	0.5	2.0	1.4	∞
Liquid Conductivity - measurement uncertainty	E2.2	4.0	R	√3	0.7	0.5	1.6	1.2	∞
Liquid Permittivity Target tolerance	E2.2	5.0	R	√3	0.6	0.5	1.7	1.4	∞
Liquid Permittivity - measurement uncertainty	E2.2	4.0	R	√3	0.6	0.5	1.4	1.2	∞
Combined Standard Uncertainty			RSS				14.3	14.2	
Expanded Uncertainty (95% confidence interval)							**28.5**	**28.3**	

5.10.1.2. Measurement Uncertainty for System Performance Check

a	*b*	*c*	*d*	*e = f(d,k)*	*f*	*g*	*h = c x f / e*	*i = c x g / e*	*k*
Uncertainty Component	**Sec.**	**Tol. (± %)**	**Prob. Dist.**	**Div.**	**c_i (1-g)**	**c_i (10-g)**	**1-g u_i (±%)**	**10-g u_i (±%)**	**v_i or v_{eff}**
Measurement System									
Probe Calibration	E1.1	3.0	N	1	1	1	3.0	3.0	∞
Axial Isotropy	E1.2	5.0	R	√3	0.7	0.7	2.0	2.0	∞
Hemispherical Isotropy	E1.2	8.0	R	√3	1	1	4.6	4.6	∞
Boundary Effect	E1.3	10.0	R	√3	1	1	5.8	5.8	∞
Linearity	E1.4	4.2	R	√3	1	1	2.4	2.4	∞
System Detection Limits	E1.5	2.0	R	√3	1	1	1.2	1.2	∞
Readout Electronics	E1.6	1.0	N	1	1	1	1.0	1.0	∞
Response Time	E1.7	1.5	R	√3	1	1	0.9	0.9	∞
Integration Time	E1.8	2.0	R	√3	1	1	1.2	1.2	∞
RF Ambient Conditions	E5.1	3.0	R	√3	1	1	1.7	1.7	∞
Probe Positioner Mechanical Tolerance	E5.2	0.4	R	√3	1	1	0.2	0.2	∞
Probe Positioning with respect to Phantom Shell	E5.3	3.0	R	√3	1	1	1.7	1.7	∞
Extrapolation, interpolation and Integration Algorithms for Max. SAR Evaluation	E4.2	3.5	R	√3	1	1	2.0	2.0	∞
Dipole									
Dipole Axis to Liquid Distance	7, X3.2	2.0	R	√3	1	1	1.2	1.2	∞
Input Power and SAR Drift Measurement	7, 5.6.2	3.0	R	√3	1	1	1.7	1.7	∞
Phantom and Tissue Parameters									
Phantom Uncertainty - shell thickness tolerance	E2.1	4.0	R	√3	1	1	2.3	2.3	∞
Liquid Conductivity – deviation from target values	E2.2	5.0	R	√3	0.7	0.5	2.0	1.4	∞
Liquid Conductivity - measurement uncertainty	E2.2	4.0	R	√3	0.7	0.5	1.6	1.2	∞
Liquid Permittivity – deviation from target values	E2.2	5.0	R	√3	0.6	0.5	1.7	1.4	∞
Liquid Permittivity - measurement uncertainty	E2.2	4.0	R	√3	0.6	0.5	1.4	1.2	∞
Combined Standard Uncertainty			RSS				10.0	9.9	
Expanded Uncertainty (95% confidence interval)							**20.1**	**19.8**	

EXHIBIT 6. SAR PRESCANS

6.1. BODY-WORN CONFIGURATION

6.1.1. Test configurations used

Body-worn operating configurations should be tested with the belt-clips and holsters attached to the device and positioned against a flat phantom in normal use configurations. Devices with a headset output should be tested with a headset connected to the device. The D.U.T. was placed against the phantom and tested in its appropriate holster as would normally be used by the end user. If the SAR measured at the middle channel for each test is at least 3.0 dB lower than the SAR limit, testing at the high and low channels is optional for such test configuration(s).

If the transmission band of the test device is less than 10 MHz, testing at the high and low frequency channels is optional.

When multiple accessories that do not contain metallic components are supplied with the device, the device may be tested with only the accessory that dictates the closest spacing to the body. When multiple accessories that contain metallic components are supplied with the device, the device must be tested with each accessory that contains a unique metallic component. If multiple accessories share an identical metallic component (e.g., the same metallic belt-clip used with different holsters with no other metallic components), only the accessory that dictates the closest spacing to the body must be tested.

Body-worn accessories may not always be supplied or available as options for some devices that are intended to be authorized for body-worn use. A separation distance of 1.5 cm between the back of the device and a flat phantom is recommended for testing body-worn SAR compliance under such circumstances. Other separation distances may be used, but they should not exceed 2.5 cm. In these cases, the device may use body-worn accessories that provide a separation distance greater than that tested for the device provided however that the accessory contains no metallic components..

6.1.2. Equipment permutation investigated for each orientation

N/A

6.1.3. Comments on non-tested configurations

N/A

6.2. RECOMMENDED CAUTION STATEMENTS TO BE INCLUDED IN USERS MANUAL

In order for users to be aware of the body-worn operating requirements for meeting RF exposure compliance, operating instructions and caution statements should be included in the manual. The information should allow users to make informed decisions on the type of body-worn accessories and operating configurations that are appropriate for the device. The following are *examples* of typical statements that provide end-users with the necessary information about body-worn accessories:

Example 1. For a product that has the potential to be used in a body worn configuration and has been tested and certified with a specific accessory device(s):

"For body worn operation, this phone has been tested and meets the FCC RF exposure guidelines when used with the (*manufacturer name*) accessories supplied or designated for this product. Use of other accessories may not ensure compliance with FCC RF exposure guidelines. "

Example 2. For a product that has the potential to be used in a body worn configuration and has not been certified with a specific accessory device(s):

"For body worn operation, this phone has been tested and meets FCC RF exposure guidelines when used with an accessory that contains no metal and that positions the handset a minimum of (specified distance) from the body. Use of other accessories may not ensure compliance with FCC RF exposure guidelines."

Example 3. For a product that has the potential to be used in a body worn configuration with future manufacturer designed accessories:

"For body worn operation, this phone has been tested and meets the FCC RF exposure guidelines when used with a (*manufacturer name*) accessory designated for this product or when used with an accessory that contains no metal and that positions the handset a minimum of (specified distance) from the body."

6.3. PRESCAN DATA FOR WORST CONFIGURATION OF RF EXPSOSURE

6.3.1. Body-Worn Configuration

Configuration // Modification	Antenna Position	SAR (W/kg)
Lap-Top Position, 54Mbps, DUT in contact with the phantom, 5320 MHz // None	Fixed	0.009
Lap-Top Position, 6Mbps, DUT in contact with the phantom, 5320 MHz // None	Fixed	0.008

Prescans, as listed above, for the feasible configurations had been performed in order to determine the worst case under the specific configurations as described in the table.

Through the prescans, the followings were determined,

1) SAR at the other than 54Mbps of the bit rate was found to be similar or less.

EXHIBIT 7. SAR MEASUREMENT

7.1. BODY-WORN CONFIGURATION

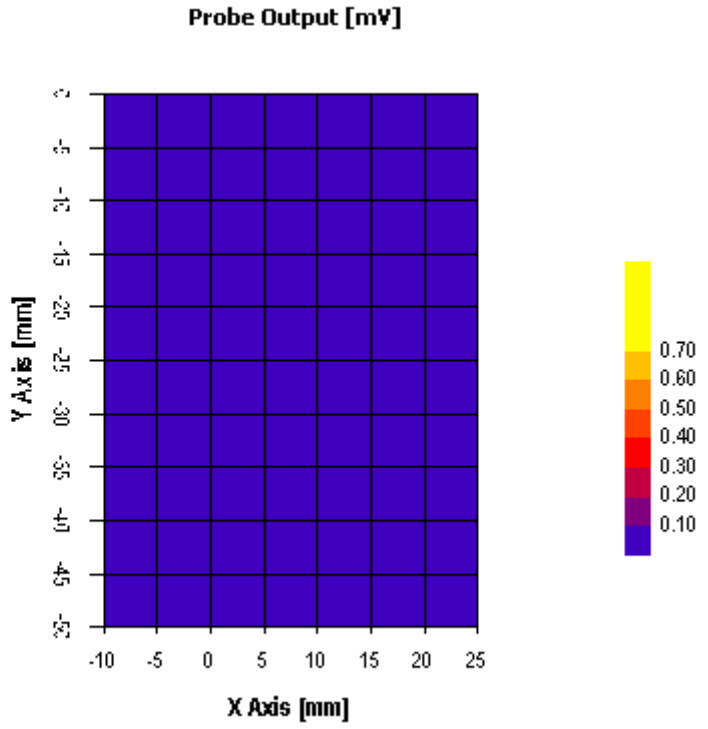
7.1.1. Lap-Top Position

#	Configuration	Device Test Positions	Antenna Position	Freq. [MHz]	Channel	Power Before [mW]	Power After [mW]	MAX SAR [W/Kg]
01	DUT in contact with the phantom 54 MBPS data rate	0 mm separation	Fixed	5180	CH36	38.6	38.4	See note*
02				5240	CH48	39.6	39.2	See note
03				5320	CH64	75.0	74.8	0.009

* It was found to be below the SAR measurement system's sensitivity (less than 0.01 [W/Kg]).

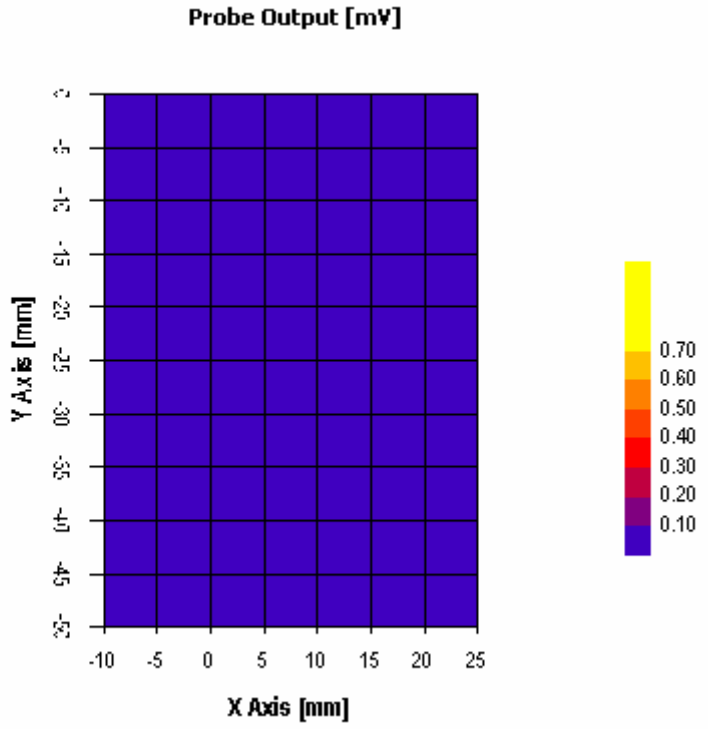
7.1.1.1. CH 36, 5180 MHz

Test date [MM/DD/YYYY]	01/10/2003
Test by	JaeWook Choi
Room temperature [°C]	21
Room humidity [%]	30
Simulated tissue temperature [°C]	21
Separation distance, d [mm]	0
Test frequency [MHz]	5180
E-field Probe	M/N: E-TR, S/N: UT-0200-1, Sensor Offset: 2.0 mm
Sensor Factor (η_{Pd}) [mV/(mW/cm^2)]	10.8
Amplifier Settings (AS_1, AS_2, AS_3)	0.00596768, 0.00563160, 0.00779221
Tissue Type	Muscle
Measured conductivity [S/m]	5.61 (+4.9 %)
Measured dielectric constant	47.3 (-3.5 %)
Conversion Factor (γ)	2.721
Sensitivity (ζ) [W/Kg/mV]	0.719
Power [mW]	38.6 conducted
Measurement Volume Specification (X × Y × Z)	5 pts × 5 pts × 13 pts, 12 mm × 12 mm × 12 mm; Resolution: 3 mm × 3 mm × 1 mm
SAR_{1g} [W/Kg]	Less than 0.01



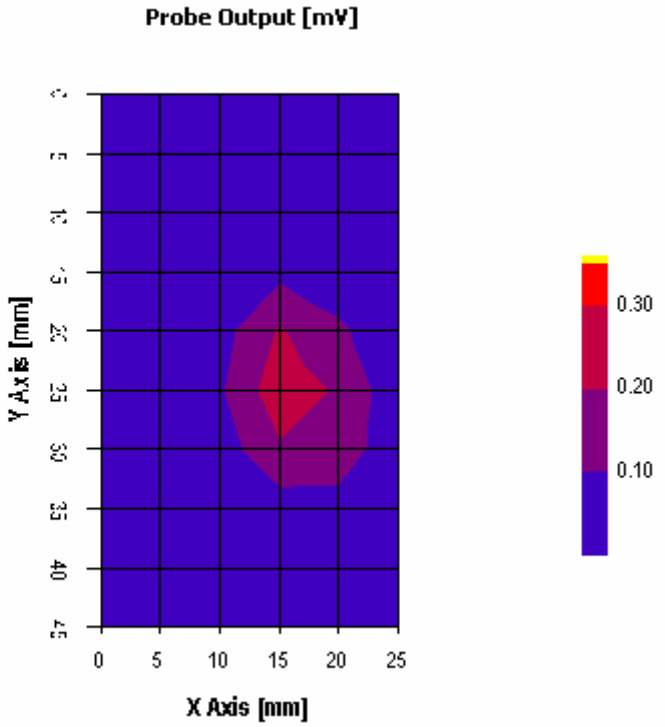
7.1.1.2. CH48, 5240 MHz

Test date [MM/DD/YYYY]	01/10/2003
Test by	JaeWook Choi
Room temperature [°C]	21
Room humidity [%]	30
Simulated tissue temperature [°C]	21
Separation distance, d [mm]	0
Test frequency [MHz]	5180
E-field Probe	M/N: E-TR, S/N: UT-0200-1, Sensor Offset: 2.0 mm
Sensor Factor (η_{Pd}) [mV/(mW/cm^2)]	10.8
Amplifier Settings (AS_1, AS_2, AS_3)	0.00596768, 0.00563160, 0.00779221
Tissue Type	Muscle
Measured conductivity [S/m]	5.61 (+4.9 %)
Measured dielectric constant	47.3 (-3.5 %)
Conversion Factor (γ)	2.721
Sensitivity (ζ) [W/Kg/mV]	0.719
Power [mW]	39.2 conducted
Measurement Volume Specification (X × Y × Z)	5 pts × 5 pts × 13 pts, 12 mm × 12 mm × 12 mm; Resolution: 3 mm × 3 mm × 1 mm
SAR_{1g} [W/Kg]	Less than 0.01



7.1.1.3. CH64, 5320 MHz

Test date [MM/DD/YYYY]	01/10/2003
Test by	JaeWook Choi
Room temperature [°C]	21
Room humidity [%]	30
Simulated tissue temperature [°C]	21
Separation distance, d [mm]	0
Test frequency [MHz]	5180
E-field Probe	M/N: E-TR, S/N: UT-0200-1, Sensor Offset: 2.0 mm
Sensor Factor (η_{Pd}) [mV/(mW/cm^2)]	10.8
Amplifier Settings (AS_1, AS_2, AS_3)	0.00596768, 0.00563160, 0.00779221
Tissue Type	Muscle
Measured conductivity [S/m]	5.61 (+4.9 %)
Measured dielectric constant	47.3 (-3.5 %)
Conversion Factor (γ)	2.721
Sensitivity (ζ) [W/Kg/mV]	0.719
Power [mW]	75.0 conducted
Measurement Volume Specification (X × Y × Z)	5 pts × 5 pts × 13 pts, 12 mm × 12 mm × 12 mm; Resolution: 3 mm × 3 mm × 1 mm
SAR_{1g} [W/Kg]	0.009



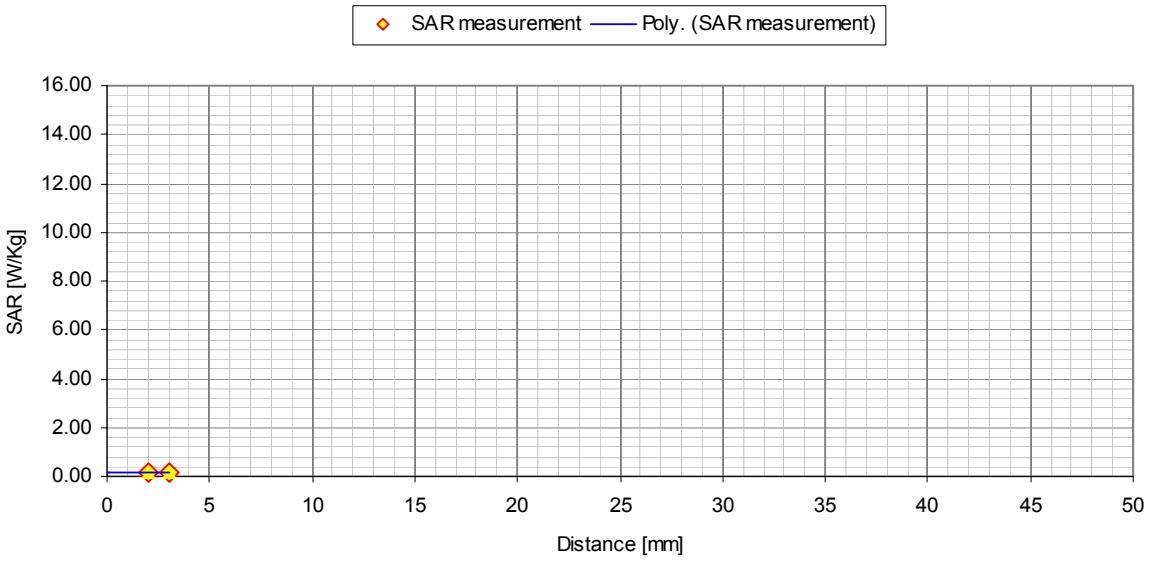

SAR measurement
Poly. (SAR measurement)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
SAR [W/Kg]
0
5
10
15
20
25
30
35
40
45
50
Distance [mm]

EXHIBIT 8. TISSUE DIELECTRIC PARAMETER CALIBRATION

The tissue conductivity was calibrated in accordance with IEEE Std 1528-200X, Draft 6.1 November 14, 2000, Sponsor IEEE SCC 34

Tissue calibration type	HP Dielectric Strength Probe System (M/N: 85070C)
Tissue calibration date [MM/DD/YYYY]	1/08/2003
Tissue calibrated by	JaeWook Choi
Room temperature [°C]	21
Room humidity [%]	30
Simulated tissue temperature [°C]	21
Tissue calibration frequency [MHz]	5240
Tissue Type	Muscle
Target conductivity [S/m]	5.35
Target dielectric constant	49.0
Composition (by weight) [%]	DI Water (77.67 %) DGBE (2.91 %) Triton X-100 (19.42 %)
Measured conductivity [S/m]	5.61 (+4.9 %)
Measured dielectric constant	47.3 (-3.5 %)
Penetration depth (plane wave excitation) [mm]	6.64

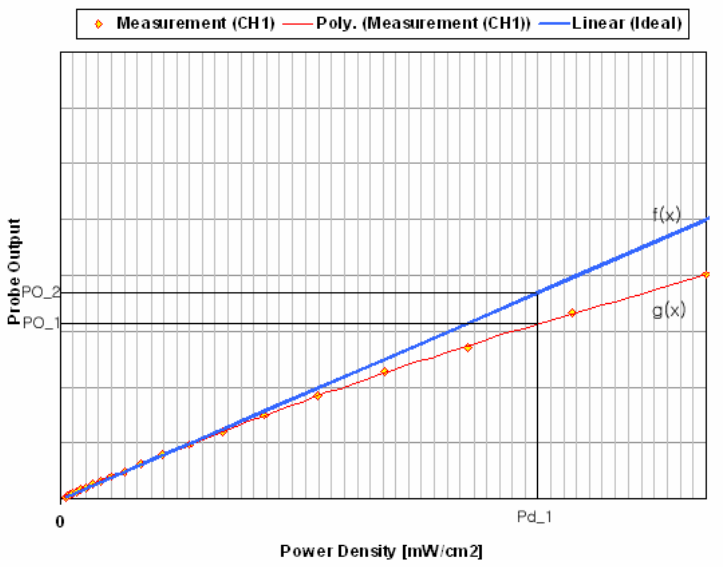
EXHIBIT 9. SAR SYSTEM CALIBRATION

9.1. GENERAL INFORMATION OF THE PROBE

Probe Type	E-Field Triangle, Isotropic
Model Number	E-TR
Serial Number	UT-0200-01
Manufacturer	3D-EMC Laboratory Inc.
Manufactured Date	February 2000
Probe Length [mm]	270
Probe offset [mm]	2.0
Probe Tip diameter [mm]	4.0
Sensor Factor (η_{Pd}) [mV/(mW/cm^2)]	10.8
Sensor Factor (η_{E2}) [mV/(V/m)^2]	10.8 / 3770

9.2. PROBE LINEARITY AND DYNAMIC RANGE

Each channel of the probe output over the range of the generated field's power density is recorded and stored as a diode compensation table to yield the polynomial equations, using the curve fitting algorithm, for the ideal diode response (linear) and the saturated diode response (the 3rd order). The linear equation and the inverse of the 3rd order polynomial equation are used to compensate for the saturated diode response to the ideal diode response.

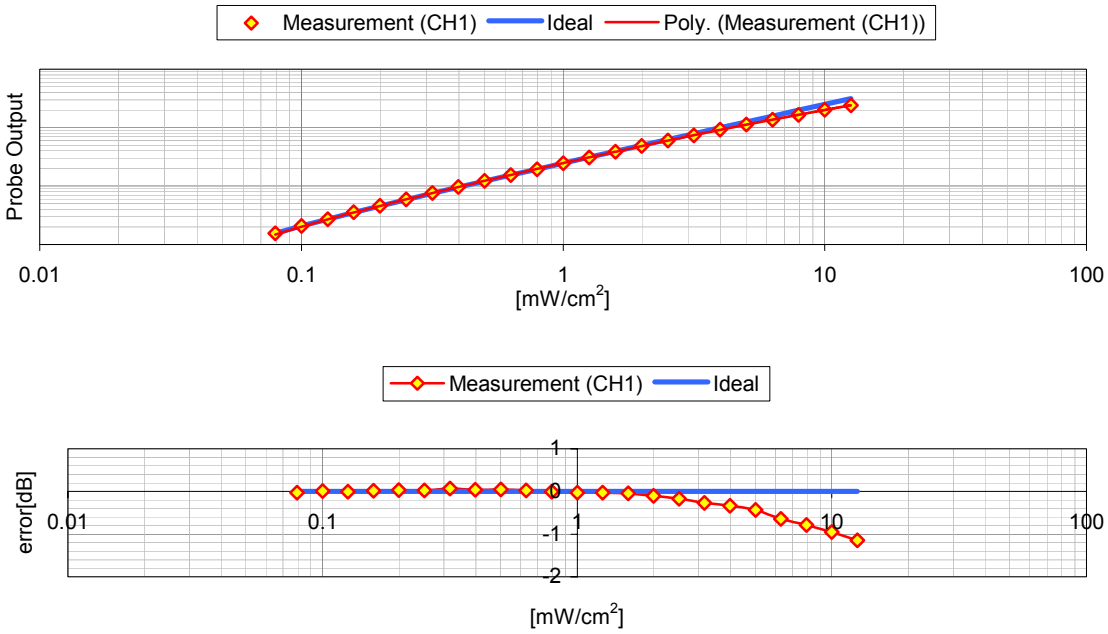


For example, Provided that linear equation, f, the 3rd order polynomial equation, g, and its inverse, g^{-1}, the saturated diode output $PO_{\_1}$ can be compensated to the ideal diode output $PO_{\_2}$ by the calculation as shown below.

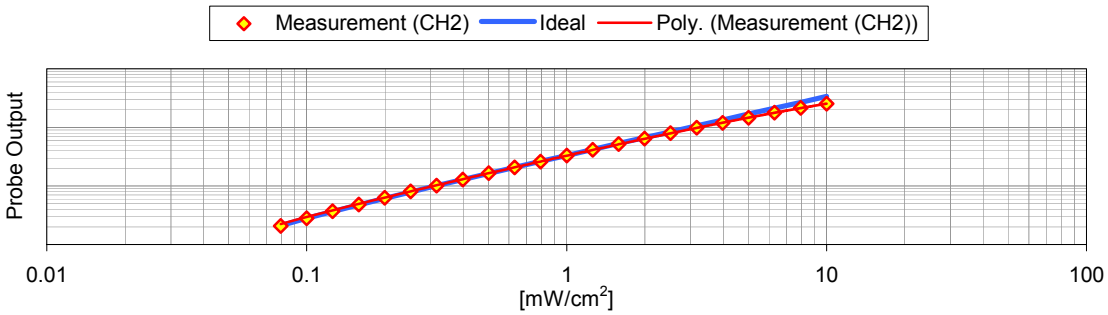
$$Pd_{\_1} = g^{-1}(PO_{\_1}),$$

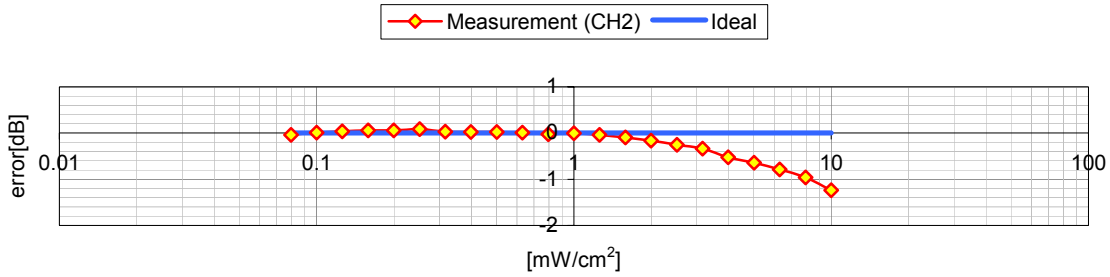
$$PO_{\_2} = f(Pd_{\_1}) = f(g^{-1}(PO_{\_1}))$$

9.2.1. Channel 1

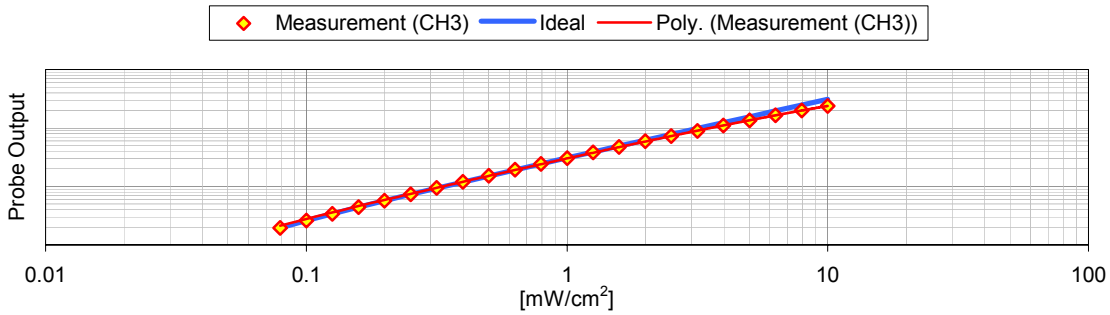


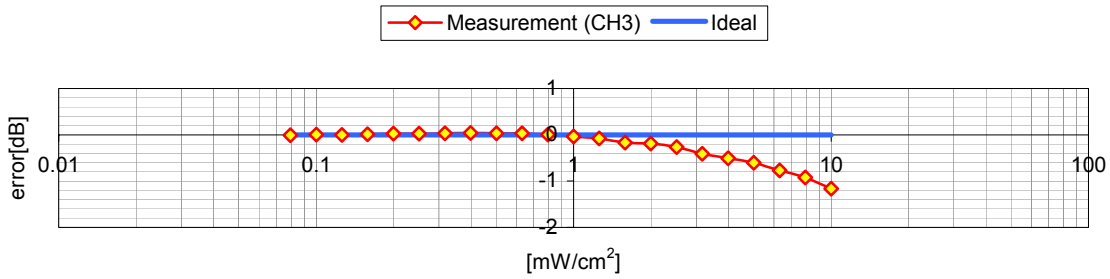
9.2.2. Channel 2





9.2.3. Channel 3





9.3. PROBE FREE SPACE CALIBRATION

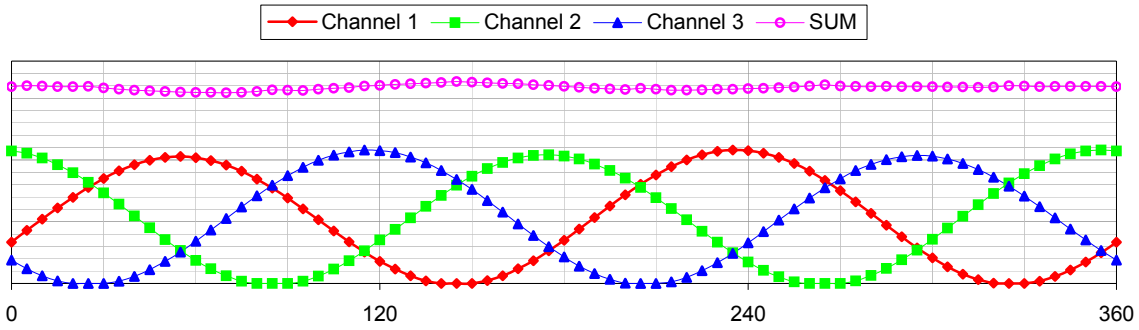
9.3.1. Calibration Setup

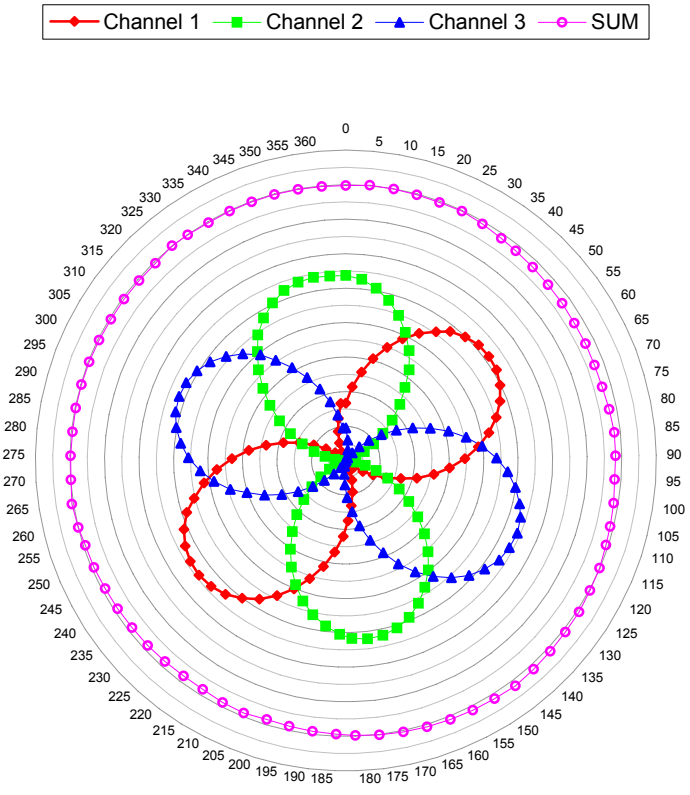
Calibration cell type	Waveguide
Model Number	11457-2
Serial Number	CO-05721-01
Manufacturer	APOLLO
Cross-sectional dimension (W × H) [mm]	40 × 20
Input Power / Power Density [mW/(mW/cm^2)] @ 5,240 [MHz]	2.794

9.3.2. Amplifier Settings

Calibration Date [MM/DD/YYYY]	07/31/2002
Calibrated by	JaeWook Choi
Calibration Frequency [MHz]	5,240
Room Temperature [°C]	24
Room Humidity [%]	30
φ [°]	90
θ_1, θ_2, θ_3 [°]	54.7, 54.7, 54.7
Pd [mW/cm^2]	2.0
V_{max1}	2413
V_{max2}	2557
V_{max3}	1848
AS_1	0.00596768
AS_2	0.00563160
AS_3	0.00779221

9.3.3. Isotropic response





9.4. PROBE THERMAL TRANSFER CALIBRATION

9.4.1. Calibration Setup

Calibration type	Thermal transfer calibration
Flat phantom dimension (W × L × H) [mm]	420 × 700 × 200
Flat phantom shell thickness (d_3) [mm]	2.0
Flat phantom shell permittivity	2.98
Calibration dipole dimension (L × h × d) [mm]	25.1 × 13.4 × 3.6
Sensor-to-Phantom (d_1) [mm]	5.0
Dipole-to-Phantom (d_2) [mm]	8.0
Sensor-to-Dipole ($d_1 + d_2 + d_3$) [mm]	15.0 (5.0 + 8.0 + 2.0)
Return Loss (at test frequency) [dB]	-21.0

9.4.2. Simulated Tissue

Tissue calibration type	HP Dielectric Strength Probe System
Tissue calibration date [MM/DD/YYYY]	07/31/2002
Tissue calibrated by	JaeWook Choi
Room temperature [°C]	24
Room humidity [%]	30
Simulated tissue temperature [°C]	24
Tissue calibration frequency [MHz]	5240
Tissue Type	Muscle
Target conductivity [S/m]	5.40
Target dielectric constant	48.5
Measured conductivity [S/m]	5.43 (+0.6 %)
Measured dielectric constant	48.8 (+0.6 %)
Penetration depth (plane wave excitation) [mm]	6.95

9.4.3. Conversion Factor

Calibration Date [MM/DD/YYYY]	07/31/2002
Calibration by	JaeWook Choi
Calibration Frequency [MHz]	5,240
Room Temperature [°C]	24
Room Humidity [%]	30
Simulated Tissue Temperature [°C]	23
PO_{tot_tissue} [mV]	6.668 @ 0.28 [W] 11.609 @ 0.49 [W] 16.193 @ 0.70 [W] 23.278 @ 0.99 [W]
$\delta(PO_{tot\_tissue})/\delta P$ [mV/W]	23.44599
$\Delta T/\Delta t$ [°C/ sec]	0.01525 @ 4.0 [W] 0.01940 @ 5.0 [W] 0.02343 @ 6.0 [W] 0.02732 @ 7.0 [W] 0.03152 @ 8.0 [W] 0.03549 @ 9.0 [W] 0.03943 @ 10.0 [W]
$\delta(\Delta T/\Delta t)/\delta P$ [°C/sec/W]	0.004029
Conversion Factor (γ)	2.721

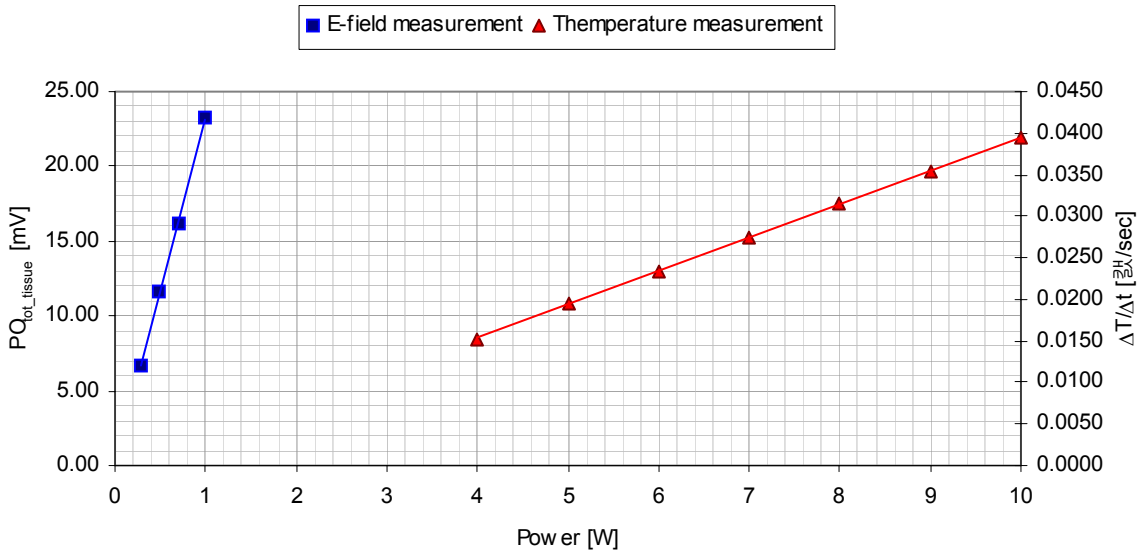


EXHIBIT 10. SAR SYSTEM VERIFICATION USING DIPOLE REFERENCE

10.1.1. Verification Setup

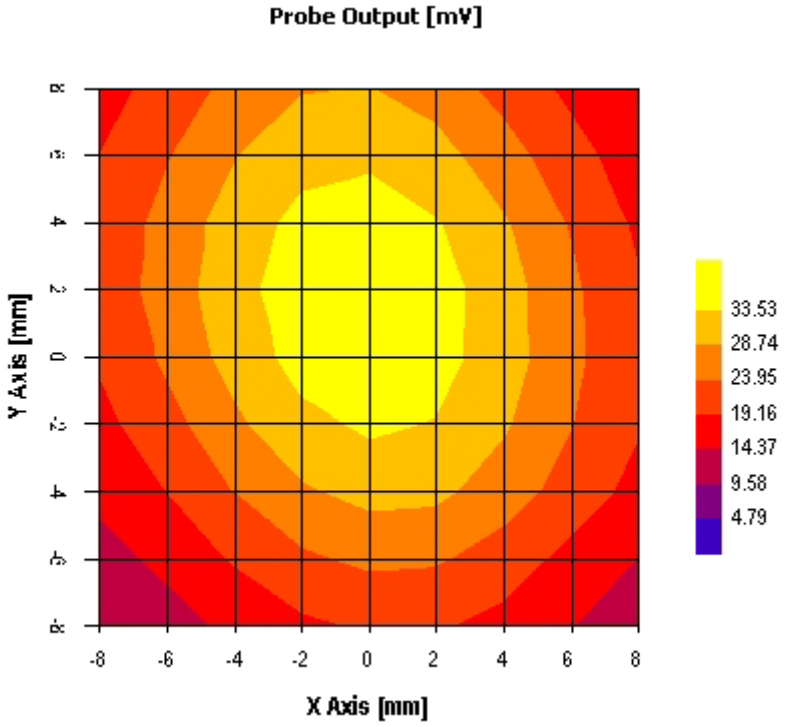
Flat phantom dimension (W × L × H) [mm]	420 × 700 × 200
Flat phantom shell thickness (d_3) [mm]	2.0
Flat phantom shell permittivity	2.98
Reference dipole dimension (L × h × d) [mm]	25.1 × 13.4 × 3.6
Dipole-to-Phantom (d_2) [mm]	8.0
Dipole-to-Liquid ($d_2 + d_3$) [mm]	10.0 (8.0 + 2.0)
Return Loss (at test frequency) [dB]	-21.0

10.1.2. Simulated Tissue

Tissue calibration type	HP Dielectric Strength Probe System
Tissue calibration date [MM/DD/YYYY]	01/09/2003
Tissue calibrated by	JaeWook Choi
Room temperature [°C]	21
Room humidity [%]	30
Simulated tissue temperature [°C]	21
Tissue calibration frequency [MHz]	5240
Tissue Type	Muscle
Target conductivity [S/m]	5.35
Target dielectric constant	49.0
Measured conductivity [S/m]	5.61 (+4.9 %)
Measured dielectric constant	47.3 (-3.5 %)
Penetration depth (plane wave excitation) [mm]	6.64

10.1.3. Verification Result

Test date [MM/DD/YYYY]	01/09/2002
Test by	JaeWook Choi
Room temperature [°C]	21
Room humidity [%]	30
Simulated tissue temperature [°C]	21
Separation distance, d [mm]	10 (8 + 2)
Test frequency [MHz]	5240
E-field Probe	M/N: E-TR, S/N: UT-0200-1, Sensor Offset: 2.0 mm
Sensor Factor (η_{Pd}) [mV/(mW/cm^2)]	10.8
Amplifier Settings (AS_1, AS_2, AS_3)	0.00596768, 0.00563160, 0.00779221
Tissue Type	Muscle
Measured conductivity [S/m]	5.61 (+4.9 %)
Measured dielectric constant	47.3 (-3.5 %)
Conversion Factor (γ)	2.721
Sensitivity (ζ) [W/Kg/mV]	0.719
Power [mW]	250 (forward power)
Measurement Volume Specification (X × Y × Z)	5 pts × 5 pts × 13 pts, 12 mm × 12 mm × 12 mm, Resolution: 3 mm × 3 mm × 1 mm
SAR_{1g} [W/Kg]	12.817
SAR_s [W/Kg]	61.878
Penetration Depth [mm]	5.22



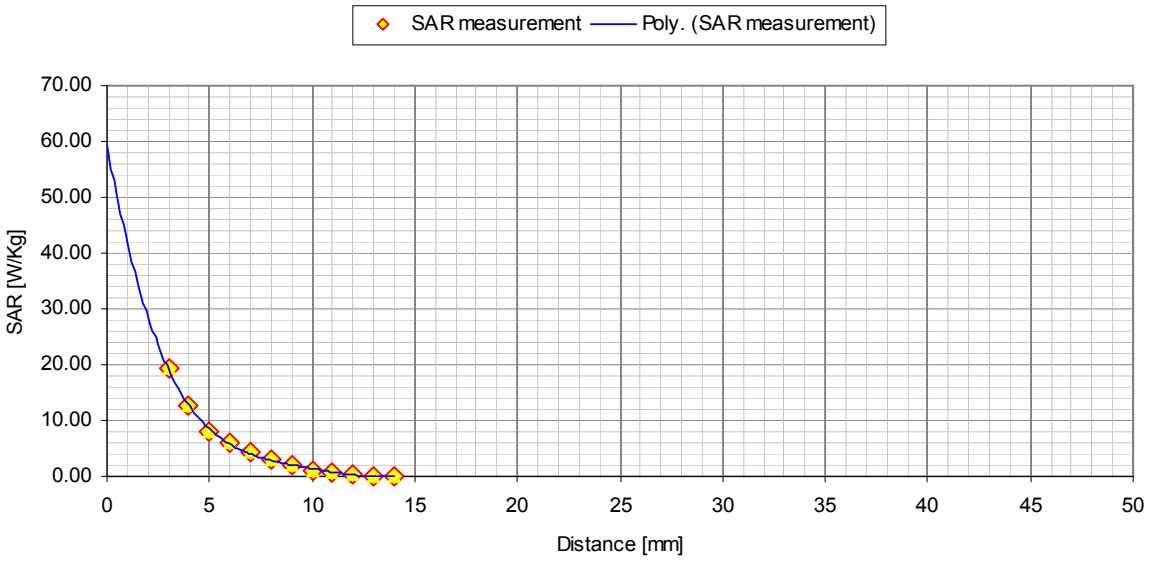

SAR measurement
Poly. (SAR measurement)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
SAR [W/Kg]
0
5
10
15
20
25
30
35
40
45
50
Distance [mm]

EXHIBIT 11. SAR CALCULATION SUMMARY

11.1. TERMINOLOGY

AS_i	Amplifier Setting for channel i (i = 1, 2, 3)
Pd	Power density at the measurement point [mW/cm^2]
PO_{tot_air}	Probe Output in the air [mV]
PO_{tot_tissue}	Probe Output in the simulated tissue [mV]
η_{E2}	Sensor Factor to the $\|E\|^2$, an arbitrary value 10.8/3,770 [mV/(V/m)^2]
η_{pd}	Sensor Factor to the uniform power density, an arbitrary value 10.8 [mV/(mW/cm^2)]
γ	Conversion factor; ratio of sensor response in air to response in the dielectric media
ζ	Sensitivity of the probe in the simulated tissue [W/Kg/mV]
c	Specific heat capacity of the simulated tissue [J/Kg/ ^oC]
$\sigma_{@cal}$	Conductivity of the simulated tissue during the thermal transfer calibration [S/m]
$\sigma_{@meas}$	Conductivity of the simulated tissue during the SAR measurement [S/m]
ρ	Mass density of the simulated tissue [Kg/m^3]
$\Delta T/\Delta t$	Initial rate of tissue heating, before thermal diffusion takes place [^{o}C /sec]

11.1.1. Sensor factor(η_{pd} and η_{E2}) in the air ($Z_0 = 377[\Omega]$)

$$\eta_{Pd} = 10.8[mV/(mW/cm)^2] \equiv \eta_{E2} = \frac{10.8}{3{,}770}[mV/(V/m)^2]$$

$$Pd[mW/cm^2] = \frac{PO_{tot}}{\eta_{Pd}}\ ,\ |E|^2[(V/m)^2] = \frac{PO_{tot}}{\eta_{E2}} \text{ and } SAR[W/Kg] = \frac{\sigma \times \frac{PO_{tot}}{\eta_{E2}}}{\rho}$$

11.1.2. Amplifier settings(AS_i) and probe output

$$AS_i = \frac{\eta_{Pd}}{V_{\max_i} - DC_i} \times \cos^2(\varphi - \theta_i) \times Pd$$

$$PO_1[mV] = (V_1 - DC_1) \times AS_1 \equiv |E_1|^2 \times \eta_{E2}$$
$$PO_2[mV] = (V_2 - DC_2) \times AS_2 \equiv |E_2|^2 \times \eta_{E2}$$
$$PO_3[mV] = (V_3 - DC_3) \times AS_3 \equiv |E_3|^2 \times \eta_{E2}$$
$$PO_{tot}[mV] \equiv |E|^2 \times \eta_{E2} = \left(|E_1|^2 + |E_2|^2 + |E_3|^2\right) \times \eta_{E2} = |E_1|^2 \times \eta_{E2} + |E_2|^2 \times \eta_{E2} + |E_3|^2 \times \eta_{E2}$$
$$\equiv PO_1 + PO_2 + PO_3$$

11.1.3. Conversion factor (γ) in the simulated tissue

$$\left|E_{tissue}\right|^2 = \frac{PO_{tot\_tissue}}{\eta_{E2}} \times \frac{1}{\gamma}$$

$$SAR_t = SAR_{tissue} = \frac{\sigma_{@cal} \times \left|E_{tissue}\right|^2}{\rho} = \frac{\sigma_{@cal} \times \frac{PO_{tot\_tissue}}{\eta_{E2}} \times \frac{1}{\gamma}}{\rho[Kg/m^3]} = \left(\frac{\sigma_{@cal} \times \frac{PO_{tot\_tissue}}{\eta_{E2}}}{\rho} \right) \times \frac{1}{\gamma} = SAR_{PO_{tot\_tissue}} \times \frac{1}{\gamma}$$

11.1.4. Conversion factor (γ) Calculation

$$\frac{\delta}{\delta P} SAR_t = \frac{\delta}{\delta P} SAR_{tissue}$$

$$\frac{\delta}{\delta P}\left(c \times \frac{\Delta T}{\Delta t} \right) = \frac{\delta}{\delta P}\left(\frac{\sigma_{@cal} \times \left|E_{tissue}\right|^2}{\rho} \right) = \frac{\delta}{\delta P}\left(\frac{\sigma_{@cal} \times \frac{PO_{tot\_tissue}}{\eta_{E2}} \times \frac{1}{\gamma}}{\rho} \right)$$

$$\gamma = \frac{\frac{\delta}{\delta P} SAR_{PO_{tot\_tissue}}}{\frac{\delta}{\delta P} SAR_t} = \frac{\frac{\sigma_{@cal} \times \frac{\delta}{\delta P} PO_{tot\_tissue}}{\eta_{E2}}}{c \times \frac{\delta}{\delta P} \frac{\Delta T}{\Delta t}} = \frac{\sigma_{@cal}}{\eta_{E2} \times c \times \rho} \times \frac{\frac{\delta}{\delta P} PO_{tot\_tissue}}{\frac{\delta}{\delta P} \frac{\Delta T}{\Delta t}}$$

11.1.5. Sensitivity (ζ) in the simulated tissue

$$\zeta[W/Kg/mV] = \frac{\sigma_{@meas}}{\eta_{E2} \times 1{,}000[Kg/m^3] \times \gamma}$$

11.1.6. SAR calculation

$$SAR[W/Kg] = \zeta[W/Kg/mV] \times PO_{tot\_tissue}[mV]$$