Therapeutic and Diagnostic Uses of Electromagnetic Energy

D. V. Giri
Dept. of ECE, Univ of New Mexico
Albuquerque, NM, USA and Pro-Tech,
11-C Orchard Ct, Alamo, CA 94507, USA
Giri@DVGiri.com

Jayanti Venkataraman
Department of Electrical Engineering
Rochester Institute of Technology
Rochester, NY 14623 USA
jnvee@rit.edu

***Abstract*—**The electromagnetic (EM) spectrum ranging from DC to Gamma rays and beyond is a vast natural resource that has been very valuable for mankind. With the rapid advances of medical technology, Radio Frequency (RF) techniques are becoming increasingly popular for a variety of applications such as non-invasive diagnosis, continuous monitoring of physiological data, communication between implanted devices, and communication to external devices. In this paper, we review medical uses of EM energy.

Keywords - EM spectrum, therapy, X rays, Gamma rays, ionizing radiation, UWB, FCC.

I. INTRODUCTION

Therapeutic applications of EM energy can be broadly classified into two groups as (1) conventional and (2) emerging therapies. Examples of conventional therapies are: a) hyperthermia (thermal therapy), b) MRI, c) X-ray and d) CT scan. In the emerging category are a) THz Imagery and b) implantable devices. Examining the EM spectrum one can observe a dichotomy at about 10^{15} Hz to delineate non-ionizing and ionizing radiation. At f =10^{15} Hz, the quantum of energy associated with the EM radiation is E = hf ~ 4 eV where 'h' is the Planck's constant. Medical applications are possible at many frequencies such as DC, RF, Microwave, X rays and Gamma rays.

II. EXAMPLE THERAPIES

A. Ionizing Radiation - Gamma Rays, X-Rays and UV

All three of these are ionizing radiation and can cause cancer in high doses. They also have beneficial applications in appropriate and low doses. For Gamma Rays, frequency is 10^{24} Hz, wavelength is 300 femto-m (size of an atom) and the photon energy is 4 BeV. Gamma rays have beneficial applications as well, such as: a) Gamma ray camera in Thallium test of the human heart, b) removing decay-causing bacteria in many food items, and c) screening merchant ship containers at US ports. Regarding X- rays, frequency is 10^{18} to 10^{21} Hz, wavelength is (300pico-m to 300 femto-m) and the photon energy is 4keV to 4MeV. It is an ionizing radiation that can cause cancer in high doses. The beneficial applications are radiography and spectrography. UV radiation frequencies are 10^{15} – 10^{18} Hz, wavelength of 10s to 100's of nm and the photon energy is 4 to 4 keV. While exposure to excessive UV radiation from sun is harmful, beneficial use of UV radiation is water sterilization or removal of pathogens.

B. Non-Ionizing Radiation

Examples of therapeutic uses of microwave radiation are: a) Microwave Balloon Angioplasty (MBA) wherein dipole or helical antenna current can heat the inner plaque surface in an artery [1]. RF ablation in the frequency range of (100 kHz to 10 MHz) is possible to treat arrhythmia caused by abnormal electrical pathways in the human heart. Catheters are threaded to the site and ablation is performed by applying a voltage between the catheter electrode 2 to 3mm and a ground plane 10 cm x 15 cm attached to the patient's back.

C. Emerging Therapies

FCC has classified UWB defined as signals having a percent bandwidth more than 20%, or an absolute bandwidth of at least 500MHz. Characteristics of UWB are: [3.1 to 10.6 GHz] band-width of 7500 MHz. High data rate capability and spectral power density limits (80 nW/MHz) on emission have opened up many technologies including medical applications ex: implantable devices; Wireless Capsule Endoscopy (WCE) is a "camera in a pill" the size of a large vitamin pill is a diagnostic tool. The applications described in this paper and many others will be presented.

D. Noninvasive Therapies

Amongst the most interesting emerging RF technology is a class of noninvasive glucose monitoring techniques. The most notable ones are infrared spectroscopy, optical coherence tomography, Raman spectroscopy, ocular spectroscopy and impedance spectroscopy. Feasibility studies have been shown [2] that an antenna's resonant frequency can track, in real time, changes in glucose concentration, from which glucose levels can be estimated. A recent release, the GlucoTrack uses ultrasound, electromagnetic and thermal techniques. Another noninvasive system is developed by Google, which is a contact lens that measures the glucose level in tears and extracts the data wirelessly.

C. Body Sensor Networks (BSN)

Body sensor networks provide a continuous monitoring of physiological data with an integrated hardware and software platform [3]. Wearable or implanted wireless sensors, gather data and are either locally processed or encrypted and transmitted to a server. BSN has the potential of revolutionizing healthcare. Some examples of continuous monitoring devices that have proved to be very effective are management of acute diabetes with implanted insulin delivery, implanted multi-programmable brain stimulators, implanted cardio-defibrillator for prevention of life threatening events such as sudden cardiac arrest, or arrhythmia.

REFERENCE

[1] R. Habash , "Bioeffects and Therapeutic Applications of Electromagnetic Energy", CRC Press , 2008.
[2] Sidley M. and Venkataraman J., "Feasibility of Blood Glucose Estimation from Real Time Monitoring", Proc. IEEE Ant and Propagation Intl. Sym., Orlando, July 8-12, 2013.
[3] Lo, B. P. L. and Yang, G. "Key Challenges and Current Implementations of Body Sensors" International Workshop on Wearable and Implantable Body Sensor Networks (April 2005)