The Dielectric Properties of Human Body Tissues at Electromagnetic Wave Frequencies

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Abstract—The study of the dielectric properties of human body tissues belongs to basic as well as applied science. The dielectric properties of a biological tissue are a measure of the interaction of electromagnetic radiation with its constituents at the cellular and molecular level. Electromagnetic wave frequencies are emitted by many natural and man made sources and is a fundamental aspect of our lives. Electromagnetic field in biological tissues depends on the spatial distribution and size of the dielectric properties of tissues. The conductivity of samples is similarly found to increase due to the increased dilution. Three shield dielectric properties at microwave frequencies of 300, 915, 1300, and 2450 MHz are selected for the shielding investigation. All measurements were performed with the tissue sample at body temperature. The optimum parameter of the dielectric shield greatly depends on the operating frequencies. Measurement of ion currents in ion concentrations in cells, although still a problem to date have been developed a method that fully resolves the problem.

Keywords- Dielectric properties; body tissues; frequency; waves; permittivity.

I. INTRODUCTION

The technologies are rapidly developed in the present. Especially, at the end of the last century, the variation of electromagnetic fields with number of them was actually increased. Thus, human are affected more than ever from the radiowaves. The study of the dielectric properties of human body tissues belongs to basic as well as applied science. Proper knowledge of the dielectric properties of biological systems is essential for either determining safe levels for personal exposure to electromagnetic radiation or for effectively employing electromagnetic radiation in beneficial biomedical applications. Thus, the measurement of the dielectric properties of biological tissues would play a significant role in any well founded effort involving body tissues interaction with electromagnetic energy. It is widely recognized that radiofrequency and microwave energy can be effectively used in the treatment of many diseases. Thus, from the knowledge of dielectric constants, tissue properties can be characterized in the microwave frequency range [1-4].

The theoretical aspects and the main findings in this subject have been widely reviewed [5-9]. They reflect on the historical perspective provided by over 100 years of interest in the electrical properties of tissues, and review the basic concepts of dielectric phenomena in biological materials and their interpretation in terms of interactions at the cellular level. Also they cover similar ground and provide an overview of theories formulated to explain the dielectric properties in terms of the underlying molecular processes. Common to all papers is a more or less extensive tabulation of dielectric properties of tissues selected to illustrate the theoretical deliberations provided by the authors. Dielectric property information is also essential to the determination of electromagnetic radiation hazards with respect to personnel. The level of electromagnetic energy which is considered to be below the level which constitutes a potential hazard to personnel working in that environment is dependent upon many factors. One of these factors is the interaction of the incident electromagnetic field with various tissues and organ systems, which is in turn dependent upon the local geometry and the dielectric properties of those systems. Therefore, an accurate knowledge of the in vivo dielectric properties of the principal tissues and organs in the body is crucial to the accurate determination of absorbed power and its spatial distribution. Without accurate knowledge of the dielectric properties, any computation of power absorption from known or measured fields is at best an estimate [10, 11]. A variety of conventional measurement techniques can be utilized to measure the dielectric properties of biological tissues [12]. With the increasing use of mw and mmw radiation in communications and radar, it is necessary to know dielectric properties of various human tissues for evaluation of potential hazards to humans. At mw and mmw frequencies ranges, the absorption of electromagnetic radiation is mostly restricted to the skin because of submillimeter depths of penetration [13]. Therefore, the knowledge of dielectric properties of human skin in vivo is of prime importance for quantifying hazardous effects of microwaves radiation. However, the majority of these techniques have several limitations. The effects of barrier layers with a generalized dielectric response on the measurement of the dielectric properties of materials are investigated, using the cluster model of relaxation to represent both the bulk and barrier properties. It
is shown that the Maxwell-Wagner response is a limiting case and only applicable when the series elements are perfect, non dispersive capacitors and resistors [14].

It is well known that the bulk electrical properties of skeletal muscle are highly anisotropic. Previous studies, some going back to the 20th century show that at audio frequencies a seven to ten fold variation in the resistivity of skeletal muscle fibres in the incident electric field. The corresponding anisotropy in the permittivity of the tissue has apparently never been directly measured, although it was indirectly estimated by Sabegno in 1930 [15]. Accurate measurements of these anisotropic properties are interesting in view of the long history of tissue impedance measurements, as well as for practical applications. Permittivity is an essential variable in any scattering or absorption derivation using Maxwell’s equations. Therefore, the patterns of absorbed radiofrequency radiation in tissues are determined, in part by the electrical properties of the tissues. The common practice seems to be interpolate tabulated data for dielectric permittivity and conductivity rather than consider the inherent dependence of the two terms of the complex permittivity on each other. A computer program was developed to fit multiple term Debye type expressions to published data of permittivity for muscle. The number of terms in this expression was varied and tested for significance [16]. Furthermore, fundamental analysis of shielding effects of lossy dielectric materials located in front of a human body have also been carried out by some researchers. However, the heat transfer model has not been included in the modeling analysis [4]. The computation of the temperature increase is one of the main tasks in the evaluation of the risk related to the exposure of humans to electromagnetic fields [17]. Nevertheless, most studies of human protection from electromagnetic field exposure have not considered the temperature increase within the domain of the human body especially in the human organism.

Effects on biological material can be placed in three categories: (1) thermal, (2) specific thermal, (3) nonthermal. Volume heating is the general heating which any type of conductor or semiconductor, such as tissue, may receive under the influence of electrical currents or waves. Specific thermal effects as structural heating exist when boundaries between different types of tissues or particles on a microscopic scale, such as small cell complexes or even bacteria, etc., can be selectively heated without substantial heating of the surrounding material. Those effects, which cannot be explained on a thermal basis, are classified as nonthermal effects [18]. It has been shown that specific thermal effects, such as the selective heating of bacteria, are not possible. The selective temperature rise which a particle may experience by developing internal heating due to absorption of electrical energy is inversely proportional to the square of the particle size.

The interaction of time varying electric fields with the human body results in the flow of electric charges (electric current), the polarization of bound charge (formation of electric dipoles), and the reorientation of electric dipoles already present in tissue. The relative magnitudes of these different effects depend on the electrical properties of the body that is, electrical conductivity (governing the flow of electric current) and permittivity (governing the magnitude of polarization effects). Electrical conductivity and permittivity vary with the type of body tissue and also depend on the frequency of the applied field. Electric fields external to the body induce a surface charge on the body; this results in induced currents in the body, the distribution of which depends on exposure conditions, on the size and shape of the body, and on the body’s position in the field. In the measurement of muscle fiber conduction velocity, the electrode position is crucial for the accurate and reliable recording of myoelectric signals. Several investigators have measured the conduction velocity using surface electrodes. They determined the electrode position based on an anatomical knowledge or on the motor point location found by the electrical stimulation technique [19, 20].

The notable increase in the exposure of people to electromagnetic fields from wireless telecommunication devices and infrastructure has sparked large research programmes into the assessment and quantification of exposure of people and on the biological effects resulting from the exposure. Information on the dielectric properties of tissues is vital to these studies, for the computation of exposure metrics and the provision of a mechanistic explanation for biological effects. At the onset of this project, there already was a credible database of dielectric properties of tissue [21].

In experimental studies, the determination of the measurement uncertainty is probably just as important as the measurement itself. Uncertainty originates from the measurement instrumentation and procedures including theoretical assumptions and simplifications. It is therefore helpful to get acquainted with the basic instrumentation and procedures. The measurement of the dielectric properties of materials is conceptually straightforward, but there are numerous techniques and related instrumentation that apply over specific frequency ranges. This report will deal specifically with measurement in the microwave region. In general, the sample is treated as a linear, time invariant and causal component of a circuit the design of which enables the dielectric properties to be obtained using electromagnetic transmission theory. The frequency range influences the theoretical and experimental implementation of the measurement including the design and modelling of the sample and sample holder.

At microwave frequencies, it is usual to incorporate the sample (and sample holder) in a transmission line assembly organised to measure one or more of its scattering parameters which are a function of the dielectric properties. The main experimental components are: a source to provide an incident signal, a sample holder to contain or define the sample, a detection system to measure its response and transmission line components to guide the electromagnetic signal from one point to another. In practice a large number of additional components such as isolators and directional couplers are usually required. Such techniques lead to the determination of the reflection and or transmission coefficient of the sample/sample holder. Both parameters are a function of the dielectric properties of the sample. The different measurement techniques are usually distinguished according to the design of the sample holder,
II. DIELECTRIC PROPERTIES OF TISSUES

The dielectric properties of a biological tissue are a measure of the interaction of electromagnetic radiation with its constituents at the cellular and molecular level. The mechanisms of interaction are well understood, the theory underpinned by experimental data and forming part of a well established classical theory of bioelectrical phenomena [5, 7].

The main features of the dielectric spectrum of a biological tissue are as follows: The dielectric properties of tissues are highly frequency and temperature dependent. Their dielectric spectrum consists of three main regions known as α, β and γ dispersions, descriptively referred to as occurring at low, intermediate and high frequencies in the frequency range from hertz to gigahertz. The low frequency dispersion in the hertz to kilohertz range is associated with ionic diffusion processes at the site of the cellular membrane. The low frequency α dispersion in the hertz to kilohertz range is associated with ionic diffusion processes at the site of the cellular membrane. The β dispersion, extends over 3-4 frequency decades centred in the hundreds of kilohertz region, and is due mainly to the polarisation of cellular membrane and organic macromolecules [22].

Electromagnetic field in biological tissues depends on the spatial distribution and size of the dielectric properties of tissues. Dielectric properties of tissues, such as dielectric constant and conductivity as the water content are determined by the dominant. Eye with high water content tissues, muscle, skin, liver, kidney, moderate amounts of water that contains the value of brain, lung, bone marrow and those with low water content, fat and bone. Dielectric properties of tissues, the frequency and also varies depending on the temperature. With increasing frequency, dielectric constant \( \varepsilon \) fell \( \sigma \) conductivity value rises [23]. When a material is introduced into a resonant cavity, the cavity field distribution and resonant frequency change; a change that is dependent upon geometry, electromagnetic properties and its position in the fields of the cavity. Dielectric material interacts only with the electric field in the cavity.

The dielectric properties of materials are obtained from their measured complex relative permittivity \( \varepsilon \) which, being a relative quantity, has no unit. It is expressed as \( \varepsilon = \varepsilon' - j\varepsilon'' \) where \( \varepsilon' \) is the relative permittivity, measure of the charge displacement and consequent energy stored in the material, and \( \varepsilon'' \) is the out of phase loss factor, a measure of the electrical energy dissipated. In a perfect dielectric material, losses are due to displacement currents and the loss factor \( \varepsilon'' \) can be expressed in terms of a displacement electrical conductivity \( \sigma_d \), dielectrics in an electric field that can move with the free ads are put into effect when the field is almost negligible loads. So, a current does not pass through dielectrics. In biological material, an external field will induce ionic as well as displacement currents, ionic currents and corresponding losses are proportionate with the material ionic conductivity \( \sigma_i \). The total conductivity of the material \( \sigma \) is given by \( \sigma = \sigma_d + \sigma_i \) and is related to the loss factor through the expression \( \varepsilon'' = \sigma / \varepsilon_0 \). In practice it is only possible to measure the total conductivity \( \sigma \). Where present \( \sigma_i \), which is frequency independent, can only be obtain from dielectric spectral analysis. In the loss factor expression, \( \varepsilon_0 \) is the permittivity of free space and \( \omega \) the angular frequency of the field. The SI unit of conductivity is siemens per metre (S/m) which presumes that, in the above expression, \( \varepsilon_0 \) is expressed in farads per metre (F/m) and \( \omega \) in radians per second. The dielectric properties are determined as \( \varepsilon' \) and \( \varepsilon'' \) values, or \( \varepsilon' \) and \( \sigma \) values, as a function of frequency. In this report, \( \varepsilon' \) will be referred to as permittivity, and \( \sigma \) as conductivity expressed in S/m.

Very briefly, the main features of the dielectric spectrum of a biological tissue are as follows:

- The relative permittivity of a tissue may reach values of up to 10⁶ or 10⁷ at frequencies below 100 Hz.
- It decreases at high frequencies in three main steps known as the α, β and γ dispersions. Other dispersions may also be present.
- The γ dispersion, in the gigahertz region, is due to the polarization of water molecules.
- The β dispersion, in the hundreds of kilohertz region, is due mainly to the polarization of cellular membranes which act as barriers to the flow of ions between the intra and extra cellular media. Other contributions to the β dispersion come from the polarization of protein and other organic macromolecules.
- The low frequency α dispersion is associated with ionic diffusion processes at the site of the cellular membrane.
- Tissues have finite ionic conductivities commensurate with the nature and extent of their ionic content and ionic mobility [2].

The data reported are those that correspond more closely to living human tissues. Consequently, human tissue and in vivo measurements were selected in preference to animal tissue and in vitro. For in vitro measurements, data obtained at temperatures closest to that of the body and nearest to the time after death were used when available. Most of the literature data were in graphical rather than tabular form, and in a logarithmic rather than linear format. Such data were retrieved for each decade. When tables were available, a more extensive frequency range was often provided. The data were translated
from the various authors’ preferred set of parameters and units to relative permittivity and conductivity expressed in S/m. Data obtained at temperatures as low as 20 °C are included in this survey. It was not considered advisable to translate them to body temperature. The temperature coefficients, for both permittivity and conductivity, are tissue type and frequency dependent. Information on these coefficients is scarce and not sufficiently robust to warrant generalization and extrapolation. Moreover, the coefficients are highest (~1-2% °C−1) at low frequencies where the uncertainties and the scatter in the data are also high.

Human Model

As shown in Fig. 1, the incident plane wave with a power density of 5 mW/cm² is incident on the shield in front of the human model.

![Figure 1. Human model with dielectric shield](image1)

From Fig. 2, a human model used in this paper is obtained by image processing technique from the work Shiba and Higaki [24].

The human model has a dimension of 300 mm in width and 525 mm in height. This human model comprises 10 types of tissues which are the skin, fat, muscle, bone, large intestine, small intestine, bladder, blood, stomach, and liver, respectively. These tissues have different dielectric and thermal properties.

The thermal properties and dielectric properties of tissues at the frequencies of 300, 915, 1300, and 2450 MHz are given in Table I, Table II and Table III, respectively.

As very few studies associated with human tissue properties have been conducted, some of the tissue properties are not quantified. It is also difficult to directly measure the tissue properties of a live human. Therefore, it should be noted that the properties based on animal experiments are used for most thermal parameters because no actual data is available for analyzing the human model. Fig. 2 shows a vertical cross section through the middle of the human trunk model. To simplify the problem, electromagnetic wave propagation is modeled in two dimensions over the y-z plane, in which waves and object interaction proceed in the open region, and the computational space in truncated by scattering boundary condition. The propagation electromagnetic wave is characterized by transverse electric fields.

<table>
<thead>
<tr>
<th>Table I. Dielectric Properties of Tissues (915 MHz)</th>
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<td>Tissue</td>
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<td>Skin</td>
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<td>Fat</td>
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<td>Muscle</td>
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<td>Bone</td>
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<td>Large intestine</td>
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<td>Small intestine</td>
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<td>Bladder</td>
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<td>Blood</td>
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<td>Stomach</td>
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<td>Liver</td>
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<th>Table II. Dielectric Properties of Tissues (2450 MHz)</th>
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<tr>
<td>Tissue</td>
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<td>Skin</td>
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<td>Fat</td>
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<td>Muscle</td>
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The electromagnetic wave propagation is calculated by Maxwell’s equations [26], which mathematically describe the interdependence of the electromagnetic waves. The general form of Maxwell’s equations is simplified to demonstrate the electromagnetic field of microwave penetrated into human model as the equation \( \varepsilon = n^2 \) where \( n \) is refractive index. Microwave energy is emitted by a microwave high power device and strikes the dielectric shield in front of the human model with a particular power density. Therefore, boundary conditions for electromagnetic wave, as shown in Fig. 3, are considered as follows.

The measurement programme was structured to provide the following information:
- a database of dielectric properties of tissues obtained in vivo at microwave frequencies,
- a statistical breakdown of measurement uncertainties and their origin,
- a study of changes in the dielectric properties of tissue as a function of age [27],
- a study of the dielectric properties of human skin.

![Figure 3. Boundary condition for analysis [4].](http://www.ijsat.com)

### III. FORMULATION OF ELECTROMAGNETIC WAVE PROPAGATION ANALYSIS

A mathematical model was developed to calculate the electric field and temperature distribution within the human model. To simplify the problem, the following assumptions were made; electromagnetic wave propagation is modeled in two dimensions over the y-z plane, in which waves and object interact proceeds in the open region, and the computational space is truncated by scattering boundary condition. The propagation of an electromagnetic wave is characterized by transverse electric fields. The dielectric properties of human tissues are frequency dependent as shown in Table 1 and Table 2. Since the temperature increase in the human model is slightly changed, the model assumes that the dielectric properties of tissues are independent to temperature change for the specified frequency.

The measurement programme was structured to provide the following information:
- a database of dielectric properties of tissues obtained in vivo at microwave frequencies,
- a statistical breakdown of measurement uncertainties and their origin,
- a study of changes in the dielectric properties of tissue as a function of age [27],
- a study of the dielectric properties of human skin.

<table>
<thead>
<tr>
<th>Tissue</th>
<th>( \rho ) (kg/m(^3))</th>
<th>( k ) (W/m.K)</th>
<th>( C_p ) (J/kg.K)</th>
</tr>
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<tbody>
<tr>
<td>1 Skin</td>
<td>1125</td>
<td>0.35</td>
<td>3437</td>
</tr>
<tr>
<td>2 Fat</td>
<td>916</td>
<td>0.22</td>
<td>2300</td>
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<tr>
<td>3 Muscle</td>
<td>1047</td>
<td>0.6</td>
<td>3500</td>
</tr>
<tr>
<td>4 Bone</td>
<td>1038</td>
<td>0.436</td>
<td>1300</td>
</tr>
<tr>
<td>5 Large intestine</td>
<td>1043</td>
<td>0.6</td>
<td>3500</td>
</tr>
<tr>
<td>6 Small intestine</td>
<td>1043</td>
<td>0.6</td>
<td>3500</td>
</tr>
<tr>
<td>7 Bladder</td>
<td>1030</td>
<td>0.561</td>
<td>3900</td>
</tr>
<tr>
<td>8 Blood</td>
<td>1058</td>
<td>0.45</td>
<td>3960</td>
</tr>
<tr>
<td>9 Stomach</td>
<td>1050</td>
<td>0.527</td>
<td>3500</td>
</tr>
<tr>
<td>10 Liver</td>
<td>1030</td>
<td>0.497</td>
<td>3600</td>
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Dielectric spectra of human blood reveal a rich variety of dynamic processes. Achieving a better characterization and understanding of these processes not only is of academic interest but also of high relevance for medical applications as, e.g., the determination of absorption rates of electromagnetic radiation by the human body. The dielectric properties of human blood are studied using broadband dielectric spectroscopy, systematically investigating the dependence on temperature and hematocrit value. By covering a frequency range from 1 Hz to 40 GHz, information on all the typical dispersion regions of biological matter is obtained. We find no evidence for a low frequency relaxation (α-relaxation) caused, e.g., by counter ion diffusion effects as reported for some types of biological matter. The analysis of a strong Maxwell-Wagner relaxation arising from the polarization of the cell membranes in the 1-100 MHz region (β-relaxation) allows for the test of model predictions and the determination of various intrinsic cell properties. In the microwave region beyond 1 GHz, the reorientational motion of water molecules in the blood plasma leads to another relaxation feature (γ-relaxation). Between β- and γ-relaxation, significant dispersion is observed, which, however, can be explained by a superposition of these relaxation processes and is not due to an additional delta-relaxation often found in biological matter. Our measurements provide dielectric data on human blood of so far unsurpassed precision for a broad parameter range. All data are provided in electronic form to serve as basis for the calculation of the absorption rate of electromagnetic radiation and other medical purposes. Moreover, by investigating an exceptionally broad frequency range, valuable new information on the dynamic processes in blood is obtained.

The heat transfer analysis is considered only in the human body domain, which does not include parts of the surrounding space as well as the dielectric shield. To reduce complexity of the problem, the following assumptions have been introduced:

- There is no phase change and mass transfer in the human model.
- The human tissues are biomaterial with constant thermal properties.
- There is no chemical reaction occurring within the human model.

- The initial temperature through the human model is uniform.

While in the frequency of 915 MHz, an insignificant shielding effect of medium lossy dielectric shield is illustrated. It is found that by using low lossy dielectric shield at the frequency of 915 MHz, specific absorption rate as well as temperature increase is higher compared to values of the unshielded case. This is because the resonance phenomena between the low lossy dielectric shield and human model is displayed stronger. The multiple reflections within the gap and the human model caused the accumulation of microwave energy in the gap which leads to an increase in the specific absorption rate and temperature in human organism by which the reflection rate of microwave strongly depends on the dielectric properties of the dielectric shield. By using the high lossy dielectric shield, the shielding effect is significant. This is because of a large reduction of microwave power density within the human model due to the weakness of resonance, corresponding to the lowering penetration depth of microwave. It is confirmed that the appropriate dielectric properties of the dielectric shield greatly depend on the operating frequencies [4].

Dielectric Measurements of Standard Liquids

Dielectric theory, there are two main problems: (1) dipole moment of an ion or molecule (microscopic quantity) with a dielectric constant (macroscopic quantity) to find the relationship between, (2) theoretical calculation of polarization is to be able to specific atoms.

System that allows ions to pass through the cell membrane is important. Potassium, sodium and calcium into cells in which way elements such as the cell membrane, muscle, nerve and muscle cells, sought answers to questions on what are the effects of electrical measurements. In general, ions in the solvent to be present as particles of a hard substance called electrolyte solutions solutions. Soluble in a liquid layer will not be solved by any solid particles in solid form, is aware of the energy of the systems in solution. This energy difference determines the solvent dielectric constant and dielectric constant of solvents that are greater than the good solvent liquids. Ions are affected by solvent molecules and ions through the ion around the regular structure than a solid turn as a sheath. With the ion concentration of the solvent dielectric constant decreases in a linear fashion. Electrostatic interactions between oppositely charged ions, in mitigating the effects of ions in a solution direction.

The dielectric measurements on all standard liquids at 20 °C in the frequency range of 50 MHz to 20 GHz were carried out using coaxial probes of 2.98 mm. After initial calibration of the network analyser, five measurements were carried out on each liquid. The calibration was then renewed and another five measurements for each liquid were carried out. The practice was repeated for the third time and 15 measurements in total were obtained for each liquid at 20 °C. The reason for changing calibration between measurements was to allow for the errors arise from calibrations to be accounted in these measurements. In a real measurement session for tissues, the calibration is renewed every 2-3 hours to maintain the performance of...
network analyser. The mean for 15 measurements on each liquid is then calculated.

IV. DISCUSSION

As the dielectric properties of a dielectric shield vary, the penetration depth will be changed and the electric field passing through the dielectric shield is altered. If the penetration depth is changing, a fraction of the incident energy absorbed is also changed. The specific absorption rate and temperature distributions in the human model are governed by the electric field as well as dielectric properties of tissue.

Contact probes are open ended transmission line sections terminated by an impedance matched lossless window. Measurements are made by placing a probe in contact with a sample and measuring its admittance or reflection coefficient using a network analyser or equivalent instrumentation. Such techniques are broadband, fast, non destructive and require minimal sample handling and are therefore quite suitable for dielectric measurement. The success of the technique depends on the theoretical model relating the measured quantity to the dielectric properties of the sample, the appropriateness of the dimensions of the probe and on the calibration procedure.

The results show an interaction between physical parameters: operating frequencies and shield dielectric properties. For human exposure to microwave energy, the installed dielectric shield strongly affects the specific absorption rate and the temperature increase in the human body. Actually, the microwaves can transmit through the dielectric shield, and can penetrate into the human model that contribute to the resonance of standing wave within the gap and human model. Since the frequency increases, the penetration depth for microwave gets smaller and resonance effect becomes weakness. Consequently, the shielding effect is significant. Therefore, the appropriate dielectric properties, which can effectively reduce the specific absorption rate and the temperature increase in human body of the dielectric shield, are greatly dependent on the operating frequency. Additionally, this paper presents an interesting viewpoint on the microwave shielding properties of dielectric shields at various operating frequencies, while focusing on the human organism.

This is mainly due to the fact that biological tissues are inhomogeneous by nature and large variations are observed in the measurements of their dielectric data. These variations are reduced when large numbers of independent measurements are carried out; however, they still contribute to the majority of the total combined uncertainty. In this project, the contribution of the systematic error to the total combined uncertainty of measured dielectric data is between 0.2-2% depending on the frequency. Systematic errors are larger at both ends of the frequency spectrum due to some reduction in the sensitivity of the probe.

The specific biological responses to radiofrequency energy are generally related to the rate of energy absorbed. The rate and distribution of radiofrequency energy absorption depends strongly on the frequency, intensity and orientation of the incident fields as well as the body size and its constitutive properties (dielectric constant and conductivity). The characteristic peculiarities of the behavior of biological tissues in the ultra short wave region lie in the elementary (microscopic) division of the high frequency energy in the biological system (cell groups, blood, colloidal suspensions, etc.). The significance of this microscopic tissue structure is expressed by the marked wavelength dependence of the high frequency conductivity and dielectric constant of the tissue, which always conforms, as experimentally demonstrated with the individual physical and anatomical characteristics.

It is therefore important not to generalise on the basis of such limited data that measurement in vitro underestimates the dielectric properties of living tissues at microwave frequencies. This may well be the case at lower frequencies, in the range of the $\alpha$ and $\beta$ dispersions in view of the sensitivity of their causal mechanism on the physiological state of the tissue. Differences between in vivo and in vitro are much less likely in the frequency range of the $\gamma$ dispersion where water content is the most important determinant factor.

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Dr. Burhan Davarcioglu, Hacettepe University, Ankara-Turkey, Faculty of Engineering in 1978, enters as the Engineer graduated from the Physics. Nuclear Medicine Department in the years 1984-1985 at Hacettepe University, Radiation Physics and Radioisotope Laboratories has participated in the creation work. 1985-1993 Research Fellow in the years of working as a Gazi University, Institute of Science and Technology, Department of Physics, in 1987, “Solid-State Lasers” with his Master’s thesis, and in 1992, “Some Complex Clathrates Infra-red Spectroscopy Investigation” of the named PhD thesis completed. Faculty Member appointed as Dr. Davarcioglu, Nigde University in 1994, took active part in the founding. Faculty of Arts and Sciences Department of Physics and Institute of Science and Technology the establishment of many administrative tasks found. Turkish National Committee on Clay Science is member and New York Academy of Sciences is an active member. Papers presented at the international level to the majority and the broadcast Dr. Davarcioglu’s many references were made to run. Of interest related to the study of various summer schools participated. Since the year 2000, industrial raw materials quality and quantity of clay, by means of the spectroscopic identification of the work operates. Aksaray University, was appointed in April of 2007 to the relay.