ENGINEERING TEST REPORT

PRISM INDIGO™
Model No.: ISL37704M

Tested For

Intersil Corporation
Rembrandtlaan 1a
3723 BG Bilthoven
P.O. Box 343
3720 AH Bilthoven
The Netherlands

In Accordance With

SAR (Specific Absorption Rate) Requirements
using guidelines established in IEEE C95.1-1991,
FCC OET Bulletin 65 (Supplement C),
Industry Canada RSS-102(Issue 1) and
ACA Radiocommunications (Electromagnetic Radiation – Human Exposure)
Amendment Standard 2000 (No. 1)

UltraTech's File No.: ITS-004-SAR

This Test report is Issued under the Authority of Tri M. Luu, Professional Engineer, Vice President of Engineering UltraTech Group of Labs Date: January 21, 2003	LICENSED PROFESSIONAL ENGINEER T.M. LUU PROVINCE OF ONTARIO
Report Prepared by: JaeWook Choi Issued Date: January 21, 2003	Tested by: JaeWook Choi Test Dates: January 09, 2003

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

UltraTech

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EXHIBIT 1. INTRODUCTION

1.1. SCOPE

Reference:	SAR (Specific Absorption Rate) Requirements IEEE C95.1-1991, FCC OET Bulletin 65 (Supplement C) Industry Canada RSS-102 (Issue 1). ACA Radiocommunications (Electromagnetic Radiation – Human Exposure), Amendment Standard 2000 (No. 1)
Title	Safety Levels with respect to human exposure to Radio Frequency Electromagnetic Fields Guideline for Evaluating the Environmental Effects of Radio Frequency Radiation
Purpose of Test:	To verify compliance with Federal regulated SAR requirements in Canada, Australia and the US.
Method of Measurements:	IEEE C95.1-1991, FCC OET Bulletin 65 (Supplement C) and Industry Canada RSS-102 (Issue 1)
Exposure Category	General Population/Uncontrolled

1.2. REFERENCES

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

Publications	**Year**	**Title**
IEEE Std. 1528-2001 Draft	2001	Draft Recommended practice for determining the Peak Spatial-Average Specific Absorption rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques.
Industry Canada RSS102	1999	"Evaluation Procedure for Mobile and Portable Radio Transmitters with respect to Health Canada's Safety Code 6 for Exposure of Humans to Radio Frequency Fields"
ACA	2000	ACA Radiocommunications (Electromagnetic Radiation – Human Exposure) Amendment Standard 2000 (No. 1)
NCRP Report No.86	1986	"Biological Effects and Exposure Criteria for radio Frequency Electromagnetic Fields"
FCC OET Bulletin 65	1997	"Evaluating Compliance with FCC Guidelines for Human Exposure to radio Frequency Fields"
ANSI/IEEE C95.3	1992	"Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave"
ANSI/IEEE C95.1	1992	"Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3kHz to 300GHz"
AS/NZS 2722.1	1998	Interim Australian/New Zealand Standard. "Radiofrequency fields, Part 1:Maximum exposure levels – 3kHz to 300GHz "

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT AND MANUFACTURER INFORMATION

APPLICANT:	
Name:	Intersil Corporation
Address:	Rembrandtlaan 1a 3723 BG Bilthoven P.O. Box 343 3720 AH Bilthoven The Netherlands
Contact Person:	Derick Sariredjo Phone #: +31 (0)30 229 60 60 Fax #: +31 (0)30 229 60 61 Email Address: derick.sariredjo@intersil.com

MANUFACTURER:	
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2.2. DEVICE UNDER TEST (D.U.T.) DESCRIPTION

The following is the information provided by the applicant.

Trade Name	PRISM INDIGO™
Type/Model Number	ISL37704M
Serial Number	0240 00027
Type of Equipment	Wireless LAN Card
Frequency of Operation	5180 ~ 5320 MHz
Rated RF Power	15.87 dBm conducted @ 5,180 MHz 15.98 dBm conducted @ 5,240 MHz 18.75 dBm conducted @ 5,320 MHz
Modulation Employed	OFDM
Antenna Type + Gain	Skycross embedded antenna (M/N: CBL-5250) Gain: 1.0 dBi (including antenna cable loss)
External Power Supply	Power supplied through the laptop computer
Primary User Functions of D.U.T.:	Data Radio Communication Through Air

2.3. LIST OF D.U.T.'S ACCESSORIES:

N/A

2.4. SPECIAL CHANGES ON THE D.U.T.'S HARDWARE/SOFTWARE FOR TESTING PURPOSES

N/A

2.5. ANCILLARY EQUIPMENT

Laptop computer (IBM, Type 2652), Hirose UFL to SMA adapter

2.6. GENERAL TEST CONFIGURATIONS

2.6.1. Equipment Configuration

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

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

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

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

2.6.2. Exercising Equipment

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

2.7. SPECIFIC OPERATING CONDITIONS

D.U.T. was made to transmit with 100% duty cycle, in other words continuously, instead of with its actual duty cycle, using the exclusive controlling software for SAR test provided by the manufacturer.

2.8. BLOCK DIAGRAM OF TEST SETUP

The D.U.T. was configured as normal intended use. The following block diagram shows a representative equipment arrangement during tests:

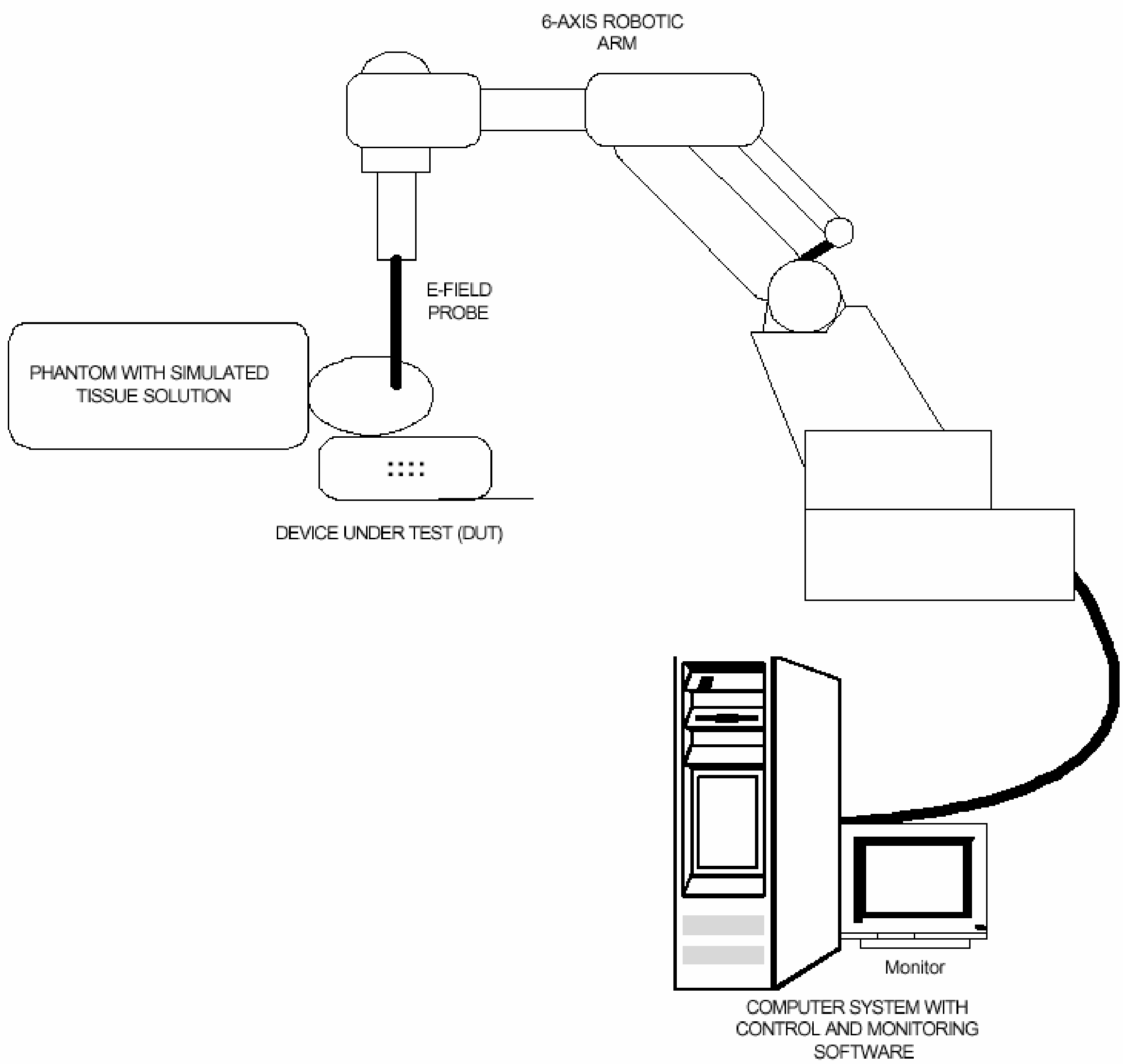

EXHIBIT 3. SUMMARY OF TEST RESULTS

3.1. LOCATION OF TESTS

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

3000 Bristol Circle, in the city of Oakville, Province of Ontario, Canada.

All measurements were performed in UltraTech's shielded chamber, 24' x 16' x 8'.

3.2. APPLICABILITY & SUMMARY OF SAR RESULTS

The maximum peak spatial - average SAR measured was found to be 0.009 W/Kg.

Exposure Category and SAR Limits	Test Requirements	Compliance (Yes/No)
General population/Uncontrolled exposure 0.08W/kg whole body average and spatial peak SAR of 1.6W/kg, averaged over 1gram of tissue Hands, wrist, feet and ankles have a peak SAR not to exceed 4 W/kg, averaged over 10 grams of tissue.	Requirements using guidelines established in IEEE C95.1-1991 FCC OET Bulletin 65 (Supplement C) Industry Canada RSS-102 (Issue 1). ACA Radiocommunications (Electromagnetic Radiation – Human Exposure) Amendment Standard 2000 (No. 1)	YES
Occupational/Controlled Exposure 0.4W/kg whole body average and spatial peak SAR of 8W/kg, averaged over 1gram of tissue Hands, wrist, feet and ankles have a peak SAR not to exceed 20 W/kg, averaged over 10 grams of tissue.	Requirements using guidelines established in IEEE C95.1-1991 FCC OET Bulletin 65 (Supplement C), Industry Canada RSS-102 (Issue 1) ACA Radiocommunications (Electromagnetic Radiation – Human Exposure) Amendment Standard 2000 (No. 1)	N/A

EXHIBIT 4. MEASUREMENTS, EXAMINATIONS & TEST DATA

4.1. TEST SETUP

D.U.T. Information		Condition	
Product Name	PRISM INDIGO™	**Robot Type**	6 Axis
Model Number	ISL37704M	**Scan Type**	SAR - Area/Zoom/Att Vs Depth
Serial Number	0240 00027	**Measured Field**	E
Frequency Band [MHz]	5180 ~ 5320	**Phantom Type**	2_{mm} base Flat Phantom
Frequency Tested [MHz]	5180, 5240, 5320	**Phantom Position**	Waist
Rated RF Output Power [dBm]	15.87 @ 5,180 MHz 15.98 @ 5,240 MHz 18.75 @ 5,320 MHz	**Room Temperature** [°C]	21.0 ± 1
Antenna Type, Gain	Embedded antenna, +1.0 [dBi]	**Room Humidity** [%]	30 ± 10
Modulation	OFDM	**Tissue Temperature** [°C]	21.0 ± 1
Duty Cycle	100 %		

Type of Tissue	Muscle
Test Frequency [MHz]	5240
Measured Dielectric Constant	47.3 (-3.5 %)
Measured Conductivity [S/m]	5.61 (+4.9 %)
Penetration Depth (Plane Wave Excitation) [mm]	6.64
Probe Model Number	E-TR
Probe Serial Number	UT-0200-1
Probe Orientation	Isotropic
Probe Offset [mm]	2.00
Probe Tip Diameter [mm]	4.00
Sensor Factor (η_{pd}) [$mV/(mW/cm^2)$]	10.8
Conversion Factor (γ)	2.721
Sensitivity (ζ) [W/Kg/mV]	0.719

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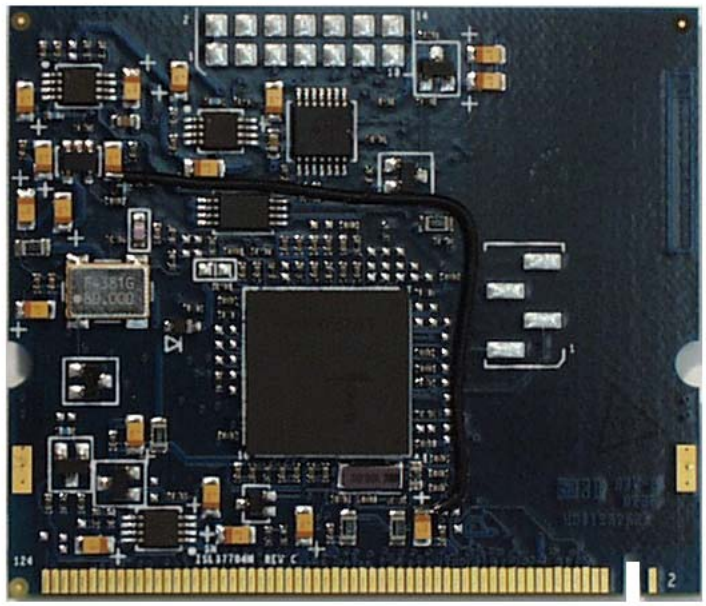
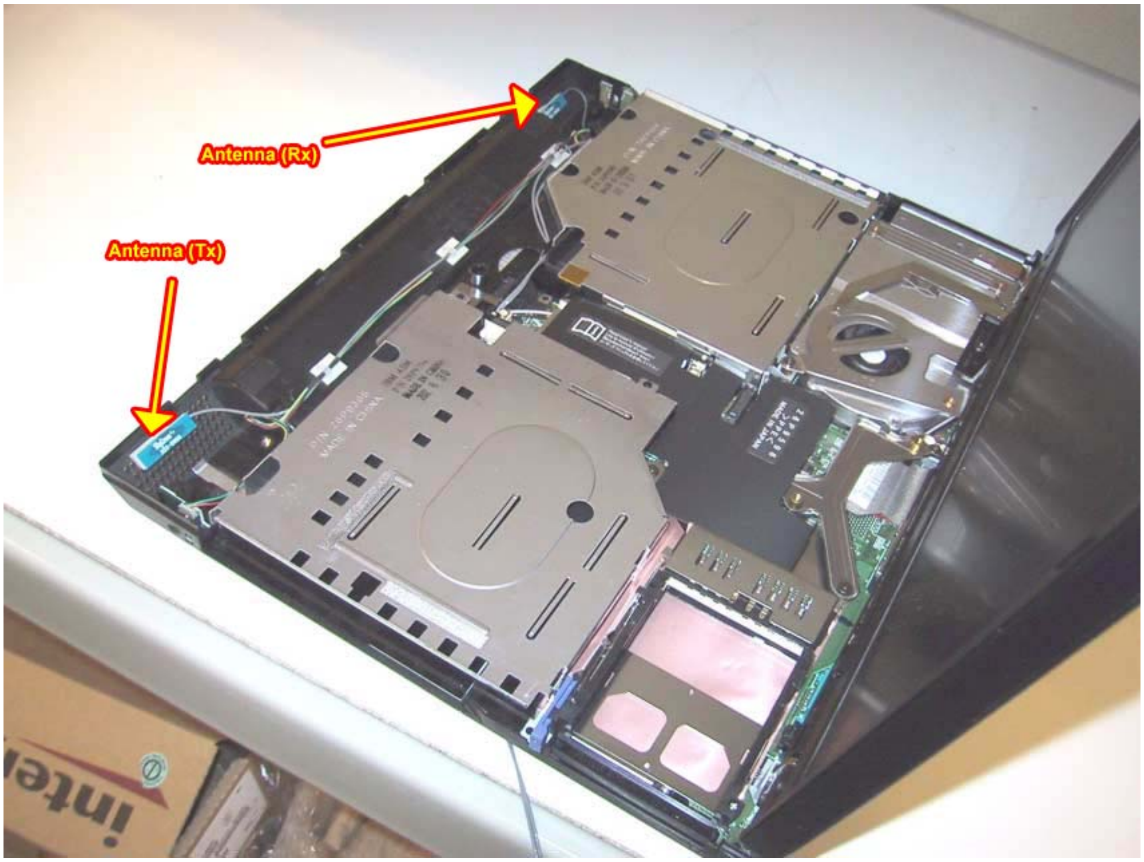
4.2. PHOTOGRAPH OF D.U.T. AND ALL ACCESORIES

< ISL 37704M miniPCI Card PCB Front View >



< ISL 37704M miniPCI Card PCB Rear View >

< D.U.T. installed in miniPCI slot >



< IBM ThinkPAD PC notebook with embedded 5GHz Skycross antenna >

4.3. PHOTOGRAPHS OF D.U.T. POSITION

4.3.1. Body-Worn Configuration

4.3.1.1. Lap-top position (minimum distance to the antenna)

< Close-up View >

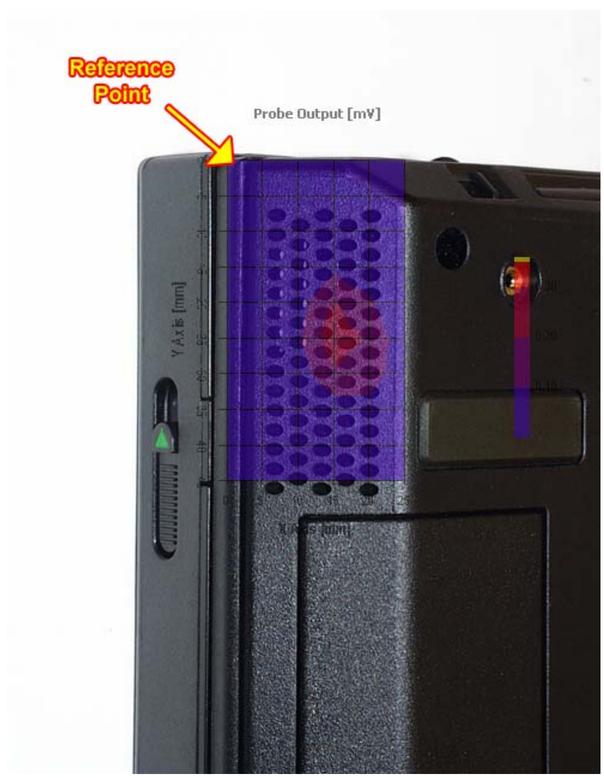
4.4. MAXIMUM PEAK SPATIAL-AVERAGE SAR

4.4.1. Maximum Peak Spatial-average SAR Data

#	Configuration	Device Test Positions	Antenna Position	Freq. [MHz]	Channel	MAX. SAR [W/Kg]
03	Lap-top position DUT in contact with the phantom 54 MBPS data rate 75.0 mW conducted power	Body-worn (By stander)	Fixed	5320	CH64	0.009

4.4.2. Maximum Peak Spatial-Average SAR LOCATION

Complete area Prescans was conducted to determine the location of the highest SAR and the device was repositioned to allow the identified hot-spots to be orientated with as large an area around the hot-spots to come into contact with the phantom surface. This procedure ensured that the maximum SAR readings would be obtained from the hot-spot areas identified.



4.5. SAR MEASUREMENT DATA

4.5.1. Body-Worn Configuration Result

4.5.1.1. 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]).

4.5.2. Power Measurement

Channel	Frequency [MHz]	Power [mW] (conducted)
CH36	5180	38.6
CH48	5240	39.6
CH64	5320	75.0

The conducted power was measured at the antenna fed point at 5240 [MHz] during the period of 30 minute. The power drift after 30 minutes of the continuous exposure at the maximum power level was found to be –1.37 [%].

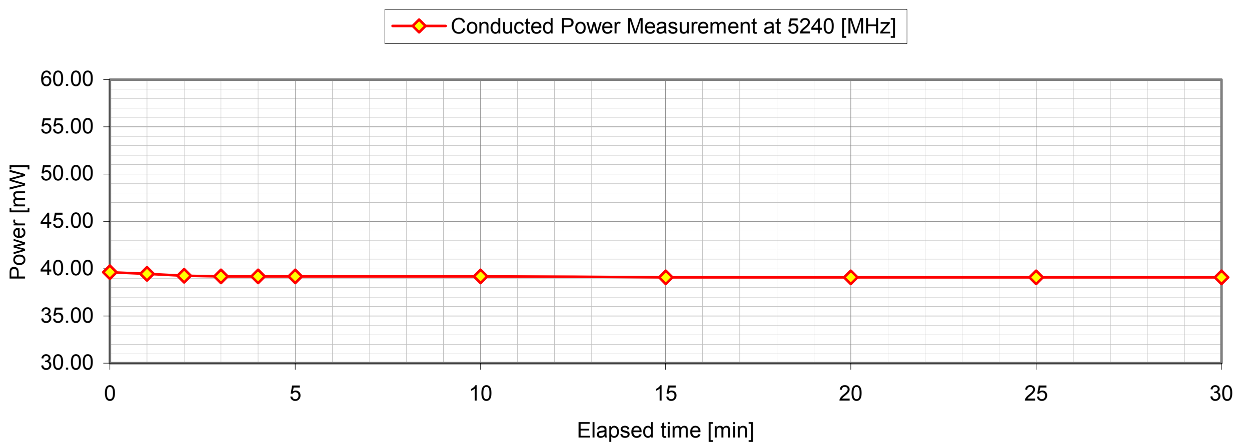


EXHIBIT 5. SAR SYSTEM CONFIGURATION & TEST METHODOLOGY

5.1. MEASUREMENT SYSTEM SPECIFICATIONS

Positioning Equipment	Probe
Type : 3D Near Field Scanner Location Repeatability : 0.1 [mm] Speed 180 [°/sec] AC motors	Sensor : E-Field Spatial Resolution : 1 [mm^3] Isotropic Response : ±0.25 [dB] Dynamic Range : 0.01 to 100 [W/Kg]
Computer	**Phantom**
Type : Pentium III 500MHz Memory : 256 MB RAM Operating System : Windows 2000 Pro Monitor : 19" SVGA	Tissue : Simulated Tissue with electrical characteristics similar to those of the human at normal body temperature. Left/Right Head: IEEE P1528 Compliant SAM manufactured by Aprel Body/Frontal Head: IEEE Flat Phantom 2 $_{[mm]}$ Base

5.2. TEST PROCEDURES

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

5.3. PHANTOM

For Head mounted devices placed next to the ear, the phantom used in the evaluation of the RF exposure of the user of the wireless device is a IEEE P1528 compliant SAM phantom, shaped like a human head and filled with a mixture simulating the dielectric characteristics of the brain. A left sided head and a right sided head are evaluated to determine the worst case orientation for SAR. For body mounted and frontal held push-to-talk devices, a flat phantom of dimensions 70x42x20cm with a base plate thickness of 2mm is used.

5.4. SIMULATED TISSUE

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

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

Table 5.4. Example of composition of simulated tissue

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

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

(ε_r = relative permittivity, σ = conductivity and ρ = 1000 Kg/m^3[*])

[*] The actual mass density of the equivalent tissue vary based on the composition of the tissue from 990 Kg/m^3 to 1,300 Kg/m^3.

5.4.1. Preparation

The weight requirements is determined and measured carefully for all the components. A clean container is used where the ingredients will be mixed. A stirring paddle mounted to a drill press is used to stir the mixture. First the heat is applied to the DI water to approximately 40 ^{o}C to help the ingredients dissolve well and then the salt and the bactericide are added. It is stirred until all the ingredients are completely dissolved. It is continuously stirred slowly while adding the sugar. Rotation of stirring paddle at a high RPM is avoided to prevent air bubbles in the mixture. Later on, the HEC is added to maintain the solution homogeneous. Mixing time is approximately 2 hours.

5.5. MEASUREMENT OF ELECTRICAL CHARACTERISTICS OF SIMULATED TISSUE

1) Slotted Coaxial Waveguide
2) HP Dielectric Strength Probe System

5.5.1. Slotted Coaxial Waveguide

5.5.1.1. Equipment set-up

The test equipment consists of a slotted coaxial transmission line with a probe connected to a vector network analyzer, as shown in Figure 4.5.1.1. The log-magnitude and phase of S_{21} should be displayed simultaneously. Source power should be set to a level high enough to provide good signal-to-noise ratio. Periodically (annually or whenever the measuring scale along the line length is changed) a measurement is made on a reference liquid to validate the system. Since the measured quantities are magnitude and phase changes versus distance, the accuracy of the scale is very critical.

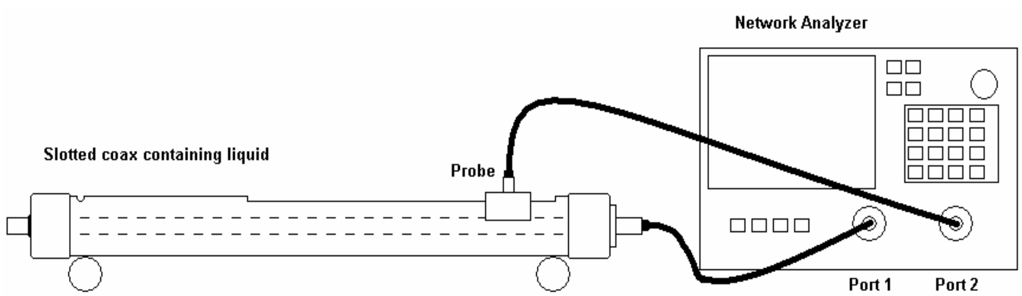


Figure 5.5.1.1. Slotted line set-up

The network analyzer injects a signal into one end of the slotted coaxial transmission line. The probe inserted through the slot into the tissue-equivalent material detects the RF amplitude and phase for each measurement position along the length of the line. A full two-port calibration of the network analyzer should be carried out prior to connecting the sample holder, and the following precautions should be observed:

a) Fill the slotted line carefully to avoid trapping air bubbles. This operation should be performed while the slotted line is horizontal.

b) The probe should be inserted into the slot at the end nearest to the input connector of the slotted line, ensuring that the tissue-equivalent liquid is flush with the inside surface of the line, and aligned with a well-defined position on the distance scale of the slotted line.

c) The probe should be inserted perpendicular to the slotted–line longitudinal axis until a stable and adequate amplitude response is achieved. Do not insert the probe too deeply into the coaxial line, because it can overly perturb the field distribution.

5.5.1.2. *Measurement procedure.*

a) Configure and calibrate the network analyzer.

b) Measure 10 to 20 log-magnitude and phase data points along the slotted line corresponding to about a 30 dB change in magnitude.

c) Plot S_{21} log-magnitude and phase vs. measurement distance.

d) Determine if the graphed points closely follow a straight-line approximation, based on the correlation coefficient or a similar statistical measure. The data should produce a good linear curve fit (expected correlation coefficient $r^2 > 0.99$ for lossy materials). If not, re-measure the liquid by increasing the sample points to extend the magnitude change from 30 to 40 dB. Note: for low loss materials, ensure that the slotted line is long enough to avoid reflections from the load-terminated end.

e) Calculate the conductivity and relative permittivity of the tissue-equivalent material using Equations (5.5.1.2.) derived from

$$\overline{\alpha} = \frac{m_m \ln(10)}{20} \quad \text{Np/cm}$$

$$\overline{\beta} = \frac{m_p \pi}{180} \quad \text{rad/cm}$$

$$\varepsilon_r' = \frac{(\overline{\beta})^2 - (\overline{\alpha})^2}{\omega^2 \mu_0 \varepsilon_0} \qquad (5.5.1.2.)$$

$$\sigma = \frac{2\overline{\alpha}\,\overline{\beta}}{\omega \varepsilon_0}\left(\frac{100\ \text{cm}}{\text{m}}\right) \quad \text{S/m}$$

where, m_m and m_p are the slopes of the least-squares linear fits of the log-magnitude and phase plots, respectively, and $\overline{\alpha}$ and $\overline{\beta}$ are the average attenuation and propagation coefficients along the line.

5.5.2. HP Dielectric Strength Probe System (open-ended coaxial transmission-line probe/sensor)

5.5.2.1. Equipment set-up

The equipment consists of a probe connected to one port of a vector network analyzer. The probe is an open-ended coaxial line, as shown in Figure B.2. Cylindrical coordinates (ρ, ϕ, z) are used where ρ is the radial distance from the axis, ϕ is the angular displacement around the axis, z is the displacement along the axis, a is the inner conductor radius, and b is the outer conductor inner radius.

The sample holder is a non-metallic container that is large compared with the size of the probe immersed in it. A probe with an outer diameter b of 2 to 4 mm is suitable for the measurement of tissue-equivalent materials in the 300 MHz to 3 GHz frequency range. This probe size is commensurate with sample volumes of 50 cc or higher. Larger probes of up to 7 mm outer diameter b may be used with larger sample volumes. A flange is typically included to better represent the infinite ground-plane assumption used in admittance calculations.

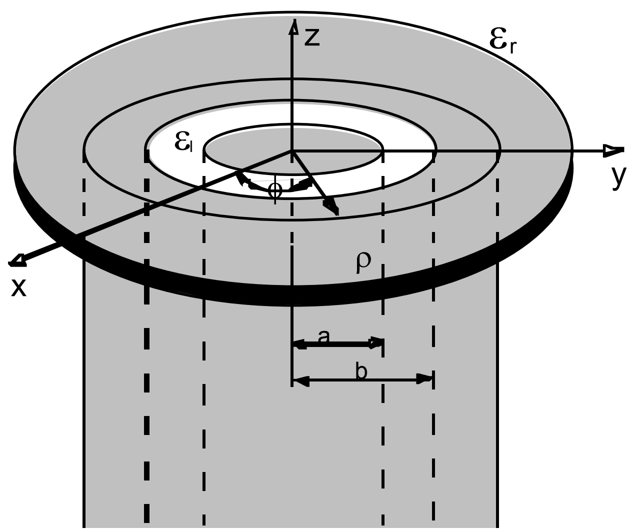


Figure 5.5.2.1. An open-ended coaxial probe with inner and outer radii *a* and *b*, respectively

The accuracy of the short-circuit measurement should be verified for each calibration at a number of frequencies. A short circuit can be achieved by gently pressing a piece of aluminum foil against the open end. For best electrical contact, the probe end should be flat and free of oxidation. Larger the sensors generally have better foil short-circuit repeatability. It is possible to obtain good contact with some commercial 4.6 mm probes using the metal-disk short-circuit supplied with the kit. For best repeatability, it may be necessary to press the disk by hand.

The network analyzer is configured to measure the magnitude and phase of the admittance. A one-port reflection calibration is performed at the plane of the probe by placing materials for which the reflection coefficient can be calculated in contact with the probe. Three standards are needed for the calibration, typically a short circuit, air, and de-ionized water at a well-defined temperature (other reference liquids such as methanol or ethanol may be used for calibration). The calibration is a key part of the measurement procedure, and it is therefore important to ensure that it has been performed correctly. It can be checked by re-measuring the short circuit to ensure that a reflection coefficient of Γ = -1.0 (linear units) is obtained consistently.

5.5.2.2. Measurement procedure

a) Configure and calibrate the network analyzer and probe system.

b) Place the sample in a non-metallic container and immerse the probe. A fixture or clamp is recommended to stabilize the probe, mounted such that the probe face is at an angle with respect to the liquid surface to minimize trapped air bubbles beneath the flange.

c) Measure the complex admittance with respect to the probe aperture.

d) Compute the complex relative permittivity $\varepsilon_r = \varepsilon_r' - j\sigma/\omega\varepsilon_0$.

5.6. SYSTEM CALIBRATION

The SAR measurement system has two main components:

a) the probe, which is connected to the inputs of
b) the instrumentation amplifier whose outputs are connected through the optical transmission line to
c) the computer.

The system is calibrated as one unit not as individual components. If any components is modified or replaced, the system must be re-calibrated.

The system calibration is performed by two steps:

1) determination of the sensitivity of the probe in the air by introducing it into the well-defined RF field, and
2) correlation of the measured E-field in the dielectric medium to the temperature rise in a dielectric medium.

5.6.1. Probe linearity

Detector diodes at the dipole feed-point are used to rectify the sensor voltage output. The rectified signal is transmitted through resistive (RF-transparent) lines to the sensor amplifier. At low field strength levels the output voltage is proportional to the square of the amplitude of the incident field; at higher signal levels, the output voltage is not linearly proportional to $|E|^2$, but becomes proportional to E. The compensation for diode compression is carried out for the each detector diode using the 3-rd order polynomial least-square fit algorithm before any further evaluation.

5.6.2. Free Space Calibration

Note: Equipment must be regularly calibrated.

- RF Signal Generator - frequency range to at least 6 GHz,
- RF Amplifier – if needed to generate the required power density in the test cell,
- Test Cell - TEM (Crawford) cell, waveguide, or other device capable of maintaining a uniform field,
- RF Power Meter - capable of measuring at least 5 Watts (current calibration is mandatory!) if possible traceable to the National Institute of Standards and Technology (NIST).
- E-Field Probe (under calibration)
- Probe Support Fixture
- Instrumentation Amplifier
- Transmission Line
- Computer Program with the Automated Calibration System Program

5.6.2.1. Method

Due to impedance variations in the diodes and the transmission line, and slight differences in gain among the channels of the instrumentation amplifier, a normalization method had been designed. The calibration method actually used is to determine the factors necessary adjust each channel of the system so it's indicated output can then be equated to the well-defined RF field. These factors are referred to as "Amplifier Settings".

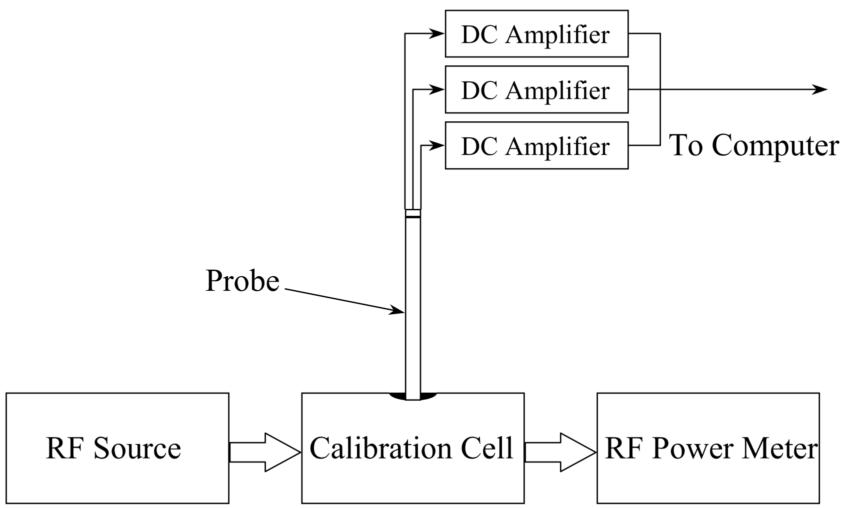


Figure 5.6.2.1. Free Space Calibration Setup for Amplifier Setting

5.6.2.2. Measurement procedure

Free Space Calibration of E-field probes can be performed using a TEM cell manufactured by IFI (Instrumentation for Industry, Farmingdale, NY 11735) with operating frequency at or below 1 GHz. Above 1 GHz, waveguides are used to calibrate the probes in free space.

- Connect the equipments as shown in Figure 5.6.2.1;
- Adjust the RF generator output so that the power density at the calibration point inside the TEM cell is well-defined. (For the IFI model CC-110 cell, the uniform power density of 1.0 [mW/cm^2] requires the power level of 271.0 [mW]);
- Mount the probe of the system to calibrate in the support fixture. Insert the probe through the aperture of the TEM cell. The probe handle should be at the geometric center of the aperture, i.e. midway between the septum and the upper surface, and orthogonal to the side of the cell. The sensing portion of the probe should be located at a point halfway across the depth of the cell (volumetric center).

- Once the prescribed position is obtained, it must be maintained during the rest of the measurement. The only movement of the probe allowed is rotation on its axis to position the dipole in the plane of the E-field and, for channel 3 only, parallel to the vertical uniform field (max./min. output).
- Verify that the RF power level remains constant throughout the measurement. While the probe is being rotated through 360 degrees, software indicators will show the maximum measured on each channel.

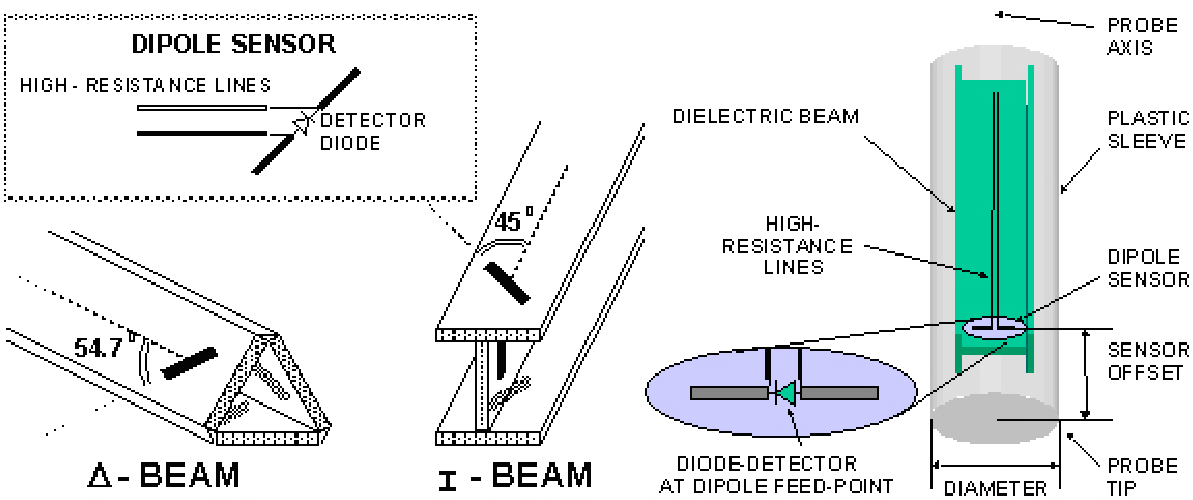


Figure 5.6.2.2. E-field probe construction

5.6.2.3. Definition of Amplifier Settings

The initial sequence of probe calibrations steps performed with SAR determinations produces the factors used in scaling probe output voltage to RF power density. For historical reasons all probes factors are compared to a factor 10.8 [mV] per [mW/cm^2] that was typical of a prototype probe, but is in fact an arbitrary number used as an intermediately constant. The factor of 10.8 [mV/(mW/cm^2)] is known as the sensor factor to the uniform power density (η_{pd}), but does not change. Also we can derive 10.8/3,770 [mV/(V/m)^2] of the sensor factor to the $|E|^2$ (η_{E2}), providing 377 [Ω] as free space impedance.

$$\eta_{Pd} = 10.8[mV/(mW/cm^2)] \equiv \eta_{E2} = \frac{10.8}{3770}[mV/(V/m)^2]$$

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

To calibrate a probe, each channel is assigned an amplifier setting. This factor is obtained from the maximum probe output voltage measured during probe calibration. This probe output voltage is corrected for any DC offset of the instrumentation amplifier, usually a very small amount.

During calibration, the sensitivity for the E-field tangential to the dipole axis caused by the geometry of the probe construction is carefully considered to obtain the correct amplifier setting for each channel. Thus, the amplifier settings for each channel are as follows:

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

Where,

AS_i	Amplifier Setting for channel i
η_{pd}	Sensor Factor to the uniform power density, an arbitrary value 10.8 [mV/(mW/cm^2)]
V_{maxi}	Maximum probe raw output recorded for channel i by rotation about the probe axis with the probe in a test cell
DC_i	Ambient DC offset of channel i (the voltage output of the transmission line with the instrumentation amplifier on and RF power off, recorded at the beginning of the probe calibration)
φ	Smaller angle between the probe axis and the direction of the E-field (90° providing the probe axis is parallel to the plane of the septum inside TEM cell)
θ_i	Smaller angle between the probe axis and the dipole sensor axis of the channel i ($\theta_1 = \theta_2 = 45°$, $\theta_3 = 90°$ for I-beam probe, and $\theta_1 = \theta_2 = \theta_3 = 54.7°$ for triangular-beam probe)
Pd	Well-defined power density [mW/cm^2] at the calibration point in a test cell

5.6.3. Thermal Transfer Calibration

5.6.3.1. Measurement procedure

An RF transparent thermistor-based temperature probe and a isotropic E-field probe are placed side-by-side in a planar phantom while both are exposed to RF energy from a half wave dipole antenna located below the phantom The E-field probe and amplifiers were previously calibrated.

First, the location of the maximum E-field close to the phantom's bottom is determined as a function of power into the dipole

Then, the E-field probe is moved sideways so that the temperature probe, while affixed to the E-field probe is placed at the previous location of the E-field probe.

Finally, temperature changes for a certain amount of time (generally 10 to 30 seconds) exposures at the same RF power levels used for the E-field are recorded. Care is taken to allow cooling down to the original temperature and temperature stabilization between tests.

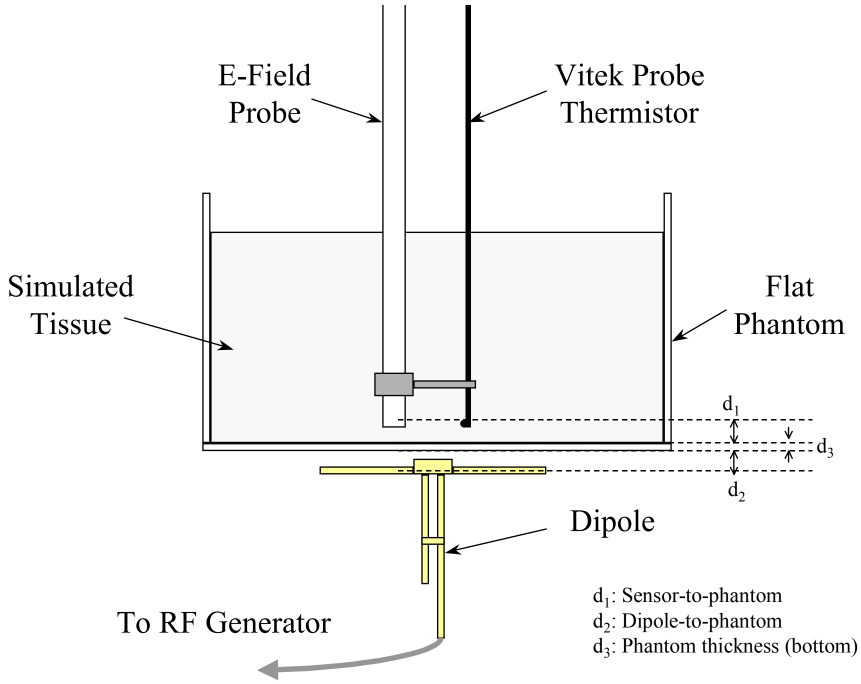


Figure 5.6.3.1. Flat Phantom, Thermistor and E-Field Probe

The following simple equation relates SAR to the initial temperature slope:

$$SAR_t = \frac{c \cdot \Delta T}{\Delta t} \qquad \text{(Eq. 1)}$$

In (Eq.1) Δt is the exposure time [sec], c is the specific heat capacity of the simulated tissue [J/Kg/ ^{o}C] and ΔT is the temperature increase [^{o}C] due to the RF exposure. SAR is proportional to ΔT/Δt, the initial rate of tissue heating, before thermal diffusion takes place.

From (Eq.1) it is possible to quantify the electric field in the simulated tissue by equating the thermally-derived SAR to the E-field:

$$SAR = \frac{|E|^2 \cdot \sigma}{\rho} \qquad \text{(Eq. 2)}$$

where σ is the simulated tissue conductivity [S/m] andρ its mass density [Kg/m^3]; The actual mass density of the simulated tissue is required during the thermal transfer calibration, while mass density of 1,000 [Kg/m^3] is conventionally chosen during the SAR measurements.