NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

EFFECT OF THE ELECTROMAGNATIC WAVES ON SAFETY

Graduation Project
EE400

Student: ZAYED MAREI (20020831)

Supervisor: Assoc. Prof. Dr. SAMEER IKHDAIR

Nicosia – 2008

ACKNOWLEDGMENT

First of all I would like to thank **ALLAH**, who gave me power and supported me until I fulfill my study, and thanks to the projects advisor **Assoc. Prof. Dr. Sameer Ikhdair** for his help, advises and comments in preparation for this project, and also respect and thanking for **Assoc. Prof . Dr Senol Pektas** and **Assist .prof**. **Dr: Ozgur.C.Ozerdem** for them support and help.

I wish to express my deepest appreciation to my family, especially my parents firstly my mother then my father and also my brother **ahmed zidan**.dedicate this happiness to them and wish that I have made them proud of me. Without their endless support and love for me, I would never achieve my current position.

Also I would like to thank **Absallah smadi,** and **MR Ramazan Ozpolat and his family** and **Obayda al Talbeshe** and **DR Hussam el Rojoob** with their kind of help, also I will never forget my wonderful times that I spent in **Cyprus** and **Near East University** with my all good friends who helped my incorporeally during my studying here and also I would like to thank all my doctors and the stuff are working in our university

And also I would like specially to thank my best friend **rami abo ayash** and his help and supporting me**.**

So thanks after all to the N.E.U. who gave all students the opportunity to be better citizens in a better future.

Abstract

This graduation project aims to determine and evaluate the effects of electromagnetic waves on the human being life safety, both for people whom use mobile phones or non user because they will affect through the radiation of base station which found for the users.

The findings is that there many types of effects of electromagnetic waves on human being life safety, mainly in the health through infected illness like cancer, brain shocks, lose of concentration, etc…, in the social life through the lost of concentration while driving and finally on the soil.

TABLE OF CONTENTS

INTRODUCTION

In our project we investigate about the risks of electromagnetic waves on safety. We have come to know that how radiations make effect on human beings these radiations may be the causes of some serious and dangers deceases. We also discussed that the brain tumor and cancer may be the effect of electromagnetic radiations.

In Chapter one, we talk about the electromagnetic waves and spectrum, we also discussed about different kinds of electromagnetic waves, such as light waves, microwaves, radio waves etc. we defined electromagnetic field and its effects.

In Chapter two, we may go through history of radiations, effect of radiations, and protection from radiations, and we have also seen the advantages and disadvantages of X-rays, gamma rays, beta rays, alpha rays etc.

In Chapter three, we talk about the electromagnetic waves and different types of antennas. We also had seen the transmission lines and its effects.

In Chapter four, we mention risks of electromagnetic interference with medical telemetry systems operation in 460-470 MHz frequency bands and also about MRI and its principles.

In Chapter five, we will give a lot of information about electromagnetic field and public health under the discussion of mobile phone and there base stations and different deceases causes of these.

In Chapter six, we talk briefly about organizations and world health organization (WHO) and about different ENGO, ES. They are working and
Searching to find the effects of risks of electromagnetic waves on safety.

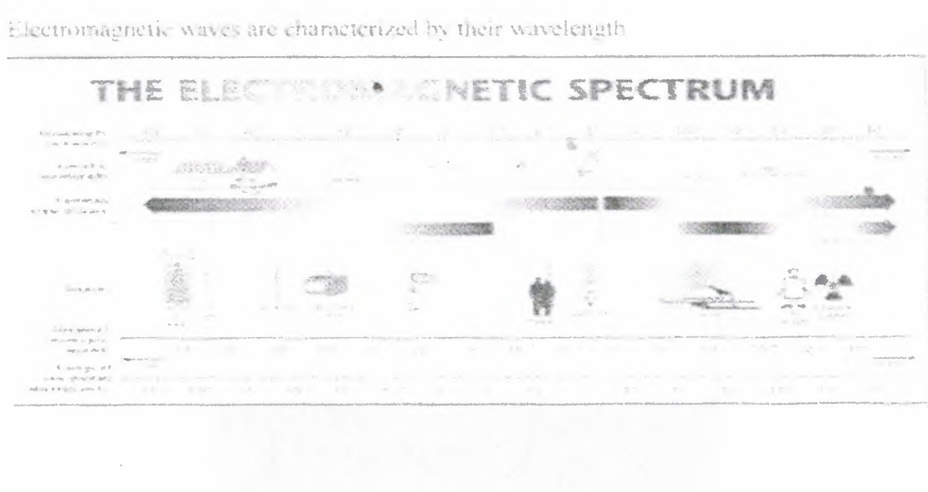
Finally in Chapter seven, we talk about the ionizations and non ionization radiation effects and the magnetic field and its relation with the current and types of Types of Radiation in the Electromagnetic Spectrum and the sources of IR and NIR.

CHAPTER ONE

What are electromagnetic waves?

Light, microwaves, x-rays, and TV and radio transmissions are all kinds of electromagnetic waves. They are all the same kind of wavy disturbance that repeats itself over a distance call the different names refer to different wave lengths, e.g. the wavelength. The wave, or "disturbance," is in an invisible thing called the electric force field.

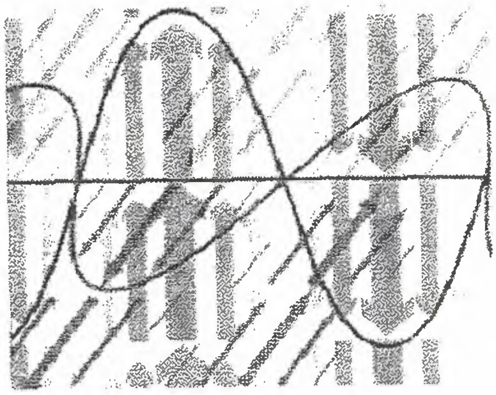
Electromagnetic waves (EMW) are formed by electric and magnetic fields, both together solutions of Maxwell's equations. The magnetic field is solenoid always, while the electric field is solenoid in charge-neutral regions only. Hence, conventionally, free-space electromagnetic fields are transverse to the direction of propagation; also, there exists a electric scalar potential but not a Magnetic companion. Contrary wise, for the same homogeneous case, we exhibit explicit examples to show that: (a) Longitudinal magnetic fields are compatible with linearly polarized non-planar EMW, and (b) Magnetic scalar potentials are compatible with EMW. The direction of propagation of non-planar EMW oscillates around the direction of propagation of the plane EMW.



figure(1.1): electromagnetic spectrum

1.1 The Electromagnetic Waves

Vibrating electric & magnetic fields regenerate each other and make up an electromagnetic wave.



Figure(1.2):magnetic wave

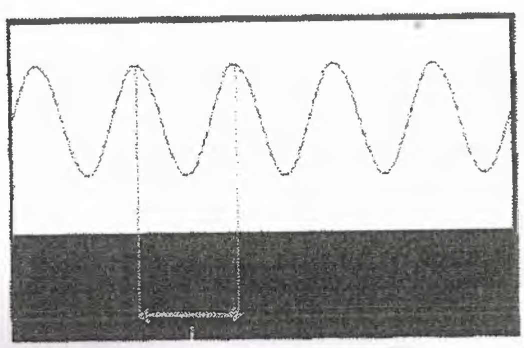
Waves: Definitions

The peak to peak distance is the wavelength, L.

The time that it takes for a wave to oscillate from peak to peak is the period, T. The number of waves that pass a point per unit time is called the frequency, v:

$v = 1/T$

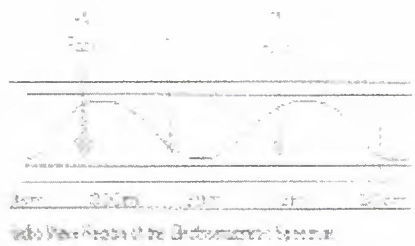
The wave's speed, u, is:



Figure(1.4): u - L/T

1.2 Radio Waves

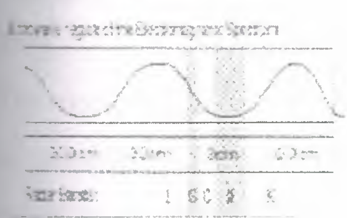
Radio waves have useful properties:



Figure(1.5): radio wave

1) Travel far through the atmosphere.
2) Easily generated by setting up currents in metal antennas.
3) They bounce off the ionosphere, and thus travel long distances around Earth.

1.3 Microwaves

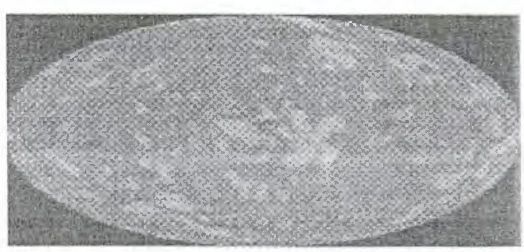


Figure(1.6): microwave

figure(1.7)

Microwave photo of the amazon

Microwaves are not obstructed by clouds, haze or any other particle smaller than the microwave wavelengths (~ 1 cm). They can be used to image Earth's surface through the clouds that cove50% the globe.



Figure(1.8) Cosmic microwave background

1.4 Electromagnetic Radiations and your Health

1.4.1 RF Radiation and Electromagnetic Field Safety (I)

Definitions

An electromagnetic field (EM) is generated when charge particles, such as electrons are accelerated. By nature these charged particles are surrounded by an electric field. Once these particles are in motion they produce a magnetic field. So, when these particles change of velocity (accelerate or slow down), an EM field is produced.

The electromagnetic spectrum is divided in frequencies. From an electrical point of view, the spectrum has been arbitrarily divided into three main bands or fields: **Extremely Low Frequency (ELF) fields** usually concern all frequencies up to 300 Hz. **Intermediate Frequency (IF) fields** concern all frequencies from 300 Hz to 10 MHz and **Radiofrequency (RF) fields** concern frequencies between 10 MHz and 300 GHz. The effects of electromagnetic fields on the human body depend not only on the concerned field intensity but on its frequency and energy as well.

The electric field (or E component of an EM field) exists whenever charge is present. Its strength is measured in **volt per meter** (V/m or dB V /m). An electric field of 1 V/m is represented by a potential difference of 1 V existing between two points that are 1 m apart. The V/m is primarily used to express the intensity of the EM field.

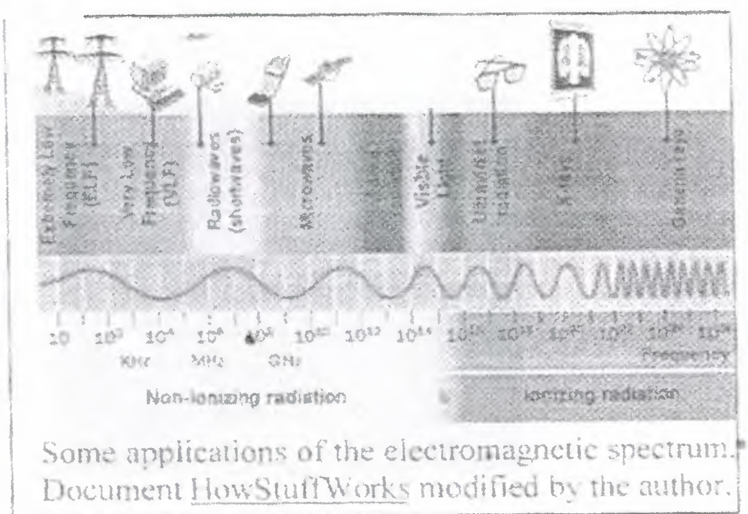
Magnetic field (or B component of an EM field) arises from current flow. Its flux density is measured in **tesla** (T) in the International System (SI), and in **gauss** (G) is the old CGS system of units (1 G=10^-^{4} T or 1 T = 10 mill gauss). A flux density of 1 G represents 1 Maxwell / cm^{2}. The tesla (or the Gauss) is mainly used to express the flux density produced by magnets commonly encountered in consumer products (monitor, microwave oven, etc). On the earth' surface, the flux density of the magnetic field is always less than 1 G.

At radio frequencies, electric and magnetic fields are closely interrelated and we measure their power densities in **watt per square meter** (W/M^2).

1.4.2 Electromagnetic Fields

Life on Earth has adapted to survive in an environment of weak, natural low frequency electromagnetic fields (in addition to the static geomagnetic field). Natural low-frequency EM fields come from two main sources: the sun, and thunderstorm activity. But since the begin of the XXth century, man-made fields of much higher intensities and distributed in a very wide spectrum have superimposed to this natural EM background in ways that are not yet fully understood. Much more research is needed to assess the biological effects of EMR.

Both RF and 50 or 60-Hz fields are classified as **non-ionizing radiation** because the frequency is too low for there to be enough photon energy to ionize atoms. Still, at sufficiently high power densities, EMR poses certain health hazards. It has been known since the early days of radio that RF energy can cause injuries by heating body tissue. In extreme cases, RF-induced heating can cause blindness, sterility and other serious health problems. These heat-related health hazards are called (**thermal effects).** In addition, there is evidence that magnetic fields may produce **biologic effects** at energy levels too low to cause body heating. The proposition that these a thermal effects may produce harmful health consequences has produced a great deal of research.



Some applications of the electromagnetic spectrum. Document HowStuffWorks modified by the author.

Figure (1.9): electromagnetic fields and its spectrum

In addition to the ongoing research, much else has been done to address this issue. For example, the American National Standards Institute, among others, has recommended voluntary guidelines to limit human exposure to RF energy. And the ARRL has established the RF Safety Committee, a committee of concerned medical doctors and scientists, serving voluntarily to monitor scientific research in the fields and to recommend safe practices for radio amateurs.

1.4.3 Thermal Effects of RF Energy

Body tissues that are subjected to very high levels of RF energy may suffer serious heat damage. These effects depend upon the frequency of the energy, the power density of the RF field that strikes the body, and even on factors such as the polarization of the wave.

At frequencies near the body's natural resonant frequency, RF energy is absorbed more efficiently, and maximum heating occurs. In adults, this frequency usually is about 35 MHz if the person is grounded and about 70 MHz if the person's body is insulated from the ground. Also, body parts may be resonant; the adult head, for example is resonant around 400 MHz, while a baby's smaller head resonates near 700 MHz.

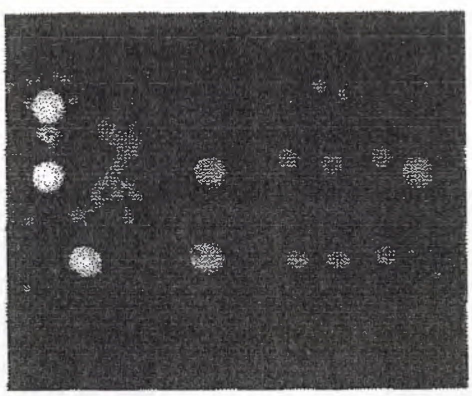


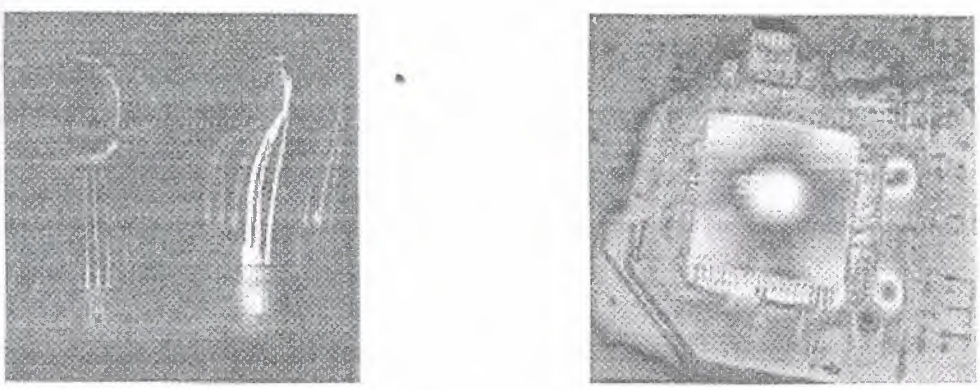
figure (1.10) Thermal image of aluminum Housing to shield a RF module document commix

Body size thus determines the frequency at which most RF energy is absorbed. As the frequency is increased above resonance, less RF heating general occurs. However additional longitudinal resonances occur at about 1 GHz near the body surface.

Nevertheless, thermal effects of RF energy should not be a major concern for most radio amateurs because of the relatively low RF power we normally use and intermittent nature of most amateur transmissions. Amateurs spend more time listening than transmitting, and many amateur transmissions such as CW and SSB use low-duty-cycle modes (with FM or RTTY, though, the RF carrier is present continuously at its maximum level during each transmission). In any event, it is rare for radio amateurs to be subject to RF fields strong enough to produce thermal effects unless they are fairly close to an energized antenna or unshielded power amplifier. Specific suggestions for avoiding excessive exposure are offered later.

1.4.4 Temperature of Semiconductors: never too hot

In a pure technical point of view, remember that the temperature of a CPU and any other electronic semiconductor components is a critical factor that affects the good functioning of your equipment, hence the use of a fan on both the CPU and on the cabinet of your transceiver, amplifier or the one of your computer, to extract the excess of heat. These are not simple accessories; they are mandatory and must remain operational if you want that your system works in good conditions.



Figure(1.11): types of simiconductors

Thermal radiation from electronic components. In domestic devices like a radio or a computer there is no risk for the health but avoid to touch them as temperature can exceed 80°C (e.g. on a fast CPU) ! Remember that a 10°C increase in junction temperature reduces by half the lifespan of a semiconductor. Documents Thermal Imaging Survey and Sierra Pacific Corp
We usually say that every 10°C rise injunction temperature will cut the mean time between failures (MTBF) of a semiconductor in half. So, as we all expect a very long life for our ham equipment, better to use oversized and powerful fans, and why not adding an extra fan on the cabinet if you noticed that your system is rather hot after have used it heavily.

1.4.5 A Thermal Effects of EMR

No thermal effects of EMR may be of greater concern to most amateurs because they involve lower level energy fields. Research about possible health effects resulting from exposure to the lower level energy fields, the thermal effects, has been of two basic types: epidemiological research and laboratory research.

Scientists conduct laboratory research into biological mechanisms by which EMR may affect animals including humans. Epidemiologists look at the health patterns of large groups of people using statistical methods. These epidemiological studies have been inconclusive. By their basic design, these studies do not demonstrate cause and effect, nor do they postulate mechanisms of disease. Instead, epidemiologists look for associations between an environmental factor and an observed pattern of illness. For example, in the earliest research on malaria, epidemiologists observed the association between populations with high prevalence of the disease and the proximity of mosquito infested swamplands. It was left to the biological and medical scientists to isolate the organism causing malaria in the blood of those with the disease and identify the same organisms in the mosquito population.

In the case of a thermal effects, some studies have identified a weak association between exposure to EMR at home or at work and various malignant conditions including leukemia and brain cancer. However, a larger number of equally well designed and performed studies have found no association. A risk ratio of between 1.5 and 2.0 has been observed in positive studies (the number of observed cases of malignancy being 1.5 to 2.0 times the "expected" number in the population).

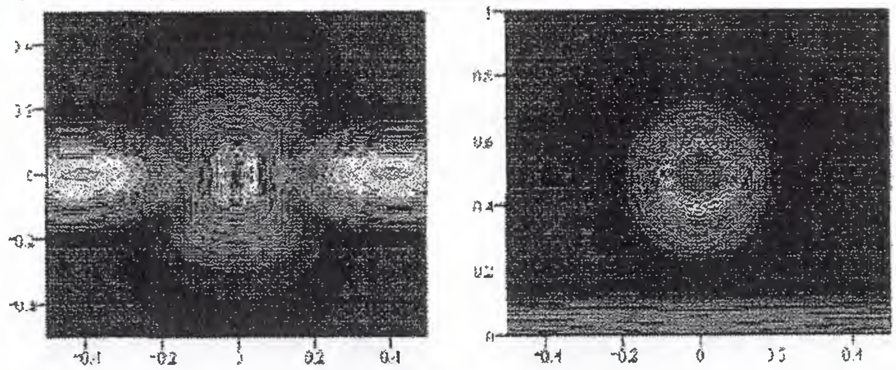
Epidemiologists generally regard a risk ratio of 4.0 or greater to be indicative of a strong association between the cause and effect under study. For example, men who smoke one pack of cigarettes per day increase their risk for lung cancer tenfold compared to nonsmokers, and two packs per day increase the risk to more than 25 times the Nonsmokers' risk.However, epidemiological research by itself is rarely conclusive.

Epidemiology only identifies health patterns in groups - it does not ordinarily determine their cause. And there are often confounding factors: Most of us are exposed to many different environmental hazards that may affect our health in various ways. Moreover, not all studies of persons likely to be exposed to high levels of EMR have yielded the same results.

There has also been considerable laboratory research about the biological effects of EMR in recent years. For example, it has been shown that even fairly low levels of EMR can alter the human body's circadian rhythms, affect the manner in which cancer-fighting T lymphocytes function in the immune system, and alter the nature of the electrical and chemical signals communicated through the cell membrane and between cells, among other things.

Much of this research has focused on low-frequency magnetic fields, or on RF fields that are keyed, pulsed or modulated at a low audio frequency (often below 100 Hz). Several studies suggested that humans and animals can adapt to the presence of a steady RF carrier more readily than to an intermittent, keyed or modulated energy source. There is some evidence that while EMR may not directly cause cancer, it may sometimes combine with chemical agents to promote its growth or inhibit the work of the body's immune system.

None of the research to date conclusively proves that low-level EMR causes adverse health effects. Given the fact that there is a great deal of research ongoing to examine the health consequences of exposure to EMF, the American Physical Society (a national group of highly respected scientists) issued a statement in May 1995 based on its review of available data pertaining to the possible connections of cancer to 60-Hz EMF exposure. This report is exhaustive and should be reviewed by anyone with a serious interest in the field. Their conclusions have not changed with years.



Electromagnetic field of a dipole tight 1/2 high. At left a side view, at right from the end. Plots calculated with MathCAD by KB7QHC.

Figure(1.12): dipole field

Among its general conclusions were the following:

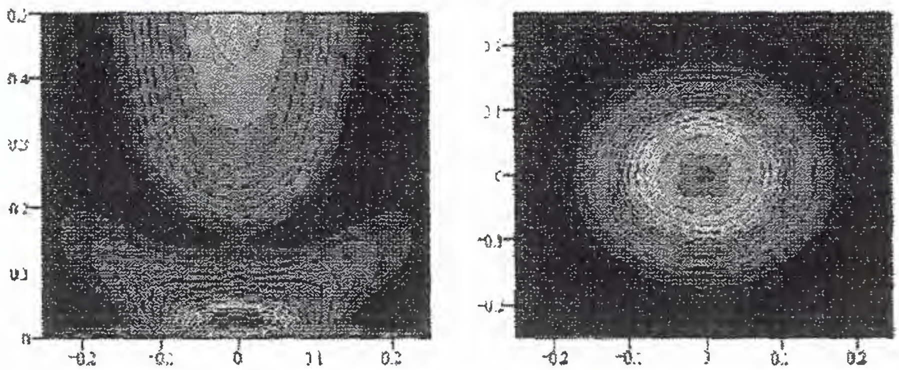
1. The scientific literature and the reports of reviews by other panels show no consistent, significant link between cancer and power line fields.
2. No plausible biophysical mechanisms for the systematic initiation or promotion of cancer by these extremely weak 60-Hz fields have been identified.
3. While it is impossible to prove that no deleterious health effects occur from exposure to any environmental factor, it is necessary to demonstrate a consistent, significant, and causal relationship before one can conclude that such effects do occur.

The APS study is limited to exposure to 60-Hz EMF. Amateurs will also be interested in exposure to EMF in the RF range.

A 1995 publication entitled *Radio Frequency and ELF Electromagnetic Energies, a Handbook for Health Professionals* includes a chapter called "Biologic Effects of RF Fields." In it the author's state: "In conclusion, the data do not support the finding that exposure to RF fields is a causal agent for any type of cancer" (page 176). Later in the same chapter they write: "Although the data base has grown substantially over the past decades, much of the information concerning no thermal effects is generally inconclusive, incomplete, and sometimes contradictory. Studies of human populations have not demonstrated any reliably effected end point" (Page 186).

Readers may want to follow this topic as further studies are reported. Amateurs should be aware that exposure to RF and ELF (50/60 Hz) electromagnetic fields at all power levels and frequencies may not be completely safe. Prudent avoidance of any avoidable EMR is always a good idea.

However, an Amateur Radio operator should not be fearful of using his or her equipment. If any risk does exist, it will almost surely fall well down on the list of causes that may be harmful to your health (on the other end of the list from your automobile).



Figure(1.13)

Electromagnetic field of a 1/4 vertical. At left a side view, at right from top. Plots calculated with MathCAD by **KB7QHC**.

1.4.6 Safe Exposure Levels

Under what energy level an EM is safe? Scientists have devoted a great deal of effort to deciding upon safe RF-exposure limits. This is a very complex problem, involving difficult public health and economic considerations. The recommended safe levels have been revised downward several times in recent years—and not all scientific bodies agree on this question even today.

The main bodies involved in these measurements are next:

- ANSI, American National Standards Institute
- IEEE, Institute of Electrical and Electronics Engineers
- ICNIRP International Commission on Non-Ionizing Radiation Protection
- NCRP, National Council on Radiation Protection and Measurements.

Among the supranational institutions having a consultative or legal function, name:

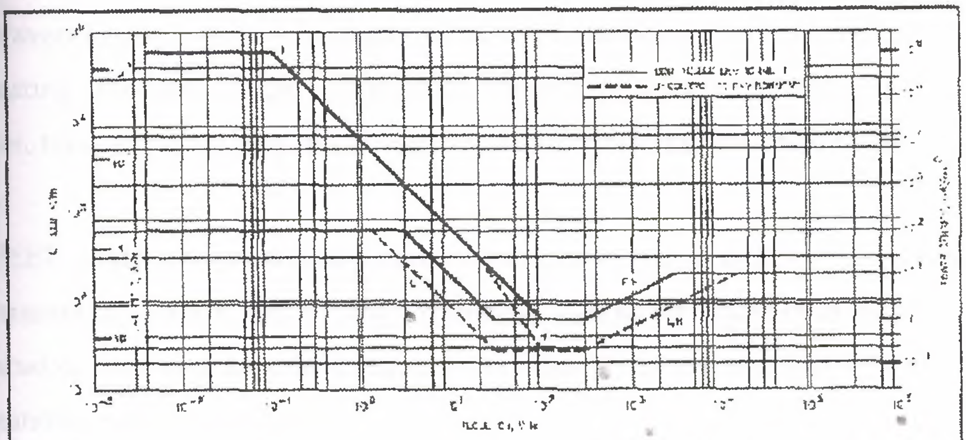
- WHO, World Health Organization

- Underwriters Laboratory that tests and certify devices

- European Parliament and European Commission that edict general rules and impose their application in Europe.

A new IEEE guideline for recommended EM exposure limits went into effect in 1991 (see IEEE C95.3-2002). It replaced a 1982 ANSI guideline that permitted somewhat higher exposure levels.

ANSI-recommended exposure limits before 1982 were higher still. This new IEEE guideline recommends frequency-dependent and time-dependent maximum permissible exposure levels. Unlike earlier versions of the standard, the 1991 standard recommends different RF exposure limits in controlled environments (that is, where energy levels can be accurately determined and everyone on the premises is aware of the presence of EM fields) and in uncontrolled environments (where energy levels are not known or where some persons present may not be aware of the EM fields). The next graph depicts the new IEEE standard. It is necessarily a complex graph because the standards differ not only for controlled and uncontrolled environments but also for electric and magnetic fields.



This graph is extracted from 2002 (data 1991) RF guide titled "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.", ref. IEEE Standard C95.3-2002.

figure(1.14)

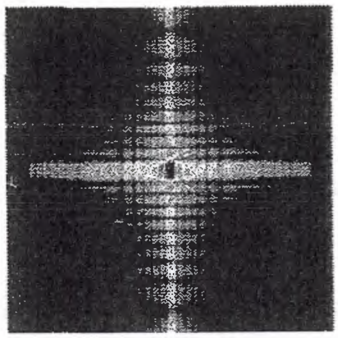
Basically, the lowest E-field exposure limits occur at frequencies between 30 and 300 MHz. The lowest H-field exposure levels occur at 100-300 MHz. The ANSI standard sets the maximum E-field limits between 30 and 300 MHz at a power density of 1 mW/cm^2 (61.4 V/m) in controlled environments but at one-fifth that level (0.2 mW/cm^2 or 27.5 V/m) in uncontrolled environments. The H-field limit drops to 1 mW/cm^2 (0.163 A/m) at 100-300 MHz in controlled environments and 0.2 mW/cm^2(0.0728 A/m) in uncontrolled environments. Higher power densities are permitted at frequencies below 30 MHz (below 100 MHz for H fields) and above 300 MHz, based on the concept that the body will not be resonant at those frequencies and will therefore absorb less energy.

In general, the IEEE guideline requires averaging the power level over time periods ranging from 6 to 30 minutes for power-density calculations, depending on the frequency and other variables. The ANSI exposure limits for uncontrolled environments are lower than those for controlled environments, but to compensate for that the guideline allows exposure levels in those environments to be averaged over much longer time periods (generally 30 minutes). This long averaging time means that an intermittently operating RF source (such as an Amateur Radio transmitter) will show a much lower power density than a continuous-duty station for a given power level and antenna configuration.

Time averaging is based on the concept that the human body can withstand a greater rate of body heating (and thus, a higher level of RF energy) for a short time than for a longer period. However, time averaging may not be appropriate in considerations of no thermal effects of RF energy.

The IEEE guideline excludes any transmitter with an output below 7W because such low-power transmitters would not be able to produce significant whole-body heating. (However, recent studies show that hand-held transceivers often produce power densities in excess of the IEEE standard within the head.)

There is disagreement within the scientific community about these RF exposure guidelines. The IEEE guideline is still intended primarily to deal with thermal effects, not exposure to energy at lower levels. A small but significant number of researchers now believe thermal effects should also be taken into consideration. Several European countries and localities in the United States have adopted stricter standards than the recently updated



Figure(1.15)

1.4.7 IEEE Standard.

Another US body is the NCRP that has also adopted recommended exposure guidelines. NCRP urges a limit of 0.2 mW/cm^2 for no occupational exposure in the 30-300 MHz range. The NCRP guideline differs from IEEE in two notable ways: it takes into account the effects of modulation on an RF carrier, and it does not exempt transmitters with outputs below[7] 7 watts. Predicted radiation directivity pattern (RDP) of an S-band antenna array (3.4 GHz). This chart represents the front hemisphere RDP for the entire feed + dish system. Document Lambda Science. Itc.

1.4.8 Cardiac Pacemakers and RF Safety

It is a widely held belief that cardiac pacemakers may be adversely affected in their function by exposure to electromagnetic fields. Amateurs with pacemakers may ask whether their operating might endanger themselves or visitors to their shacks who have a pacemaker. Because of this and similar concerns regarding other sources of electromagnetic fields, pacemaker manufacturers apply design methods that for the most part shield the pacemaker circuitry from even relatively high EM field strengths.

It is recommended that any amateur who has a pacemaker or is being considered for one discuss this matter with his or her physician. The physician will probably put the amateur into contact with the technical representative of the pacemaker manufacturer. These representatives are generally excellent resources and may have data from laboratory or "in the field" studies with pacemaker units of the type the amateur needs to know about.

One study examined the function of a modern (dual chamber) pacemaker in and around an Amateur Radio station. The pacemaker generator has circuits that receive and process electrical signals produced by the heart and also generate electrical signals that stimulate (pace) the heart as briefly described at left.

In one series of experiments the pacemaker was connected to a heart simulator. The system was placed on top of the cabinet of a 1-kW HF linear amplifier during SSB and CW operation. In addition, the system was placed in close proximity to several 1 to 5-W 2-meter hand-held transceivers. The test pacemaker connected to the heart simulator was also placed on the ground 9 meters below and 5 meters in front of a three-element Yagi HF antenna.

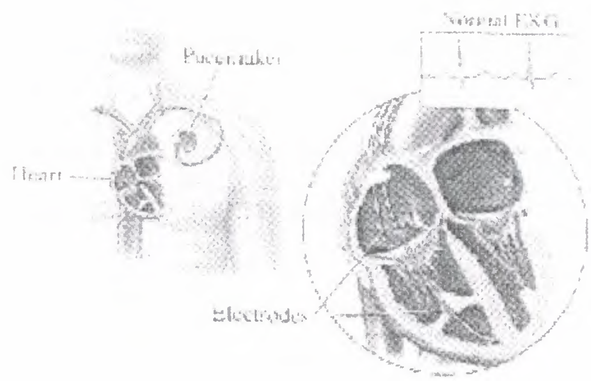


Figure (1.16): effect on humen heart

No interference with pacemaker function was observed in this experimental system. Although the possibility of interference cannot be entirely ruled out by these few observations, these tests represent more severe exposure to EM fields than would ordinarily be encountered by an amateur with an average amount of common sense. Of course prudence dictates that amateurs with pacemakers using hand-held VHF transceivers keep the antenna as far from the site of the implanted pacemaker generator as possible and use the lowest transmitter output required for adequate communication.

For high power HF transmission, the antenna should be as far from the operating position as possible and all equipment should be properly grounded.

CHAPTER TWO

Radiations and Risks of Health

2.1 Introduction

Radiation is an extraordinarily versatile and useful tool in medicine, industry, and research. It helps saves lives and provides great benefits to mankind in innumerable ways. Radiation is no different than other tools. If used improperly it can be hazardous to health or cause injury. But if proper precautions are followed radiation can be used safely to achieve superior results. We will briefly introduce some basic radiation safety concepts and principles as they apply to the use of portable nuclear gauges. While the human body can sense and take actions to prevent injury by many physical agents, such as heat and noise, it cannot sense radiation. Therefore, it is important to understand the nature of radiation, its sources, and how to protect yourself and others.

2.1.1 A Brief History

In 1895, a German physicist named Wilhelm Roentgen fortuitously discovered X-rays while experimenting with evacuated glass tubes through which an electric current was passed. Roentgen discovered he could take a picture of the bones in his hand with the mysterious new rays. Henri Becquerel of France discovered natural radioactivity a year later. In 1898, Pierre and Marie Curie isolated the first radioactive elements, radium-226 and polonium-210. The momentous discoveries of these physicists led to a rapid advancement of scientific knowledge about radiation and radioactivity, as well as to many practical uses.

2.2 Types of Radiation

For purposes of radiation safety only radiation with the capability to cause ionization is of concern. Ionization occurs when electrons are dislodged from a neutral atom. When this happens an atom becomes positively charged and some energy is transferred.

Ionization is the process by which radiation affects the human body and by which it can be detected as well. There are four basic types of ionizing radiation: alpha, beta, gamma and neutron. The main properties of each type of radiation are briefly discussed below. Alpha particles consist of two protons and two neutrons and carry a positive charge. They are emitted with high energy from the nucleus of heavy elements during radioactive decay, but lose energy rapidly in passing through material.

A couple sheets of paper are sufficient to stop most alpha particles. Since they cannot penetrate even the outer dead layer of our skin, they are not an external hazard. Beta particles are electrons emitted from nucleus of atoms at nearly the speed of light. They have a very small mass compared to protons or neutrons and carry a negative charge. Very energetic beta particles can penetrate 1/2 inch of wood. Gamma rays are electromagnetic energy waves emitted from the nucleus of atoms and have no charge. X-rays are the same as gamma rays, except they originate outside the nucleus from processes involving electrons. Other familiar types of electromagnetic wave radiation include: visible light, ultraviolet light infrared light, microwaves, and radio waves. These differ from X-rays and gamma rays only in wave frequency and energy.

Gamma rays are much more penetrating than alpha or beta particles. Neutrons are elementary particles which are emitted during certain types of nuclear reactions. Neutrons have no charge and are also highly penetrating.

2.2.1 Units of Measure for Radiation

The primary quantity of interest in radiation protection is dose equivalent. It so happens that some types of radiation produce greater effects on the body than others for the same amount of energy absorbed (absorbed dose). To account for this, a Quality Factor (QF) is assigned to each type of radiation to express its relative effectiveness in producing damage. Dose equivalent is the product of the absorbed dose and the QF for that type of radiation. It expresses the risk of harm resulting from exposure to different types of radiation on a common scale. The basic unit of dose equivalent is the rem. Because a rem is relatively large amount, the milligram (1/1000 of a ram) is often used instead.

2.2.2 Natural Sources of Radiation

Radiation is emitted by radioactive elements naturally present in the soil, water, and air. The major sources include potassium-40, uranium-238, and thorium-232. By virtue of their presence in the environment, radio nuclides are found all the way up the food chain to humans. The human body contains a number of radioactive elements, including potassium-40, radium-226, and carbon-14.

Building materials, like granite, contain radioactive thorium-232. Even the air we breathe contains small concentrations of the radioactive gas, radon-222, which seeps from the Earth's crust. Cosmic rays from outer space are another significant natural source of radiation. The atmosphere screens out most of the cosmic rays, but some still penetrate to ground level. The dose from cosmic rays increases with altitude. For example, people living in mile-high Denver receive about twice as much dose from cosmic rays as people living at sea level. The interaction of cosmic rays with nitrogen in the atmosphere also produces radioactive carbon-14 and tritium (H-3).

2.3 Man Made Sources of Radiation

Manmade radiation is produced directly through the operation of devices like X-ray machines, particle accelerators, and nuclear re actors. Accelerators and nuclear reactors may also produce manmade radioactive elements that emit radiation. Many manmade nuclides are used in medicine, industry, and research. For example, moisture-density gauges use the manmade sources: cesium-137 (gamma source), Cf-252 (neutron source), and americium-241: beryllium (neutron source).

2.4 Uses of Radiation and Radioactive Materials

Radiation and radioactive materials have many uses in medicine, industry, education, agriculture, consumer products, scientific research, and many other fields. Here is a partial list of current uses:

medical imaging for disease diagnosis	disease treatment
lightning rods	material composition determination
flow detection	smoke detection
medical instrument and food sterilization	well logginig
radiocarbon dating	radiotracer studies
Anti-static devices	gemstone coloration
vulcanization, cross-linking	deep space power source
weapon detection, baggage scanning	reactor fuel
bomb detection	emergency exit signs
airport runway lights	spark gap tubes or glow lamps
spark gap irradiators	timepiece, instrument, and gunfight lighting
physical property measurement (thickness, moisture, density)	

Table(1.1): partial list of current uses

2.5 How Radiation Affects People

Radiation causes ionization in the molecules of living cells. The ions react with other atoms in the cell causing damage that interferes with vital cell processes and with cell reproduction. At low doses, such as we receive from natural background radiation, the cell may be able to repair the damage with no adverse effect. At higher doses, the cells might not be able to repair the damage and the cells die or may reproduce abnormal cell that become cancerous. The primary risk from occupational exposure to radiation is a slightly increased risk of developing cancer. Several factors influence how much *effect* a given radiation dose will have on living cells.

•All cells are not equally sensitive to radiation. Cells that divide rapidly, like blood cells and the lining of the Gl tract, are more susceptible to damage than cells that divide slowly, like nerve and brain cells.

•Dose to the whole body dose carries greater risk than dose to a portion of the body.

•A given dose received over long time period (years) is less likely to cause an effect than the same dose received over a short time period (hours).

Radiation Dose Limits

The federal government has set standards for how much radiation can be received safely. The limit for whole body radiation for persons working in occupations that involve radiation exposure is 5000 milligram per year. To put this value in perspective, the average American receives about 360 memos a year from natural background radiation.

2.6 Protection from Radiation Sources

The radioactive material in portable gauges is in the form of sealed sources; therefore, there is negligible chance of internal exposure or contamination from working with a nuclear gauge. The primary concern is external exposure. The fundamental principle in radiation protection is that all radiation exposures should be maintained as low as reasonably achievable. This is referred to as the ALARA principle. The three key factors which influence an individual's radiation dose from a given source are time, distance and shielding. Control of these factors, therefore, is the key to keeping radiation dose ALARA.

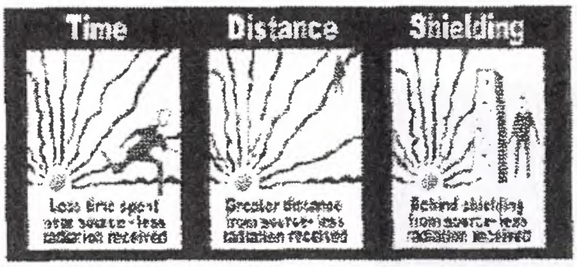


Figure (2.1): sorces effects on individual radiation

Time:

The most direct way to reduce radiation dose is to reduce the time spent working with or in the vicinity of radiation sources. If the exposure time is cut in half, the dose will be reduced by the same fraction.

Distance:

Distance is one of the most effective means to reduce dose thanks to basic principles of geometry. When the working distance from a point radiation source is increased by a factor of two, the dose received from that source will be reduced by a factor of four. This is referred to as the inverse square law, i.e., the radiation intensity from a point source decreases with the square of the distance from the source.

Shielding:

Shielding is any material used to reduce the intensity of radiation by absorbing or attenuating the radiation coming from the source. Nuclear gauges have a significant amount of shielding already built in to protect the operator.

2.7 Infrared Radiation

Wavelength: 1 urn -1000 um

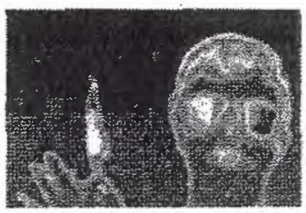


figure (2.2): IR photo of man

We emit IR In fact all the objects around us emit IR Radiation. Hotter objects emit more IR radiation, which we are warmed by, and which we sense with our skin.

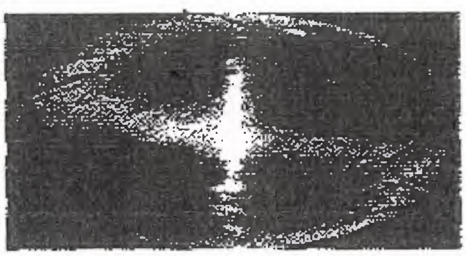


Figure (2.3): IR photo of the dust in the Solar system

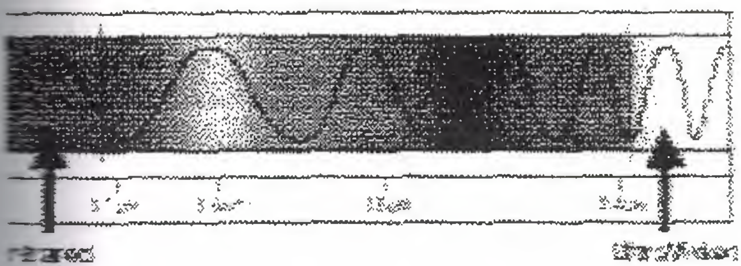


Figure (2.4): IR wave shape

Visible Light

We see the very part of the Electromagnetic that the Sun emits. That is we have detectors that are sensitive the radiation that illuminates our world.

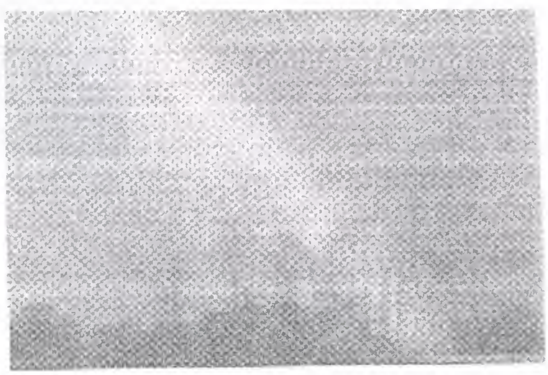


Figure (2.5) White light is made up of light from all different colors

Ultraviolet Light

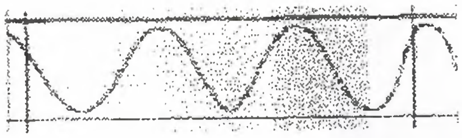


Figure (2.6): Ultra violet region of the electromagnetic spectrum

Some birds & bees can see UV as well as visible light.

Ultraviolet light has just the right energy to break molecular bonds apart. For this reason it is detrimental to life. The Earth has a natural shield to Solar UV light in the form of an ozone layer (80 km above the surface).

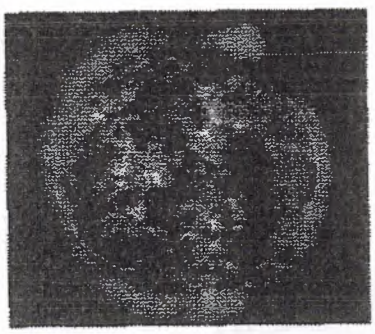
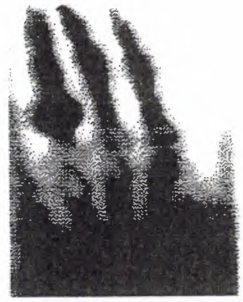


Figure (2.7)10% of sun light is in the UV

2.8 Types of Rays

2.8.1 X-rays

X-rays were discovered 1895 by Wilhelm Conrad Roentgen (a German scientist) by accident. A week later he took this x-ray of his wife.



Figure(2.8): x ray photo

2.8.2 Gamma Rays

Wavelength: 10-12-10-13m Gamma Rays are the most energetic of all electromagnetic waves. These EM waves are therefore emitted in the hottest events. Shown in figure (2.9)

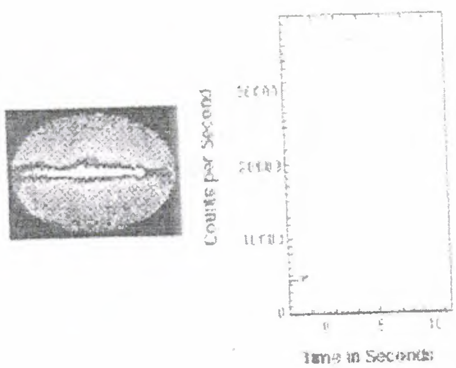


Figure (2.9) gamma rays

2.8.3 Gamma Ray Bursts

Can release more energy in 10 seconds, then released by the Sun in 10 billion yrs. Their source is unknown.

2.9 Light: both waves and particles

Light acts like a bunch of particles; It is absorbed by molecules as discrete particle packages. Light acts like waves: e.g. it can be refracted and can combine (or superpose).

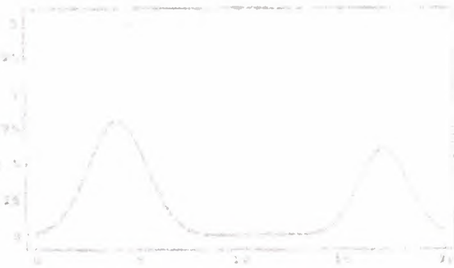


Figure (2.10): light wave shape.

Velocity of light

Light travels at a velocity c~2.99xl08m/s in a vacuum.

Is this a little odd?

Yes: imagine standing on the top of a train moving at a velocity v and shining a flashlight towards someone in front of the train on the ground. The velocity of light leaving the train is c. The velocity of the light received by the person on the ground is c too, not c+v!

Summary

•Changing electric fields produce changing magnetic fields, which produce changing electric fields, which propagate as waves.
•These waves are called EM waves.
•EM waves behave as particles & as waves
•They are characterized by their wavelength.
•The energy of High particles depends on the frequency (E = hv), or
Equivalently, their wavelength (E^hc/1)
•Light travels at 2.99x108m/s in a vacuum.

CHAPTER THREE

Electromagnetic Waves and Antennas

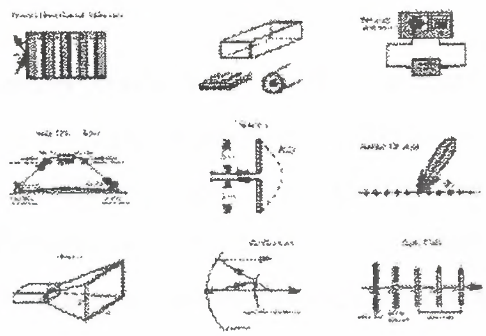


Figure (3.1) types of communications and antenna

Communications antenna radar and microwave engineers must deal with the generation transmission propagation and reception of electromagnetic waves. Computer and solid-state device engineers working on ever smaller integrated circuits and at ever higher frequencies must take into account wave propagation effects at the chip and circuit-board levels. Communication and computer network engineers routinely use wave guiding systems, such as transmission lines and optical fibers. Novel recent developments in materials, such as photonic band gap structures, omni directional dielectric mirrors, and birefringent multilayer films, promise a revolution in the control and manipulation of light. These are just some examples of topics discussed in this book.

The text is organized around three main topic areas:

- The propagation, reflection, and transmission of plane waves, and the analysis and design of multilayer films.
- Waveguides, transmission lines, impedance matching, and S-parameters.
- Linear and aperture antennas, scalar and vector diffraction theory, antenna array design, and coupled antennas.

The text emphasizes connections to other subjects. For example, the mathematical techniques for analyzing wave propagation in multilayer structures, multisegment transmission lines, and the design of multilayer optical filters are the same as those used in DSP, such as the lattice structures of linear prediction, the analysis and synthesis of speech, and geophysical signal processing. Similarly, antenna array design is related to the problem of spectral analysis of sinusoids and to digital filter design, and Butler beams are equivalent to the FFT.

Maxwell's Equations

Review of Maxwell's equations, Lorenz force, constitutive relations, boundary conditions, charge and energy conservation, Painting's theorem, simple models of dielectrics, conductors, and plasmas, relaxation time in conductors.

1 Uniform Plane Waves

Uniform plane waves in lossless media, monochromatic waves, wave impedance, polarization, waves in lossy media, waves in weakly lossy dielectrics, propagation in good conductors, propagation in oblique directions, complex waves, Doppler effect.

2 Propagation in Birefringent Media

Linear and circular birefringence, uniaxial and biaxial media, chiral media, natural vs. Faraday rotation, gyro tropic media, linear and circular dichroism, oblique propagation in birefringent media.

3 Reflections and Transmission

Reflection and transmission at normal incidence, propagation and matching matrices, reflected and transmitted power, single and double dielectric slabs, reflection less slab, time-domain reflection response, lattice diagrams, reflection by a moving boundary, such as a moving mirror.

4 Multilayer Structures

Multiple dielectric slabs at normal incidence, antireflection coatings, dielectric mirrors, propagation band gaps, narrow-band transmission filters, quarter-wave phase-shifted Fabry-Perot resonators, fiber Bragg gratings, equal travel-time multilayer structures, applications of layered structures, Chebyshev design of reflection less multilayer.

5 Oblique Incidence

Oblique incidence and SnelFs laws, transverse impedance, propagation and matching of transverse fields, Fresnel reflection coefficients, total internal reflection, Brewster angle, complex waves, oblique reflection by a moving interface, geometrical optics, Fermat's principle of least time, ray tracing techniques in geometrical optics illustrated by several exactly solvable examples drawn from several applications, such as atmospheric refraction, mirages, ionosphere refraction, propagation in a standard atmosphere and the effect of Earth's curvature, and propagation in graded-index optical fibers.

6 Multilayer Film Applications

Multilayer dielectric structures at oblique incidence, antireflection coatings at oblique incidence, omni directional dielectric mirrors, polarizing beam splitters, reflection and refraction in birefringent media, Brewster and critical angles in birefringent media, multilayer birefringent structures, giant birefringent optics.

3.1 Waveguides

Longitudinal-transverse decompositions of Maxwell's equations, power transfer and attenuation in guiding systems, "IBM, TE, TM modes, rectangular waveguides, higher TE and TM modes, operating bandwidth, power transfer, energy density, and group velocity in waveguides, power attenuation, reflection model of waveguide propagation, dielectric slab guides.

3.2Transmission Lines

General properties of JEM transmission lines, parallel-plate, micro strip, coaxial, and two-wire lines, distributed circuit model of a transmission line, wave impedance and reflection response, two-port equivalent circuits, terminated lines, power transfer from generator to load, open- and short-circuited lines, Thevenin and Norton equivalent circuits, standing wave ratio, determination of unknown load impedance. Smith chart. Transient Response.

- **Coupled Lines**

Coupled transmission lines, even-odd mode decomposition for identical matched or unmatched lines, crosstalk between lines, weakly coupled lines with arbitrary terminations, coupled-mode theory, co-directional couplers, fiber Bragg gratings as examples of contra-directional couplers, quarter-wave phase-shifted fiber Bragg gratings as narrow-band transmission filters, and the Schuster-Kubelka-Munk theory of diffuse reflection and transmission as an example of contra-directional coupling.

- **Impedance Matching**

Conjugate and reflection less matching, multisection transmission lines, quarter-wavelength impedance transformers, two-section dual-band Chebyshev transformers, quarter-wavelength transformers with series sections and shunt stubs, two-section series impedance transformers, single-stub matching, balanced stubs, double- and triple-stub matching, L-, T-, and Π-section lumped reactive matching networks and their Q-factors.

- **S-Para meters**

Scattering parameters, power flow, parameter conversions, input and output reflection coefficients, stability circles, transducer, operating, and available power gains, generalized S-parameters and power waves, simultaneous conjugate matching, power gain circles, unilateral gain circles, operating and available power gain circles, noise figure circles, design examples of low-noise high-gain microwave amplifiers and their micro strip matching circuits.

- **Radiation Fields**

Currents and charges as sources of fields, retarded potentials, fields of a linear wire antenna, near and far fields of electric and magnetic dipoles, Ewaid-Oseen extinction theorem of molecular optics, radiation fields, radiation Held approximation, computing the radiation fields, radiation vector.

3.3 Transmitting and Receiving Antennas

Energy flux and radiation intensity from a radiating system, directivity, gain, and beamwidth of an antenna, effective area, gain-beamwidth product, antenna equivalent circuits, effective length and polarization and load mismatches, communicating antennas, Fries formula, antenna noise temperature, system noise temperature, limits on bit rates, satellite links, radar equation.

- **Linear and Loop Antennas**

Linear antennas, Hertzian dipole, standing-wave antennas, half-wave dipole, monopole antennas, traveling wave antennas, veer and rhombic antennas, loop antennas, circular and square loops, dipole and quadruple radiation.

- **Radiation from Apertures**

Field equivalence principle, magnetic currents and duality, radiation fields from magnetic currents, radiation fields from apertures, Kottler's formula, Huygens sources, directivity and effective area of apertures, uniform, rectangular, and circular apertures and their gain-beamwidth products, Rayleigh diffraction limit, vector diffraction theory, Stratton-Chu, Kottler, Franz, and Kerchief diffraction integral formulas, extinction theorem, vector diffraction from apertures, Fresnel diffraction, Knife-edge diffraction, geometrical theory *of* diffraction and Sommerfeld's solution for a conducting half-plane.

- **Aperture Antennas**

Open-ended waveguides, horn antennas, horn radiation fields, horn directivity, optimum horn design, micro strip antennas, parabolic reflector antennas, gain and beam width of reflector antennas, aperture-field and current-distribution methods, radiation patterns of reflector antennas, dual-reflector antennas, lens antennas.

3.4 Antenna Arrays

Antenna arrays and translational phase shift, array pattern multiplication, one-dimensional arrays, visible region, grating lobes, uniform arrays, array directivity, steering, and beamwidth.

- **Array Design Methods**

Schelkunoffs zero-placement method, Fourier series design method with windowing, sector beam array design, Woodward-Lawson frequency-sampling design, narrow-beam low-side lobe designs, binomial arrays, Dolph-Chebyshev arrays, Taylor-Kaiser arrays, multi-beam arrays, emphasis on the connections to DSP methods of digital filter design and spectral analysis of sinusoids.

- **Currents on Linear Antennas**

Hallen and Pocklington integral equations, delta-gap and plane-wave sources, solving Hallen[1] s equation, sinusoidal current approximation, reflecting and center-loaded receiving antennas, King's three-term approximation, numerical solution of Hallen's equation, numerical solutions using pulse functions and for arbitrary incident field, numerical solution of Pilkington's equation.

- **Coupled Antennas**

Near fields of linear antennas, self and mutual impedance, coupled two-element arrays, arrays of parallel dipoles, Yagi-Uda antennas, Hallen equations for coupled antennas.

CHAPTER FOUR

FDA Public Health Notification

4.1 Risk of Electromagnetic Interference with Medical Telemetry Systems Operating in the 460-470 MHz Frequency Bands

This is to notify you that after December 31, 2005, any medical telemetry systems operating in the460~470 MHz frequency bands will be an increased risk for interference, which could compromise patient safety. In January 2006 the Federal Communications Commission (FCC) will begin issuing new licenses for mobile radio transmitters to operate in the 460-470 MHz band.

Background

In 2000, the FCC dedicated a portion of the radio spectrum for wireless medical telemetry. This part of the spectrum is known as the Wireless Medical Telemetry Service (WMTS). The WMTS bands include 608-614 MHz, 1395-1400 MHz, and 1427-1432 MHz. With Spectrum dedicated for medical telemetry use, the FCC's intent *for* the past several years has been to grant new licenses to higher power mobile radio users in the 460-470 MHz band. However, because of the potential for serious interference with existing medical telemetry systems the FCC has delayed implementing this change in order to allow time for medical facilities to migrate out of the 460-470 MHz band. This freeze on new land mobile licenses in the 460-470 MHz band will expire on December 31; 2005.After December 31, 2005, the FCC will begin granting a great many licenses for mobile radio transmitters that will use new channels in the 460-470 MHz band. The new licenses will be for transmitters of 2 Watts or higher. It is estimated that there are several hundred thousand users waiting for these new channels. Most of the radio users in this band will include hand-held and other mobile transmitters such as those operated by police; fire and rescue; taxis; and commercial trucks. These users could likely operate in and around your hospital Wireless medical telemetry equipment still using channels in the 460 - 470 MHz band after December 31, 2005, could be adversely affected by mobile radios operating under the new FCC licenses. According to tests conducted by the FDA. the transmitters operating under new licenses in this frequency band can interfere with medical telemetry systems. This could lead to lapses in patient monitoring and missed alarm events, putting patients at risk. The anticipated interference will not be limited to urban areas. Any medical facility in the vicinity of a mobile radio could be affected.

Recommendations

We recommend that you:

- Determine if your current wireless medical telemetry systems are operating in the 460-47 MHz frequency band. You may need to consult with the
telemetry equipment manufacturer to determine this.
- Migrate out of the 460-470 MHz band if you are operating wireless medical telemetry equipment in that band and move to less vulnerable frequencies, such as the WMTS bands, by December 31, 2005.
- Register any WMTS equipment with the frequency coordinator for WMTS - the American Society for Healthcare Engineering (ASHE) of the American Hospital Association (AHA). Registration of WMTS equipment is required by the FCC.
- Assess and manage the risks for all medical telemetry. Medical telemetry still operating in the TV channels 7-13 (174-216 MHz), 14-36 (470 -608 MHz), and 38-46 (614-668 MHz) are particularly at risk. This is because in July 2005, the FCC ordered most major commercial broadcasters in the top 100 markets to operate their Digital TV (DTV) transmitters at their maximum licensed power. All others broadcasters will be required to do so by July 2006.
- Establish lines of communication or meet regularly with local broadcasters so that you can be aware of local changes in the high-power broadcast use of the RF spectrum.

Reporting Adverse Events to FDA

FDA requires hospitals and other user facilities to report deaths and serious injuries associated with the use of medical devices. If you suspect that a reportable adverse event was related to interference with medical telemetry, you should follow the reporting procedure established by your facility. If a telemetry system fails to function due to interference or any other reason, it is a device malfunction. We encourage you to report these malfunctions directly to the device manufacturer.

4.2 Magnetic Resonance Imaging (MRI) and Electromagnetic Fields (EMF)

Introduction

The European Parliament and the Council of the European Union have published a draft directive on the minimum health and safety requirements regarding the exposure of workers to the risks arising from electromagnetic fields and waves. These limitations for workers, especially those for static magnetic fields, given in the draft directive make the operation of MR scanners in the hospital environment virtually impossible, because the MR operators in the hospital would no longer be allowed to position the patient in the scanner in an effective way.

The draft directive also restricts or prohibits directly a number of specific MR applications for patient treatment such as interventional MR applications. With this application patients are treated directly inside the MR system under permanent control through MR imaging (for example tracking a biopsy needle or catheter). This is a situation were the medical staff is inside the examination room and can be exposed by the static magnetic-, the gradient- and radio-frequency-field (RF-field), The clinical benefit for the patient is estimated to be favorable compared to the potential adverse effects for the workers (for this application both the operators and medical doctors in the hospital). This new technique also might replace interventional procedures with conventional X-ray equipment which is beneficial for both patients and medical staff.

In addition the limitations given in the draft directive make development, manufacturing and service of MR-scanners very cumbersome if not impossible. In the following we would like to provide some basic information about MRI and the electro-magnetic fields associated with it. In the discussion, the practical situation in the hospitals for MR scanners and for exposure to static magnetic-, gradient- and RF fields is described, the clinical benefits are illustrated briefly and the objections to the proposed European directive are discussed.

4.3 What is MRI?

The beginnings of MRI go back more than 25 years. This imaging technique is based on the fact that body tissues act differently in strong magnetic fields, because the water content of the individual tissues varies. The hydrogen nuclei within the water molecules align themselves in a specific direction in strong magnetic fields. When radio wave pulses of an appropriate frequency are directed perpendicular to the magnetic field at a tissue, the nuclei are deflected from their normal alignment. When the radio waves are switched off, the nuclei return to their original orientation an emit weak electromagnetic waves during this short "relaxation time". These electromagnetic waves are acquired as signals, which are used by a computer to generate high-contrast images of the tissue. Stronger magnetic fields enable stronger signals to be received, resulting in clearer images and/or shorter total examination times.

MRI-Principle

Routine MRI is based on the magnetic characteristics of the 1H hydrogen atom. The patient is placed in a strong magnetic field (e.g., 1 Tesla = 10,000 Gauss) that is externally shielded. 'To *compare: the Earth's magnetic field is 0.3 to 0.7 Gauss, a magnet on the refrigerator door has a strength ofapprox. 100 Gauss or 0,01 Tesla* ".

High-frequency energy in the form of radio waves is applied to the patient. This energy is then emitted by the body in specific forms and at certain intervals. An antenna (coil) receives this energy, called the MR signal. For localisation of these MR signals low frequency magnetic pulses are applied to the patient by the gradient system. Using a mathematical transformation, the MR signals are converted into grey scale images. A patient study may take up typically 30 minutes per examination.

4.4 The Field Generating Components of the MR System and the Field Exposure to Patients and Personnel Magnet

The largest component in an MR system is the magnet, which creates the external magnetic field (B0). Hydrogen nuclei in the body placed into the magnetic field align themselves, thereby enabling MR imaging. The system provides a measurement field of up to 50 cm diameter at the highest possible homogeneity, enabling e.g., the display of the entire spinal column. Active magnetic shielding keeps the stray field to a minimum. As a result the exclusion zone (the 5 Gauss line) is usually limited to the examination room. MR scanners routinely apply static magnetic fields in the range from 0.2 T up to 3 T, whereby the whole body of the patient is exposed to this magnetic field. These types of scanners are commercially available world wide. An MR operator gets exposed when for example positioning a patient in the magnet bore. Another more long term exposure is unavoidable for the medical staff when applying interventional MR techniques. The exposure values can be as high as those experienced by the patient. The scientific literature is saying that no adverse effects from the exposure by static magnetic fields are observed up till now. Instantaneous health effects of exposure to higher magnetic field strengths (>1.5 T) are well known and reported in literature. These health effects (dizziness, nausea, metal taste) do not require treatment and no lasting effects nor cumulative (-dose) effects have been observed. The exposure values would exceed the limits given in the draft directive for 0 Hz in table 2.

Gradient System

The gradient system is the decisive component in determining measurement speed and spatial resolution. It localizes the body slice to be measured, it consist of the power amplifier and the gradient coil system. The gradient system generates low frequency (up to 1 kHz) magnetic pulses with mostly trapezoidal wave forms. The amplitude and switching speed of the gradient pulses are limited such that the occurrence of peripheral nerve stimulation for the patient is limited. Outside the gradient coils the pulsed magnetic field rapidly drops to negligible values. So generally the MR personnel is not exposed from pulsed gradient tildes even if a person is inside the examination room during the acquisition. However, during interventional MR at least a partial body exposition cannot be avoided. The exposure values would exceed the limits given in the draft directive in the frequency range close to 1 kHz in table 2.

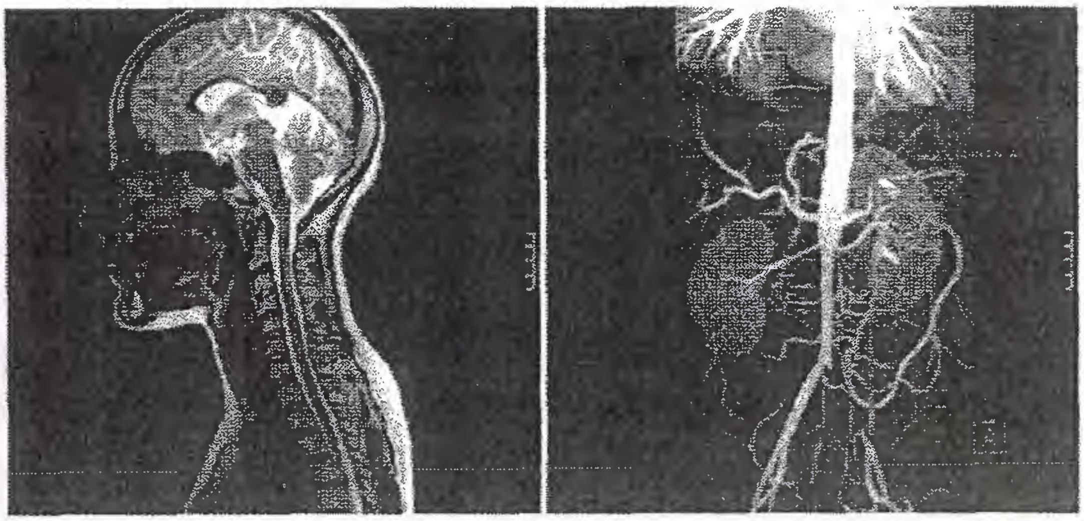
4.5 RF system

The RF-system can be separated in a transmit and receive path. The transmit path which consists of the RF power amplifier and a transmit antenna creates the pulses to deflect the hydrogen-nuclei from their alignment. The receive path consisting of different types of receive antennas detects the signals from the body tissue and prepares it for further processing to calculate the final MR image.

The RF power emitted by the transmit antenna causes slight heating in the patient body tissue. The power absorbed in the patient body is limited such that the body temperature does not increase by more than IOC. Outside the RF transmit antenna the RF field is negligible. Similar to pulsed gradient fields under normal circumstances the MR personnel is not exposed by the RF-fields. In case of interventional MR the exposition would be limited to the extremities or body parts of the staff working close to the magnet bore (or between the magnet poles).

Discussion

MR! Has moved to the forefront of medical imaging in recent years covering almost all areas ranging from neurological imaging, musculoskeletal imaging to cardiovascular and interventional. Complex, novel techniques like diffusion and perfusion imaging, functional imaging have even affected the approach to certain diseases and patients. The advance in hardware has had an impact in the still growing and maturing applications like parallel imaging techniques. These new advances might start a revolution in patient management and the role of MR in diagnosis of diseases. These statements only prove true if the application and further technological development of MR systems are not constricted by strict occupational exposure limits applicable to the medical personnel working at the MR system. The clinical benefit of MR scanners for the patient can best be illustrated by reference to the enormous amount of literature on MR in the medical and scientific international journals (some URLs are listed at the end of this text). As an illustration two clinical images are given in Fig.4.1



Figure(4.1) two clinical images can be effect

The number of MR units installed world wide is estimated to be > 20.000 and since the introduction in 1983 more then 200.000.000 patients have been examined in the scanners. Up till now no adverse effects from the exposure of these patients or from the exposure of the workers to the electromagnetic field created by MR systems is known. The exposure of patients is not addressed in the European Directive proposal and therefore only mentioned in this memo for illustration. Actual limits for the parameters for patient scanning are given in the IEC 60601-2-33 particular standard for the safety of MR scanners. For information, the static magnetic field ceiling value is 4 T for patients for whole body scanning, a number which is based on the clinical experience with 4 T MR Scanners at a limited number of hospital sites since 1987.

At present the exposure to the static magnetic field of system engineers in the manufacturing area and service engineers in the hospital environment is minimized by introducing specific tools. For all normal engineering activities these tools can be applied. For abnormal situation, whereby troubleshooting is required, it may however be unavoidable that these engineers are exposed to higher values (then proposed in the draft directive).
The exposure time to the static magnetic field of the operators in the hospital is typically a few

minutes per patient. In the worst case they are exposed to the maximum static magnetic field of the magnet, because they must position the patient on the patient support and therefore approach the magnet at a position where the static magnetic field is as high as the main magnetic field of the system. The operators in the hospital are typically not exposed to gradient- and RF-fields, because during the scanning of the patient, the operator is relative far away from the patient (at the operators' console of the scanner).

The exposure of the medical staff during interventional MR however is much higher than the proposed limits in the draft directive. For both, the open MR systems and the cylindrical MR systems, the medical doctor can he present near the scanner during a longer time (up to one hour or even more) and is present in or close to the maximum static magnetic field with his hands and partially with his body. Since he is present near the patient during scanning, he is also exposed by gradient- and RF-fields. At parts of the body (extremities, head) they can reach values which can be maximally equal to those applied to the patient.

Conclusion

In view of the practical experience up to now, the large installed base for MR scanners at present, the importance of the diagnostic capabilities of these MR scanners for the health care and the weak scientific base for the proposed limiting values, it seems unrealistic and not in the interest of the patients to impose the requirements in the draft directive to medical equipment and MR scanners in particular.

There are already several national and international guidelines, recommendations and standards in place addressing the safety of medical personnel in the MR environment (for example: the recommendation of the "Strahlenschutzkommission" in Germany, the White Paper on MR safety of the American College of Radiology or the I EC 60601-2-33 particular standard for the safety of MR scanners). These papers also require permanent training of the personnel, special procedures to be defined and followed or the generation of emergency plans. That means, they are much more specific in addressing the potential hazards in the particular MR vicinity.

CHAPTER FIVE

Electromagnetic Fields and Public Health

5.1 Mobile Telephones and Their Base Stations

Mobile telephones, sometimes called cellular phones or handiest, are now an integral part of modern telecommunications. In some parts of the world, they are the most reliable or only phones available. In others, mobile phones are very popular because they allow people to maintain continuous communication without hampering freedom of movement.

This fact sheet has been updated in the light of recent reviews of the effects on human beings of exposure to radiofrequency (RF) fields conducted by the World Health Organization **(WHO)** in November 1999, the Royal Society of Canada (1999), and a review on mobile phones and health by an expert committee in the United Kingdom (IEGMP 2000).

Use of mobile phones

In many countries, over half the population already uses mobile phones and the market is still growing rapidly. The industry predicts that there will be as many as 1.6 billion mobile phone subscribers worldwide in the year 2005. Because of this, increasing numbers of mobile base stations have had to be installed. Base stations are low-powered radio antennae that communicate with users' handsets. In early 2000 there were about 20,000 base stations in operation the United Kingdom and about 82,000 cell sites in the United States, with each cell site holding one or more base stations.

5.2 CONCERNS FOR HEALTH

Given the immense numbers *of* users of mobile phones, even small adverse effects on health could have major public health implications. This fact sheet addresses these concerns.

Several important considerations must be kept in mind when evaluating possible health effects of RF fields. One is the frequency of operation. Current mobile phone systems operate at frequencies between 800 and 1800 MHz. It is important not to confuse such RF fields with ionizing radiation, such as X-rays or gamma rays. Unlike ionizing radiation, RF fields cannot cause ionization or radioactivity in the body. Because of this, RF fields are called non-ionizing.

5.3 EXPOSURE LEVELS

Mobile phone handsets and base stations present quite different exposure situations. RF exposure to a user of a mobile phone is far higher than to a person living near a cellular base station. However, apart from infrequent signals used to maintain links with nearby base stations, the handset transmits RF energy only while a call is being made, whereas base stations are continuously transmitting signals

HANDSETS

Mobile phone handsets are low-powered RF transmitters, emitting maximum powers in the range of 0.2 to 0.6 watts. Other types of hand held transmitter, such as "warlike talkies", may emit 10 watts or more. The RF field strength (and hence RF exposure to a user) falls off rapidly with distance from the handset. Therefore, the RF exposure to a user of a mobile phone located 10s of centimeters from the head (using a "hands free" appliance) is far lower than to a user who places the headset against the head. RF exposures to nearby people are very low.

Base stations: Base stations transmit power levels from a few watts to 100 watts or more, depending on the size of the region or "cell" that they are designed to service. Base station antennae are typically about 20-30 cm in width and a meter in length, mounted on buildings or towers at a height of from 15 to 50 meters above ground. These antennae emit RF beams that are typically very narrow in the vertical direction but quite broad in the horizontal direction. Because of the narrow vertical spread of the beam, the RF field intensity at the ground directly below the antenna is low. The RF field intensity increases slightly as one move away from the base station and then decreases at greater distances from the antenna.

Typically within 2-5 meters of some antennae mounted on rooftops, fences keep people away from places where the RF fields exceed exposure limits. Since antennae direct their power outward, and do not radiate significant amounts of energy from their back surfaces or towards the top or bottom of the antenna, the levels of RF energy inside or to the sides of the building are normally very low.

Other RF sources in the community: Paging and other communications antennae such as those used by fire, police and emergency services, operate at similar power levels as cellular base stations, and often at a similar frequency. In many urban areas television and radio broadcast antennae commonly transmit higher RF levels than do mobile base stations.

5.4 Health Effects

RF fields penetrate exposed tissues to depths that depend on the frequency - up to a centimeter at the frequencies used by mobile phones. RF energy is absorbed in the body and produces heat, but the body's normal thermoregulatory processes carry this heat away. All established health effects of RF exposure are clearly related to heating. While RF energy can interact with body tissues at levels too low to cause any significant heating, no study has shown adverse health effects at exposure levels below international guideline limits.

Most studies have examined the results of short-term, whole body exposure to RF fields at levels far higher than those normally associated with wireless communications. With the advent of such devices as walkie-talkies and mobile phones, it has become apparent that few studies address the consequences of localized exposures to RF fields to the head.

Who has identified research needs to make better health risk assessment and promoted the research to funding agencies. Briefly, at present time this research indicates:

• Cancer

Current scientific evidence indicates that exposure to RF fields, such as those emitted by mobile phones and their base stations, is unlikely to induce or promote cancers. Several studies of animals exposed to RF fields similar to those emitted by mobile phones found no evidence that RF causes or promotes brain cancer. While one 1997 study found that RF fields increased the rate at which genetically engineered mice developed lymphoma, the health implications of this result is unclear. Several studies are under wave to confirm this finding and determine any relevance of these results to cancer in human beings. Three recent epidemiological studies found no convincing evidence of increase in risk of cancer or any other disease with use of mobile phones.

• Other health risks

Scientists have reported other effects of using mobile phones including changes in brain activity, reaction times, and sleep patterns. These effects are small and have no apparent health significance. More studies are in progress to try to confirm these findings.

• Driving

Research has clearly shown an increased risk *of* traffic accidents when mobile phones (either handheld or with a "hands-free" kit) are used while driving.

• Electromagnetic interference

When mobile phones are used close to some medical devices (including pacemakers, implantable defibrillators, and certain hearing aids) there is the possibility of causing interference. There is also the potential of interference between mobile phones and aircraft electronics.

5.5 EMF Guidelines.

International guidelines developed by the International Commission on non-Ionizing Radiation Protection (ICNIRP) are based on careful analysis of all scientific literature (both thermal and non- thermal effects) and offer protection against all identified hazards of RF energy with large safety margin safety. Both measurements and calculations shows that RF signal levels in areas of public access from base stations are far below international guidelines typically by a factor of 100 or more RF exposure levels to a user from mobile handsets are considerably larger but below international guidelines.

WHAT, WHO IS DOING

In response to public concerns, WHO established the International Electromagnetic Fields (EMF) Project to assess the scientific evidence of possible health effects of EMF. Specific studies have been identified to address the problem of localized exposure. The project has established a formal mechanism for reviewing the research results and conducting risk assessments of RF exposure. It is also developing public information materials, and bringing together standards groups worldwide in an attempt to harmonies international exposure standards.

Who is also conducting RF research? Large epidemiology study is being co-ordinate in over 10 countries by the International Agency for Research on Cancer (IARC), a specialized cancer research agency of whom to identify if there are links between use of mobile phones and head and neck cancers, the study is anticipated to be completed in 2003.

Conclusions and Recommendations

None of the recent reviews have concluded that exposure to the RF fields from mobile phones or their base stations causes any adverse health consequence. However, there are gaps in knowledge that have been identified for further research to better assess health risks. It will take about 3-4 years for the required RF research to be completed, evaluated and to publish the final results of any health risks. In the meantime, WHO recommends: Strict adherence to health-based guidelines; International guidelines have been developed to protect everyone in the population: mobile phone users, those who work near or live around base stations, as well as people who do not use mobile phones.

Precautionary measures

- Government: If regulatory authorities have adopted health-based guidelines but, because of public concerns, would like to introduce additional precautionary measures to reduce exposure to RF fields, they should not undermine the science base of the guidelines by incorporating arbitrary additional safety factors into the exposure limits. Precautionary measures should be introduced as a separate policy that encourages, through voluntary means, the reduction of RF fields by equipment manufacturers and the public. Details of such measures are given in a separate WHO Background document.

- Individuals: Present scientific information does not indicate the *need* for any special precautions for use of mobile phones. If individuals are concerned, they might choose to limit their own or their children's' RF exposure by limiting the length of calls, or using "hands-free" devices to keep mobile phones away from the head and body.

Obey local restrictions on mobile phone use to avoid EMF interference: Mobile phones may interfere with certain electro medical devices, such as cardiac pacemakers and hearing aids. In hospital intensive care departments mobile phone use can be a danger to patients and should not be used in these areas. Similarly mobile phones should not be used in aircraft as they may interfere with its navigation systems.

Driving safety: In moving vehicles there is a well established increase in the risk of traffic accidents while the driver is using a mobile phone, either a conventional handset or one fitted with a "hands free" device. Motorists should be strongly discouraged from using mobile phones while driving.

Simple protective measures: Fences or barriers or other protective measures are needed for some base stations (principally, those located on building rooftops) to preclude unauthorized access to areas where exposure limits may be exceeded.

RF absorbing devices: Scientific evidence does not indicate any need for RF-absorbing covers or other "absorbing devices" on mobile phones. They cannot be justified on health grounds and the effectiveness of many such devices in reducing RF exposure is unproven.

Consultations with the community in sitting base stations: Base station sites must offer good signal coverage and be accessible for maintenance. While RF field levels around base stations are not considered a health risk, sitting decisions should take into account aesthetics and public sensibilities. Sitting base stations near kindergartens, schools and playgrounds may need special consideration. Open communication and discussion between the mobile phone operator, local council and the public during the planning stages for a new antenna can help create public understanding and greater acceptance of a new facility.

CHAPTER SIX

Effects of Radiations and Researching Institutes

6.1 Ozone (03)

Performs the essential task of filtering out most of the sun's biologically harmful ultraviolet (UV-B) radiation. There is a direct link between increased exposure to UV radiation and elevated risk of contracting certain types of skin cancers. Human health effects include increases in the incidence of certain types of skin cancers, cataracts and immune deficiency disorders. Increased penetration of UV results in additional production of ground level ozone, which causes respiratory' illnesses. In 1985 scientists discovered a thinning of the Ozone layer directing correlated to Ozone Depleting Substance such as CFCs, which have been regulated under the Montreal Protocol.

The protection of the public and the workforce from the harmful effects of ionizing radiation forms the basis on which the broader issues of nuclear safety and waste management are developed by the European Commission.

Electromagnetic fields of all frequencies represent one of the most common and fastest growing environmental influences, about which anxiety and speculation are spreading. All EU populations are now exposed to varying degrees of EMF, and the levels will continue to increase as technology advances. As well as the WHO the European Commission also considers EMF.

6.2 WHO and Environmental NGOs Assess Chernobyl Health Effects

On the occasion of the 20th anniversary[7] of the Chernobyl accident occurred on 26 April 1986, the World Health Organization (WHO) published an accurate and detailed report on the health impacts of the most serious nuclear accident in history. The WHO report on the health effects of Chernobyl aims to give the most affected countries, and their people, the information they need to be able to make vital public health decisions as they continue to rebuild their communities. Entitled Health (...)

6.3 European NGOs Against Nuclear Power

In the year of the 20th anniversary of Chernobyl, NGOs around Europe have joined in the campaign "1 MILLION AGAINST NUCLEAR" to explain to the public why nuclear power is not only an extremely dangerous resource, but also a no solution for our energy needs. NGOs therefore aim to collect 1 million signatures to show to politicians that nuclear power is not an option. The campaign, initiated by atomstopp, Sortie du Nuclear, WISE, and Women for Peace, is being supported by many (...)

6.4 ICNIRP Workshop on Electromagnetic Fields

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) is organizing a workshop on "EMF Dosimeter and Biophysical Aspects Relevant to Setting Exposure Guidelines" in Berlin on 20-22 March 2006.

The workshop will cover the whole frequency range from static fields to terahertz. Invited experts will present lectures on those topics and discuss the relevance of recent research findings with regard to exposure limits for workers and the general public. The workshop's main (...)

6.5 New Publication on Health and Electromagnetic Fields

A new publication on "Health and electromagnetic fields" has been released in January 2006 as part of an EU-funded research into the impact of electromagnetic fields and mobile telephones on health. The publication describes the background to research on the health impacts of electromagnetic fields and gives some examples of research projects funded by the Commission. It also places this research in the context of EU policies and initiatives at international level. While electromagnetic (...)

6.6 Who launches programming to Minimize Risks of Radon

In an effort to reduce the rate of lung cancer around the world, the World Health Organization (WHO) launched on 21 June the International Radon Project to help countries reduce the health risks associated with radon gas. The Project will identify effective strategies for reducing the health impact of radon, promote sound policy options for countries and increase public and political awareness about the consequences of exposure to radon. The project is initially expected to run for three (...)

6.7 Who International Seminar and Working Group meeting on EMF Hypersensitivity

The International Seminar and Working Group Meeting on EMF Hypersensitivity took place in Prague, Czech Republic, from 25 to 27 October 2004. The meeting comprised a 2-day international meeting, open to all persons who would like to contribute or attend, followed by a 1-day working group meeting to prepare a report summarizing current scientific understanding of this syndrome and the discussions at the international meeting.
Sensitivity to EMF has been given the general name (...)

6.8 Better Protection for Workers Against Electromagnetic Waves

On 30 March 2004 the European Parliament adopted a new Directive to protect the health and safety of workers against the dangers of exposure to electromagnetic fields. The Parliament at second reading adopted only 5 amendments to the Council's common position - and these amendments are apparently acceptable to the Council. Member States will have four years to enact the directive into national law. The Directive lays down maximum values for exposure to electromagnetic fields to protect the (...)

6.9 New Agreement to Protect Workers from Electromagnetic Fields and Waves » October 2003

A new Directive about health and safety at work the new directive will provide protection to workers from over exposure to high levels of electro-magnetic fields and waves. It is intended to provide protection from health risks like electric shocks and burns. Employers will need to conduct risk assessments which may result in remedial measures to reduce levels of the electro-magnetic field. This directive will mostly affect those at risk of irradiation in heavy industries, but will also (...)

6.10 Precautionary Principle and EMF

Conducting Human Health and Environmental Risk Assessment and Risk Management under the precepts of Precautionary Principle represents

Challenges and opportunities for scientists, policy makers and the public. Responding to the need to provide a framework and test it in a case study, the World Health Organization, The European Commission and the US National Institute of Environmental Health Science held a 3 day meeting on "Application of the Precautionary Principle to (...)

6.11 Future of Nuclear Energy in the EU and Candidate Countries

Members of the European Convention are being called upon to reject proposals that would effectively introduce in a new EU constitution a primary^ legal requirement to promote nuclear power. In a letter sent to all Convention members. Friends of the Earth, Greenpeace, WWF, the European Environment Bureau and over 100 other organizations have urged support instead for earlier proposals that would require the abolition of the Erratum treaty commitments. Presidium's approach Contribution (...)

6.12 Cancer Epidemic Blamed on Nuclear Power

A major review of the risks of radiation links nuclear pollution with increased rates of breast cancer and child leukemia. This new assessment appears at a time when environmental groups are urging a reform of Erratum, the European nuclear energy treaty. The present cancer epidemic is a result of pollution from nuclear energy and of exposures to global atmospheric weapons fallout, which peaked in the period 1959-63, according to a report from the European Committee of Radiation Risk (...)

CHAPTER SEVEN

Ionizing & Non-Ionizing Radiation

7.1 Ionizing Versus & Non-Ionizing Radiation

We live in a sea of radiation. In recent years, people have learned to fear the effects of radiation. They don't want to live near nuclear reactors. They are frightened by reports of links between excess exposure to sunlight and skin cancer. They are afraid of the leakage from microwave ovens, or the radiation produced by their television sets.

Several factors combine to heighten the public's anxiety about both the short-range and long-range effects of radiation. Perhaps the most important source of fear is the fact that radiation can't be detected by the average person. Furthermore, the effects of exposure to radiation might not appear for months or years or even decades.

To understand the biological effects of radiation we must first understand the difference between **ionizing radiation** and **non-ionizing radiation**. In general, two things can happen when radiation is absorbed by matter: excitation or ionization.

- *Excitation* occurs when the radiation excites the motion of the atoms or molecules, or excites an electron from an occupied orbital into an empty, higher-energy orbital.
- *Ionization* occurs when the radiation carries enough energy to remove an electron from an atom or molecule.

Because living tissue is 70-90% water by weight, the dividing line between radiation that excites electrons and radiation that forms ions is often assumed to be equal to the ionization of water: 1216 kJ/mol. Radiation that carries less energy can only excite the water molecule. It is therefore called *non-ionizing radiation*. Radiation that carries more energy than 1216 kJ/mol can remove an electron from a water molecule, and is therefore called *ionizing radiation*.

The table below contains estimates of the energies of various kinds of radiation. Radio waves, microwaves, infrared radiation, and visible light are all forms of non-ionizing radiation. X-rays, γ -rays, and α- and ï¿½/i>-particles are forms of ionizing radiation. The dividing line between ionizing and non-ionizing radiation in the electromagnetic spectrum falls in the ultraviolet portion of the spectrum. It is therefore useful to divide the UV spectrum into two categories: UV_A and UV_B. Radiation at the high-energy end of the UV spectrum can be as dangerous as x-rays or γ-rays.

Table (7.1) *Energies of Ionizing and Non-Ionizing Forms of Radiation*

Radiation	*Typical Frequency (s^{-1})*	*Typical Energy (kJ/mol)*	
Particles			
α-particles		4.1×10^{8}	
ï¿½/i>-particles		1.5×10^{7}	
Electromagnetic radiation			*ionizing*
cosmic rays	$6 \times 10^{21} s^{-1}$	2.4×10^{9}	*radiation*
γ-rays	$3 \times 10^{20} s^{-1}$	1.2×10^{8}	
x-rays	$3 \times 10^{17} s^{-1}$	1.2×10^{5}	
ultraviolet	$3 \times 10^{15}\ s^{-1}$	1200	
visible	$5 \times 10^{14}\ s^{-1}$	200	
infrared	$3 \times 10^{13}\ s^{-1}$	12	*non-ionizing*
microwaves	$3 \times 10^{9}\ s^{-1}$	1.2×10^{-3}	*radiation*
radio waves	$3 \times 10^{7}\ s^{-1}$	1.2×10^{-5}	

When ionizing radiation passes through living tissue, electrons are removed from neutral water molecules to produce H_2O^+ ions. Between three and four water molecules are ionized for every 1.6×10^{-17} joules of energy absorbed in the form of ionizing radiation.

$$H_2O \rightarrow H_2O^+ + e^-$$

The H_2O^+ ion should not be confused with the H_3O^+ ion produced when acids dissolve in water. The H_2O^+ ion is an example of a free radical, which contains an unpaired valence-shell electron. Free radicals are extremely reactive. The radicals formed when ionizing radiation passes through water are among the strongest oxidizing agents that can exist in aqueous solution. At the molecular level, these oxidizing agents destroy biologically active molecules by either removing electrons or removing hydrogen atoms. This often leads to damage to the membrane, nucleus, chromosomes, or mitochondria of the cell that either inhibits cell division, results in cell death, or produces a malignant cell.

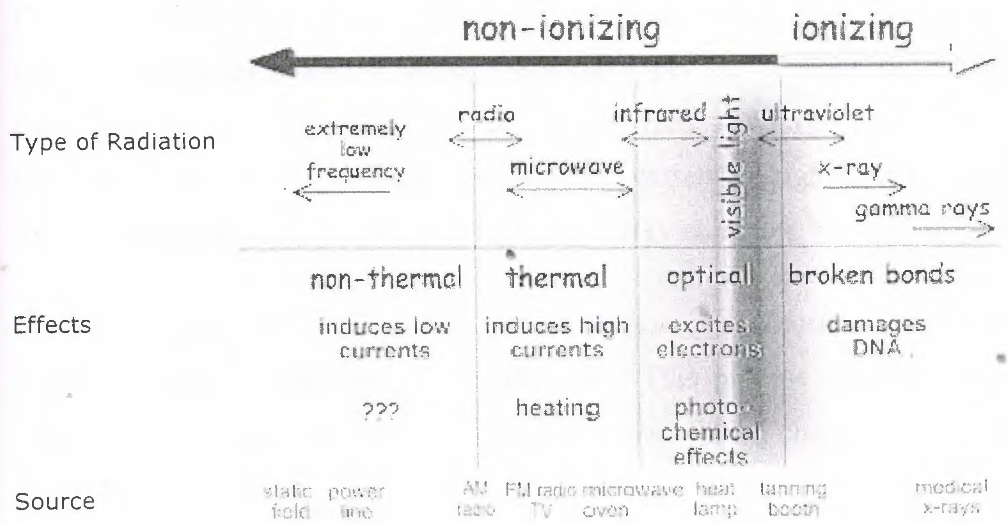


Figure (7.1) Types of Radiation in the Electromagnetic Spectrum

7.1.1 No ionizing Radiation

We take advantage of the properties of non-ionizing radiation for common tasks:

- microwave radiation-- telecommunications and heating food
- infrared radiation --infrared lamps to keep food warm in restaurants
- radio waves-- broadcasting

Non-ionizing radiation ranges from extremely low frequency radiation, shown on the far left through the audible, microwave, and visible portions of the spectrum into the ultraviolet range.

Extremely low-frequency radiation has very long wave lengths (on the order of a million meters or more) and frequencies in the range of 100 Hertz or cycles per second or less. Radio frequencies have wave lengths of between 1 and 100 meters and frequencies in the range of 1 million to 100 million Hertz. Microwaves that we use to heat food have wavelengths that are about 1 hundredth of a meter long and have frequencies of about 2.5 billion Hertz.

7.1.2 Ionizing Radiation

Higher frequency ultraviolet radiation begins to have enough energy to break chemical bonds. X-ray and gamma ray radiation, which are at the upper end of magnetic radiation have very high frequency --in the range of 100 billion billion Hertz--and very short wavelengths--1 million millionth of a meter. Radiation in this range has extremely high energy. It has enough energy to strip off electrons or, in the case of very high-energy radiation, break up the nucleus of atoms.

Ionization is the process in which a charged portion of a molecule (usually an electron) is given enough energy to break away from the atom. This process results in the formation of two charged particles or ions: the molecule with a net positive charge, and the free electron with a negative charge.

Each ionization releases approximately 33 electron volts (eV) of energy. Material surrounding the atom absorbs the energy. Compared to other types of radiation that may be absorbed, ionizing radiation deposits a large amount of energy into a small area. In fact, the 33 eV from one ionization is more than enough energy to disrupt the chemical bond between two carbon atoms. All ionizing radiation is capable, directly or indirectly, of removing electrons from most molecules.

7.2 INTRODUCTION TO NIR

Non-ionizing radiations (NIR) encompass the long wavelength (> 100 nm), low photon Energy (<12.4 eV) portion of the electromagnetic spectrum, from 1 Hz to 3 x 1015 Hz. Except For the narrow visible region, NIR cannot be perceived by any of the human senses unless its Intensity is so great that it is felt as heat. The ability of NIR to penetrate the human body, the Sites of absorption, and the subsequent health effects are very much frequency dependant.
The NIR part of the electromagnetic spectrum is divided into four approximate regions [1-3]:
* Static electric and magnetic fields, 0 Hz;
* Extremely low frequency (ELF) fields, >0 Hz to 300 Hz;
* Radiofrequency (RF) and microwave (MW) radiation,
300 Hz to 300 GHz;
* Optical radiations: infrared (IR) 760 - 106 nm
Visible 400 - 760 nm
Ultraviolet (UV) 100 - 400 nm
(On the other hand, ionizing radiations, with wavelengths less than 100 nm, constitute the High photon energy portion of the electromagnetic spectrum.)

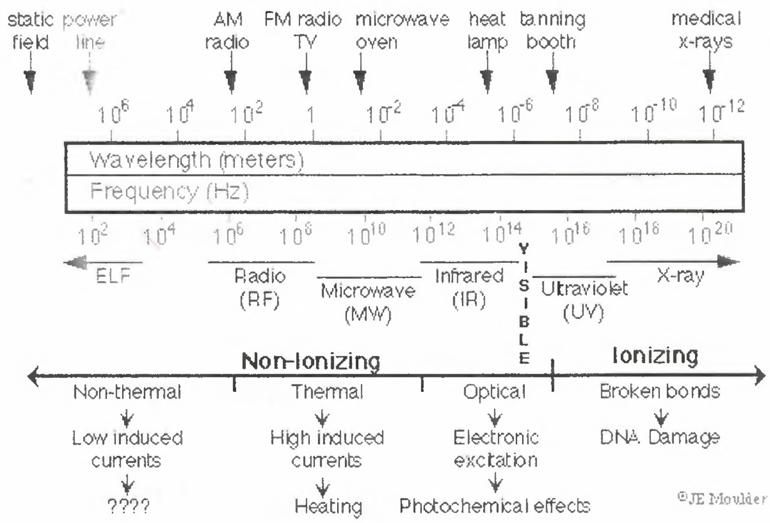


Figure.(7.2): Electromagnetic Spectrum and associated Biological Effects (Reproduced with permission from John Moulder and Begell House [1]).

7.2.1 SOURCES OF NIR

Non-Ionizing radiation originates from various sources: Natural origin (such as sunlight or lightning discharges etc.) and man made (seen in wireless communications, industrial, scientific and medical applications). The NIR spectrum is divided into two main regions: optical radiations and electromagnetic fields.

7.2.1.1 Optical Radiations

The optical radiations are centered around visible light; those with higher energies are termed UV radiation and those with lower energies IR radiation.

Sources of UV radiation are the sun, arc welding, oxy-gas welding, sun lamps, lasers (UV), sterilization (germicidal) lamps, low pressure gas discharge lamps, high pressure discharge lamps. Sources of IR radiation are from hot processes such as steelmaking, glassmaking, welding, and also lasers (IR). The application of laser as a coherent light source is increasing rapidly.

Medical applications include UV and neonatal phototherapy, surgical and therapy lasers, Physiotherapy heat lamps.

7.2.1.2 Electromagnetic fields

Microwaves are used in telecommunications, radar/satellite links, mobile phones, microwave ovens, TV transmitters. RF is used in radio communications, visual display units, television sets. Extremely low-frequency (ELF) electric and magnetic fields (EMFs) surround electrical machinery, home appliances, electric wiring, and high-voltage electrical transmission lines and transformers.

Medical applications include: microwave hyperthermia, therapeutic and surgical diathermy, And magnetic resonance imaging (MRI).

7.3 BIOLOGICAL EFFECTS OF NIR

A biological effect occurs when a change can be measured in a biological system after the introduction of some type of stimuli. However, the observation of a biological effect, in and of itself, does not necessarily suggest the existence of a biological hazard or health effect. A biological effect only becomes a safety hazard when it "causes detectable impairment of the health of the individual or of his or her offspring" [3]. Biological effects could be physiological, biochemical or behavioral changes induced in an organism, tissue or cell.

NIRs usually interact with tissue through the generation of heat. The hazards depend on the ability to penetrate the human body and the absorption characteristics of different tissues (Table 1). There are still much uncertainties about the severity of effects of both acute and Chronic exposure to various types of NIRs. Generally the public is concerned about the risks From ELF, RF and MW. However, the greatest risk to the public probably arises from natural UV radiation.

Damage from optical radiations is largely confined to the eye and skin, and fall into two categories – thermal damage and photochemical damage. Despite having insufficient energy to ionize atoms, single photons of ultraviolet radiation can damage tissue through disruption of bonds within DNA molecules and give a long-term risk of cancer. This must be borne in mind when determining allowable exposures. Visible light and IR only produce damage through high-intensity multi-photon interactions. The biological effects induced are essentially the same for both, but lasers (coherent light) are capable of producing higher irradiances and can heat localized volumes of tissue to a high enough temperature to produce rapid physical change.

Table (7.2): Biological Effects of Different Non-Ionizing Radiations (Reproduced with permission from Martin & Sutton, 2002 [2]).

	Wavelength, frequency	Biological Effects
	100 nm	
UVC		Skin – Erythema, inc pigmentation
	280 nm	Eye – Photokeratitis (inflammation of cornea)
		Skin – Erythema, inc pigmentation
UVB		*Skin cancer*
	315 nm	Eye – Photochemical cataract
		Photosensitive skin reactions
UVA		Skin – Erythema, inc pigmentation
	400 nm	*Skin photo-ageing, Skin cancer*
Visible		Eye – Photochemical & thermal retinal injury
	780 nm	Eye – Thermal retinal injury
IRA		Eye – Thermal retinal injury, thermal cataract
	1.4 µm	*Skin burn*
IRB		Eye – Corneal burn, cataract
	3 µm	*Skin burn*
IRC		Eye – Corneal burn, cataract
	1 mm	Heating of body surface
Micro-wave	300 GHz	
		Heating of body surface
	1 GHz	Heating with 'penetration depth' of 10 mm
		Raised body temperature
	<100 KHz	Cumulation of charge on body surface
		Disturbance of nerve & muscle responses
Static	0 Hz	Magnetic field – vertigo/ nausea
		Electric field – charge on body surface
Long-term effects are given in italics.		

The nature, extent, and physiological importance of biological effects from NIR exposures will depend on many factors such as the energy of the incident radiation (determines the penetration depth), the power density of the field or beam, source emission characteristics, duration of exposure, environmental conditions, and the spatial orientation and biological characteristics of the irradiated tissues (molecular composition, blood flow, pigmentation, functional importance, etc.).

In the lower frequency range (300 Hz to 1 MHz), induction currents may interfere with the functioning of the central nervous system. In the intermediate frequency range (100 kHz to 10 GHz), the absorption of EMF generates heat. At the upper frequency range of 10 GHz to 300 GHz, heating of superficial tissues is possible. It is generally recognized that, except for optical radiation, there is scarce data on the quantitative relationships between exposures to different types of NIR and pathological responses in humans.

Biological effects that result from heating of tissues by RF radiation are referred to as *'thermal' effects*. The body has effective ways to regulate its temperature, but if exposures are too intense the body no longer copes.

Much of the current debate is about relatively low levels of exposure to RF radiation from mobile phones and base stations producing *'non-thermal' effect*s. Some experiments have suggested that there may be biological effects at non-thermal exposure levels, but the evidence for production of health hazard is contradictory and unproven [4-8] The scientific community and international bodies acknowledge that further research is needed to improve our understanding in some areas. Meanwhile the consensus is that there is no consistent and convincing scientific evidence of adverse health effects caused by RF radiation [4-8].

7.3.1 Electric and Magnetic Fields

Exposure can arise at home, work, or school and is measured using personal or environmental monitoring. The Electric fields depend on the magnitude of the voltage and distance from the source. Generally, voltages are stable and remain the same; however electric fields are easily perturbed by many common objects.

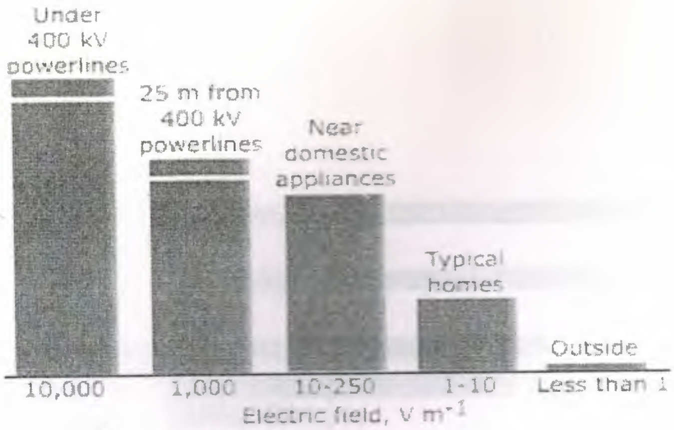


Figure (7.3)
Fig. 3 Exposures to Electric Fields [14] (Reproduced with permission from NRPB)

Exposure to magnetic fields arises from power lines and the use of electrical appliances. Ambient fields from the supply to the house are always present and expose the whole body, whereas those from appliances are intermittent and expose part of the body. The magnetic field strength depends upon the magnitude of the current and on the distance from the appliances.

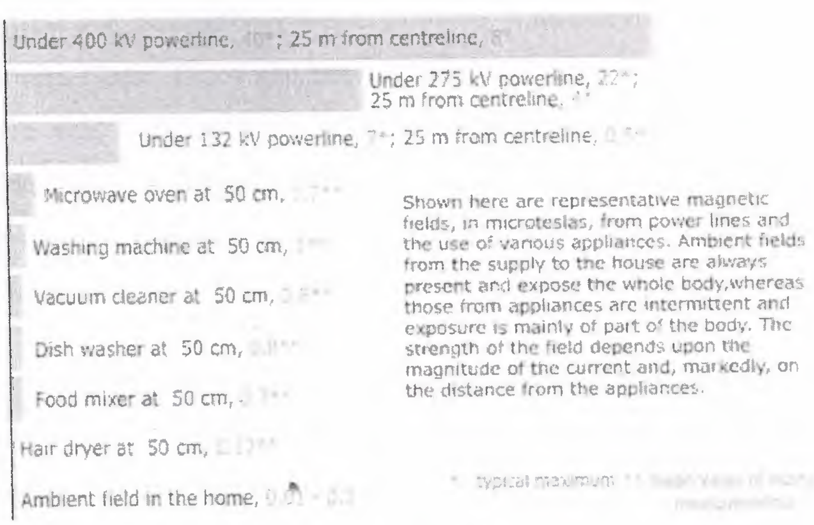


Figure. (7.4) Exposures to Magnetic Fields [14] (Reproduced with permission from NRPB)

Occupational exposures to magnetic fields range from levels found in homes to several mT.

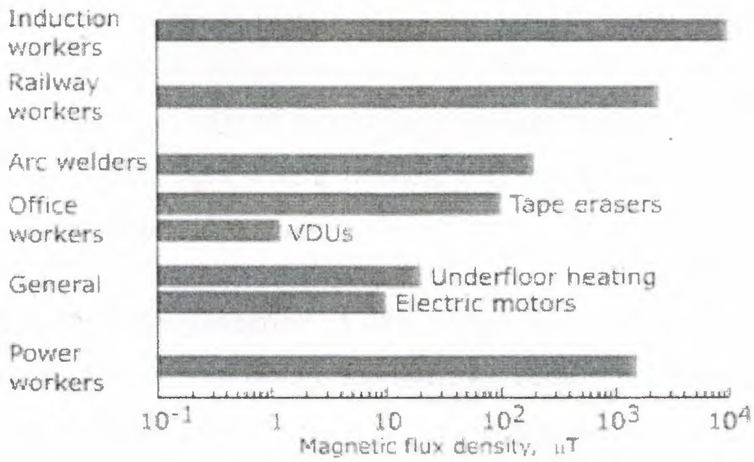


Figure.(7.5) Occupational Exposures to Magnetic Fields [14] (Reproduced with permission from NRPB)

7.4 Biological Effects of Ionizing Radiation

From the time that radioactivity was discovered, it was obvious that it caused damage. As early as 1901, Pierre Curie discovered that a sample of radium placed on his skin produced wounds that were very slow to heal. What some find surprising is the magnitude of the difference between the biological effects of non-ionizing radiation, such as light and microwaves, and ionizing radiation, such as high-energy ultraviolet radiation, x-rays, γ-rays, and α- or ï¿½/i>-particles.

Radiation at the low-energy end of the electromagnetic spectrum, such as radio waves and microwaves, excites the movement of atoms and molecules, which is equivalent to heating the sample. Radiation in or near the visible portion of the spectrum excites electrons into higher-energy orbital. When the electron eventually falls back to a lower-energy state, the excess energy is given off to neighboring molecules in the form of heat. The principal effect of non-ionizing radiation is therefore an increase in the temperature of the system.

We experience the fact that biological systems are sensitive to heat each time we cook with a microwave oven, or spend too long in the sun. But it takes a great deal of non-ionizing radiation to reach dangerous levels. We can assume, for example, that absorption of enough radiation to produce an increase of about 6C in body temperature would be fatal. Since the average 70-kilogram human is 80% water by weight, we can use the heat capacity of water to calculate that it would take about 1.5 million joules of non-ionizing radiation to kill the average human. If this energy was carried by visible light with a frequency of 5 x 10^{14} s^{-1}, it would correspond to absorption of about seven moles of photons.

Ionizing radiation is much more dangerous. A dose of only 300 joules of x-ray or γ-ray radiation is fatal for the average human, even though this radiation raises the temperature of the body by only 0.001C. α-particle radiation is even more dangerous; a dose equivalent to only 15 joules is fatal for the average human. Whereas it takes seven moles of photons of visible light to produce a fatal dose of non-ionizing radiation, absorption of only 7 x 10^{-10} moles of the α-particles emitted by ^{238}U is fatal.

There are three ways of measuring ionizing radiation.

- Measure the activity of the source in units of disintegrations per second or curies, which is the easiest measurement to make.
- Measure the radiation to which an object is exposed in units of roentgens by measuring the amount of ionization produced when this radiation passes through a sample of air.
- Measure the radiation absorbed by the object in units of radiation absorbed doses or "rads." This is the most useful quantity, but it is the hardest to obtain.

One **radiation absorbed dose**, or **rad**, corresponds to the absorption of 10^{-5} joules of energy per gram of body weight. Because this is equivalent to 0.01 J/kg, one rad produces an increase in body temperature of about 2 x 10^{-6}C. At first glance, the rad may seem to be a negligibly small unit of measurement. The destructive power of the radicals produced when water is ionized is so large; however, that cells are inactivated at a dose of 100 rads, and a dose of 400 to 450 rads is fatal for the average human.

Not all forms of radiation have the same efficiency for damaging biological organisms. The faster energy is lost as the radiation passes through the tissue, the more damage it does. To correct for the differences in **radiation biological effectiveness** (**RBE**) among various forms of radiation, a second unit of absorbed dose has been defined. The **roentgen equivalent man,** or **rem**, is the absorbed dose in rads times the biological effectiveness of the radiation.

$$\text{Rems} = \text{rads} \times \text{RBE}$$

Values for the RBE of different forms of radiation are given in the table below.

Table (7.3) the Radiation Biological Effectiveness of Various Forms of Radiation

Radiation	RBE
x-rays and γ-rays	1
ï¿½sup>- particles with energies larger than 0.03 MeV	1
ï¿½sup>- particles with energies less than 0.3 MeV	1.7
thermal (slow-moving) neutrons	3
fast-moving neutrons or protons	10
α-particles or heavy ions	20

Estimates of the per capita exposure to radiation in the United States are summarized in the table below. These estimates include both external and internal sources of natural background radiation.

Table (7.4) Average Whole-Body Exposure Levels for Sources of Ionizing Radiation

Source	Per Capita Dose (rems / y)
natural background	0.082
medical x-rays	0.077
nuclear test fallout	0.005
consumer and industrial products	0.005
nuclear power industry	0.001
total:	0.170

External sources include cosmic rays from the sun and α-particles or γ-rays emitted from rocks and soil. Internal sources include nuclides that enter the body when we breathe (^{14}C, ^{85}Kr, ^{220}Rn, and ^{222}Rn) and through the food chain (^{3}H, ^{14}C, ^{40}K, ^{90}Sr, ^{131}I, and ^{137}Cs). The actual dose from natural radiation depends on where one lives. People who live in the Rocky Mountains, for example, receive twice as much background radiation as the national average because there is fewer atmospheres to filter out the cosmic rays from the sun. The average dose from medical x-rays has decreased in recent years because of advances in the sensitivity of the photographic film used for x-rays. Radiation from nuclear test fallout has also decreased as a result of the atmospheric nuclear test ban. The threat of fallout from the testing of nuclear weapons can be appreciated by noting that a Chinese atmospheric test in 1976 led to the contamination of milk in the Harrisburg, PA, vicinity at a level of 300 pCi (3.00×10^{-10} Ci) per lite. This was about eight times the level of contamination (41 pCi per liter) that resulted from the accident at Three Mile Island.

The contribution to the radiation absorbed dose from consumer and industrial products includes radiation from construction materials; x-rays emitted by television sets, and inhaled tobacco smoke. The most recent estimate of the total radiation emitted from the mining and milling of uranium, the fabrication of reactor fuels, the storage of radioactive wastes, and the operation of nuclear reactors is less than 0.001 rem per year.

The total dose from ionizing radiation for the average American is about 0.170 rem per year. The Committee on the Biological Effects of Ionizing Radiation of the National Academy of Sciences recently estimated that an increase in this dose to a level of 1 rem per year would result in 169 additional deaths from cancer per million people exposed. This can be compared with the 170,000 cancer deaths that would normally occur in a population this size that was not exposed to this level of radiation.

Conclusion:

In this project we observe the effects of all types of radiations like Magnetic radiation, Ionization radiation, non ionization and all bands of radiations. The results that we obtained from this study can be concluding as.

In view of the practical experience up to now, the large installed base for MR scanners at present, the importance of the diagnostic capabilities of these MR scanners for the health care and the weak scientific base for the proposed limiting values, it seems unrealistic and not in the interest of the patients to impose the requirements in the draft directive to medical equipment and MR scanners in particular.

None of the recent reviews have concluded that exposure to the RF fields from mobile phones or their base stations causes any adverse health consequence. However, there are gaps in knowledge that have been identified for further research to better assess health risks. It will take about 3-4 years for the required RF research to be completed, evaluated and to publish the final results of any health risks. In the meantime, WHO recommends: Strict adherence to health-based guidelines; International guidelines have been developed to protect everyone in the population: mobile phone users, those who work near or live around base stations, as well as people who do not use mobile phones

One of the most important effects that we find, is the effects on the ozone, the radiation affects ozone through preventing the coming radiation from the sun passing to our planet.

After this findings the radiation have harmful effects on our life in many direction, that's why we must give more attention in trying to solve the dangerous, and trying to minimize those effects if we can not stop it.

REFERENCES

[1] .JOHN, D. K. Electromagnetic. 4th edition, MC Grawhill. 1992.

[2]. KENNETH, R. D. Engineering Electromagnetic. Prentice Hall. 1998.

[3]. DAVID, K. C. Field and Wave Electromagnetic. 2nd edition, Addison Wesley. 1989.

[4]. AKIRA, I. Electromagnetic Wave Propagation, Radiation and Scattering. Prentice Hall. 1991.

[5]. DRENLEY, G. & NORTHOP, D. C. Semiconductors Countries for Nuclear Radiations. Spoon Ltd. 1963.

[6]. Installation and Regulation, Michael needle, Third Edition

[7]. The Electricians Guide Fifth Edition by John Whitfield.

[8]. The 16th Edition IEE Regulations

[9] .Web site references:

[1].http://www.wikipeedia.com

[2].http://www.answers.com