Minor Project Report

On

CANSAT FOR MEASUREMENT OF ELECTROMAGNETIC RADIATION

This Minor Project report is submitted in
Partial fulfillments of the requirements for sixth semester term work in
Electronics & Telecommunication Engineering

Submitted by

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(An Autonomous Institute Affiliated to RTM Nagpur University)

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2018-2019

March -2019

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2018-2019

Certificate

This is to certify that the Minor project titled

‘CANSAT FOR MEASUREMENT OF ELECTOMAGNETIC RADIATION’

is in partial fulfillment of the requirement for sixth semester term work in

Electronics & Telecommunication Engineering of Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur is a bonafide work carried out & completed under my guidance & supervision during the academic year

2018-2019

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ACKNOWLEDGEMENT

It is our privilege to express our sincerest regards to our project guider,

Dr. Bhushan Vidhale & Dr.K.A.Akant

for their valuable inputs, able guidance, encouragement, whole-hearted cooperation and constructive criticism throughout the duration of our project.

We deeply express our sincere thanks to our Head of Department

Dr. Prof. M.M.Khanapurkar

for encouraging and allowing us to present the project on the topic

'CANSAT FOR MEASUREMENT OF ELECTROMAGNETIC RADIATION'

at our department premises for the partial fulfillment of the requirements leading to the award of BE degree.

We take this opportunity to thank all our lecturers who have directly or indirectly helped our project. I have to appreciate the guidance given by other supervisor as well as the panels especially in our project presentation that has improved our presentation skills thanks to their comment and advices.

I would like to thank all my friends and especially my classmates for all the thoughtful and mind stimulating discussions we had, which prompted us to think beyond the obvious.

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Declaration

We hereby declare that the project titled "**CANSAT FOR MEASUREMENT OF ELECTROMAGNETIC RADIATION**" submitted herein has been carried out by us in the Department of Electronics and Telecommunication Engineering of G.H. Raisoni College of Engineering, Nagpur. The work is original and has been submitted and has not been submitted earlier as a whole or in part for the award of any degree/ diploma at this or any other Institution / University.

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Abstract

Along with development of electronics and software technology, amount of electromagnetic (EM) radiation, which expose to people, has significantly risen. For people who uses or do not use technology, it is of great importance that they should have enough information about EM radiation exposing them.

So, not only EM radiation is described, but also effects of EM radiation sources are researched in this study. EM radiation is mainly divided into two parts as ionizing and non-ionizing radiation.

Technologies which we mostly use in daily life and whose radiation we are exposed to are chiefly telecommunication systems. EM radiation emitted by these systems is non-ionizing type due to their low energy levels. However, exposure of ionizing EM radiation is almost not present and its exposure is personally arisen at only special situations.

As examples for this type of EM radiation, medical radiography and security screening systems using x-ray may be said. In this context, each person needs to be informed about these topics and cautious for human health. In respect of health of next generation, definition, types and sources of EM radiation have great importance to be learnt.

Keywords –Electromagnetic Radiation Sources, Electromagnetic Field, Electromagnetic Spectrum

INTRODUCTION

Last decade wireless telecommunication technologies have developed significantly. The radio waves used in mobile telephony are, like visible light and X-rays, electromagnetic waves that consist of both an electric and a magnetic component which vary periodically with time. The of variation determines the wave properties and their uses. Radio waves, which can be used for various types of communication, are found in the lower part of the spectrum and classified as non-ionizing radiation. Many of the existing safety guidelines governing microwave/RF/ELF, controlled /uncontrolled exposure are based on intensity of exposure that produces heating of tissues due to energy absorption leading to temperature rise and manifested as thermal effects. On the other hand, though the human body could compensate for and handle the extra energy load through the thermoregulatory mechanisms without obvious increase in temperature, stress could still develop. Indeed, we can utilize mobile phone in a way we desire, that is, we can turn it off in order to avoid its radiation when we do not want to use it. However, we cannot control base stations; moreover, we do not know where they are mounted. So, radiation of base stations has more importance than that of mobile phones in this respect. International Telecommunication Union (ITU-T) has issued several recommendations to regulate the nonionizing radiation emitted from mobile base stations, namely, K.52. This work concentrates on the long term measurements during specific time at specific points and 24 hours at a fixed point. Second type of this study is focus on mapping road measurements that show the power density in some roads in Sana'a on the map. The measurements for every point are registered but the maximum value is taken. The frequency and power density are registered for every band by the measurement device. Yet, then maximum readings with its frequencies that reveal which company they belong are taken. The readings are determined by several units (dBm, mW/m^2, $\mu W/cm^2$, and V/m). The measurements are carried out via using a spectrum analyser device, manufactured by Aaronia Company in Germany. It includes a spectrum analyser (SPECTRAN®HF-2025E) at frequency range from 700 MHz to 2.5 GHz, with an antenna (HyperLOG®7025), and a new antenna (OmniLOG®9000).

Although much work has been done toward measuring RFR, most techniques reported, such as for example the study developed by Leen Verloock et al. on temporal 24-hours assessment of radio frequency exposure in schools and homes. For the first time, temporal 24-hour measurements of all present RF signals, including LTE (Long Term Evolution), are performed with accurate spectral narrowband equipment in these environments where children are present. The largest maximal variations are obtained for the cordless telephone (DECT) signals (10.6 dB) and for the Wi-Fi 2.4 GHz signals (12.7 dB), while variations of broadcasting signals and telecommunication signal were much lower namely, 2.9 dB and33 dB, respectively.

In the study presented by Agence Nationale des Fréquences , relating to electromagnetic field strength measurements in Yemen. This assignment will give the opportunity to make measurement between 100 kHz and 3 GHz, and to train some Yemeni engineers on the handling of measurement equipment's. The measurements took place in the 4 main industrial towns in Yemen. This choice is justified by the presence of the highest density of radio networks in these areas: Sanaa, Taiz, Eden, and Hodidah. The study reported at that time (xx) that all levels measured were compliant with ICNIRP reference levels for general public exposer. Finally, we quote the measurement presented by Lalrinthara Pachuau et al. [10]. RF radiation from mobile phone towers and their effects on human body. In this paper, power density of RF radiation have been measured in close proximity (less than 50 m) to mobile base station Global system for Mobile Communications 900 (GSM 900) at the selected locality in Aizawal and Mizoran, India. Absolute power densities have been measured at some selected houses. Frequency spectrum was analysed at different sites. Different symptoms of RF exposure on human body are studied and results is analysed in this paper.

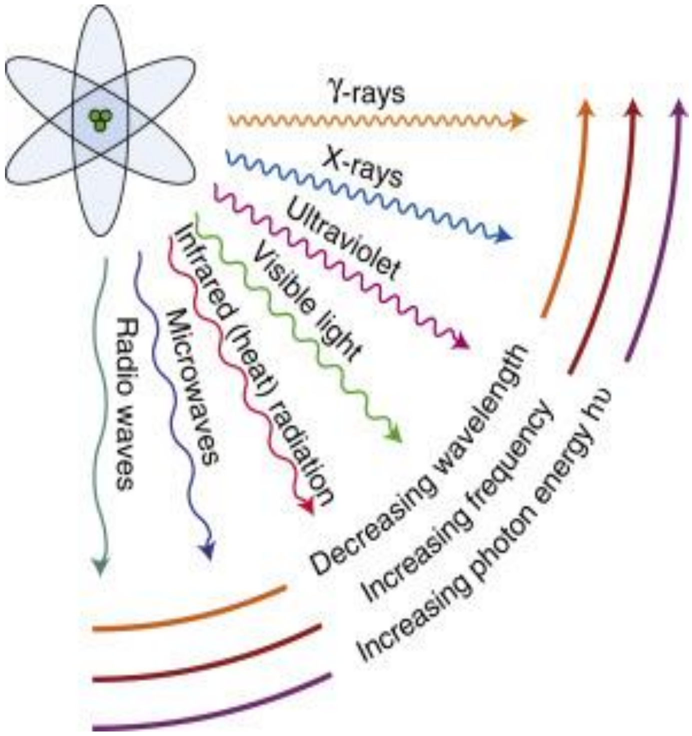

Fig. 1. Radiation waves and their layers

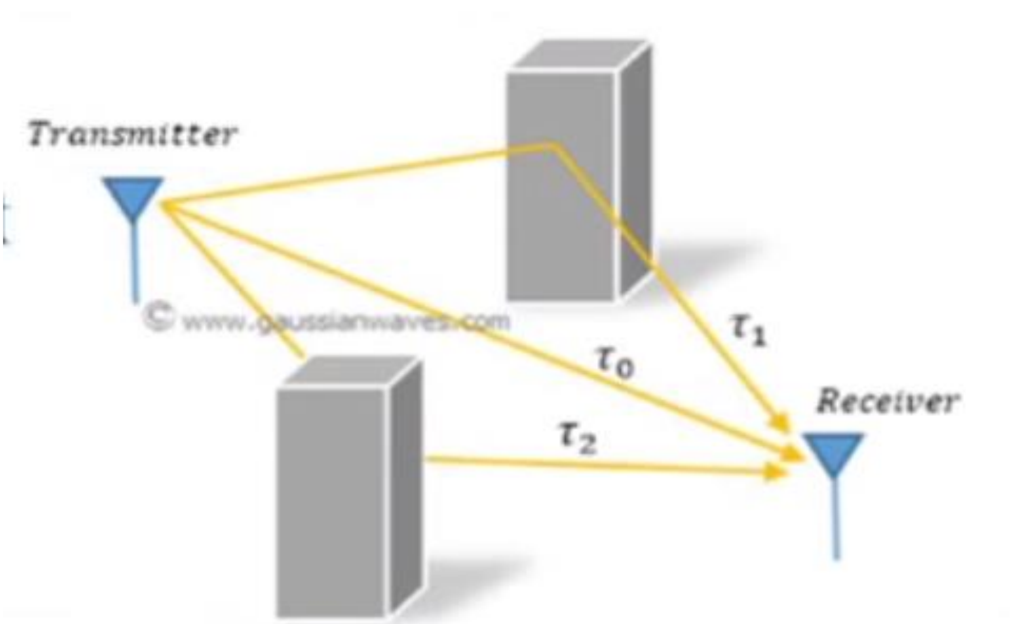

Fig. 2. Transmitter to Receiver channel

Electromagnetic Radiation

The electromagnetic radiation consists of electromagnetic waves, which are synchronized oscillations of electric and magnetic fields that propagate at the speed of light, which, in a vacuum, is commonly denoted c. In homogeneous medium the oscillations of this fields are get mutually right angled to each other and also to the energy and wave propagation.

A. Alpha Radiation

Alpha radiation consists of positively (+2) charged particles emitted from the nucleus of an atom in the process of decay. These particles are also very dense which, with their strong positive charge, precludes them from penetrating more than an inch of air or a sheet of paper. Because of this, Alpha particles are not a serious health hazard, except when they are emitted from within the body as a result of ingestion, for instance, when their high energy poses an extreme hazard to sensitive living tissue. A weak form of ionizing radiation detectable on some models of Geiger counters, typically those that incorporate a thin mica window at one end of the Geiger -Mueller tube.

B. Beta Radiation

Beta radiation consists of negatively charged (-1) particles emitted from an atom in the process of decay. These particles are relatively light and can penetrate somewhat better than an Alpha particle, though still only through a few millimeters of aluminum at best. If ingested, Beta radiation can be hazardous to living tissue. A relatively weak form of ionizing radiation detectable on many Geiger counters, generally dependent on the thickness of the Geiger-Mueller tube wall or the existence of a window at the end of the tube.

C. Gamma Radiation

Gamma radiation represents one extreme of the electromagnetic spectrum, particularly that radiation with the highest frequency and shortest wavelength. (That same spectrum also includes the more familiar X-rays, ultraviolet light, visible light, infrared rays, microwaves, and radio waves, listed in order of decreasing frequency and increasing wavelength from Gamma rays.) Gamma rays can pass through virtually anything, and are effectively shielded or absorbed only by materials of high atomic weight such as lead. Gamma rays are produced naturally by the sun and other bodies in outer space, their transmission to earth is known as "cosmic radiation". A very powerful and potentially very dangerous type of ionizing radiation detectable on virtually all Geiger counters.

D. Background Radiation

Certain minerals that makeup part of the earth containing the radioactive elements Uranium and/or Thorium also emit Gamma rays. This, along with the cosmic radiation (Gamma rays which come from the sun and other stars), combine to produce the "background count" of a Geiger counter. This might typically be in the range of 15 to 60 counts per minute but will vary depending upon your location on the earth, your altitude, and the efficiency of the Geiger counter. The background count should always be factored in or "subtracted" from the overall reading derived from a specific radioactive source. Common background radiation goes from 0.041μSv/h to 0.081μSv/h (3650 - 7200μSv/year).

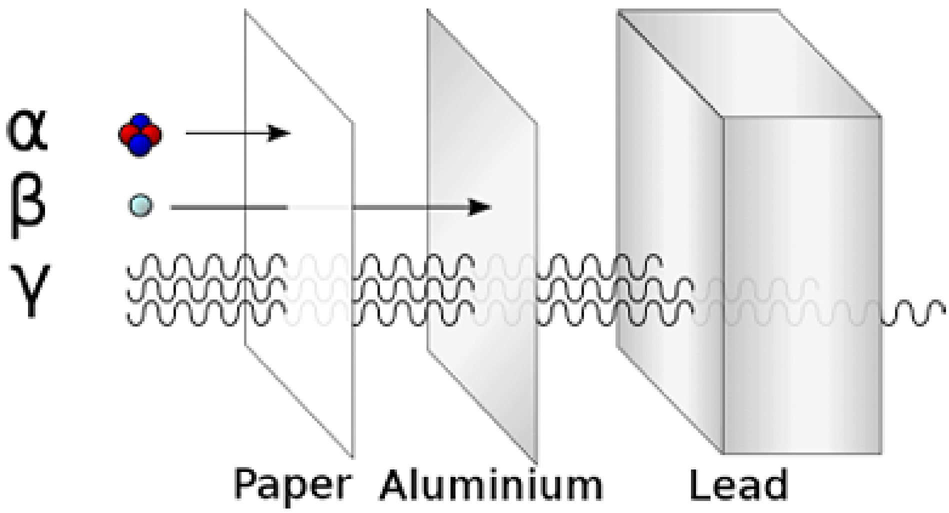

Fig. 3. Alpha, Beta and Gamma Radiation

Electromagnetic Spectrum

There are four, and only four known forces in the universe (although the so-called dark energy hints at another). These are, in order of strength, the nuclear strong force, the electromagnetic force, the nuclear weak force and the gravitational force. The two nuclear forces exert their influence over only very very short (nuclear) distances, and apart from holding all matter together do not directly influence us in everyday life. It is gravity and particularly electromagnetism that are of direct concern to us in our daily interactions. Gravity springs from the property of matter we call mass, while electromagnetic effects derive from the property we call charge. When a charge is stationary, it has around it an electrostatic field. If it moves with a constant velocity it produces a magnetic field, and when it accelerates or declerates it generates electromagnetic radiation.

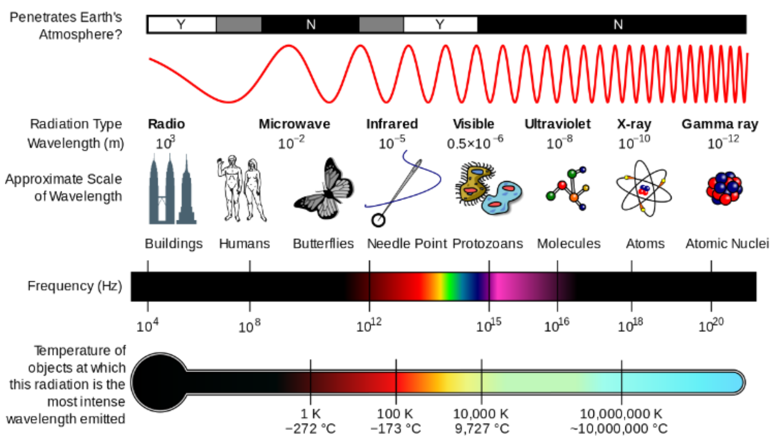

Fig. 4. Electromagnetic Spectrum

MEASUREMENT OF ELECTROMAGNETIC RADIATION

EMF measurements are measurements of ambient (surrounding) electromagnetic fields that are performed using particular sensors or probes, such as EMF meters. These probes can be generally considered as *antennas* although with different characteristics. In fact, probes should not perturb the electromagnetic field and must prevent coupling and reflection as much as possible in order to obtain precise results. There are two main types of EMF measurements:

- *broadband measurements* performed using a broadband probe, that is a device which senses any signal across a wide range of frequencies and is usually made with three independent diode detectors;
- *frequency selective measurements* in which the measurement system consists of a field antenna and a frequency selective receiver or spectrum analyzer allowing to monitor the frequency range of interest.

EMF probes may respond to fields only on one axis, or may be tri-axial, showing components of the field in three directions at once. Amplified, active, probes can improve measurement precision and sensitivity but their active components may limit their speed of response.

A. Ideal Isotropic Measurements

Measurements of the EMF are obtained using an E-field sensor or H-field sensor which can be isotropic or mono-axial, active or passive. A mono-axial, omnidirectional probe is a device which senses the Electric (short dipole) or Magnetic field linearly polarized in a given direction.

Using a mono-axial probe implies the need for three measurements taken with the sensor axis set up along three mutually orthogonal directions, in a *X, Y, Z* configuration. As an example, it can be used as a probe which senses the Electric field component parallel to the direction of its axis of symmetry. In these conditions, where E is the amplitude of incident electric field, and θ is the amplitude of the angle between sensor axis and direction of electric field E, the signal detected is proportional to $|E|\cos\theta$ (*right*).

An isotropic (tri-axial) probe simplifies the measurement procedure because the total field value is determined with three measures taken without changing sensor position: this results from the geometry of the device which is made by three independent broadband sensing elements placed orthogonal to each other. In practice, each element's output is measured in three consecutive time intervals supposing field components being time stationary.

B. EMF Meters

An *EMF meter* is a scientific instrument for measuring electromagnetic fields (abbreviated as EMF). Most meters measure the electromagnetic radiation flux density (DC fields) or the change in an electromagnetic field over time (AC fields), essentially the same as a radio antenna, but with quite different detection characteristics.

The two largest categories are single axis and tri-axis. Single axis meters are cheaper than tri-axis meters, but take longer to complete a survey because the meter only measures one dimension of the field. Single axis instruments have to be tilted and turned on all three axes to obtain a full measurement. A tri-axis meter measures all three axes simultaneously, but these models tend to be more expensive.

Electromagnetic fields can be generated by AC or DC currents. An EMF meter can measure AC electromagnetic fields, which are usually emitted from man-made sources such as electrical wiring, while gauss meters or magnetometers measure DC fields, which occur naturally in Earth's geomagnetic field and are emitted from other sources where direct current is present.

C. Sensitivity

As most electromagnetic fields encountered in everyday situation are those generated by household or industrial appliances, the majority of EMF meters available are calibrated to measure 50 and 60 Hz alternating fields (the frequency of European and US main electricity). There are other meters which can measure fields alternating at as low as 20 Hz, however these tend to be much more expensive and are only used for specific research purposes.

D. Active and Passive Sensor

Active sensors are sensing devices which contain active components; usually this solution allows for a more precise measurement with respect to passive components. In fact, a passive receiving antenna collects energy from the electromagnetic field being measured and makes it available at a RF cable connector. This signal then goes to the spectrum analyzer but the field characteristics can be someway modified by the presence of the cable, especially in near-field conditions.

On the other hand, an effective solution is to transfer on an optical carrier, the electric (or magnetic) field component sensed with an active probe. The basic components of the system are a receiving electro-optical antenna which is able to transfer, on an optical carrier, the individual electric (or magnetic) field component picked up and to return it in the form of an electrical signal at the output port of an opto-electric converter.

The modulated optical carrier is transferred by means of a fiber-optic link to a converter which extracts the modulating signal and converts it back to an electrical signal. The electrical signal thus obtained can be then sent to a spectrum analyzer with a 50 Ω common RF cable.

EMR in SYSTEM

EMR forms the basis for remote sensing (RS), which has gained great relevance in studying and monitoring of hazards (Tralliet al., 2005). RS is divided into passive and active methods: reflected or emitted radiation is recorded (passive), or the response of an artificial signal is received (active, for example radar).

To detect or monitor phenomena related to hazards, a careful selection of the appropriate part of the EMS is critical. Most Earth observation instruments, such as regular cameras, passively record EMR in the visible part of the spectrum (approximately 0.4–0.7 mm [106 m]), and in the adjacent near-infrared (NIR, 0.7–1.4 mm). This is ideal to detect the state of vegetation, as the cell structure of healthy green leaves strongly reflects NIR energy, which declines in stressed leaves. Vegetation stress possibly leading to crop failure can thus be detected early.

Less common are detectors that record thermal infrared (TIR) radiation (8–14 mm), for example, to measure sur-face temperatures. The main forms of active RS are Lidar(laser scanning), radar, and sonar (light/radio/sound detection and ranging, respectively). Lidar uses very shortwaves between about 400 nm and 1 mm, whereas radar waves range between approximately 0.1–1 m. Sonar uses acoustic waves several meters long. An advantage of all active sensors is that they are largely weather-independent and may also be applied at night. EMR is also the basis for other tools important in hazard work.

For example, GPS, which uses radio waves of about 20 cm, marginally more than other important communication systems, such as wireless networks. EMR itself can constitute a hazard to living organisms. Well-known examples of radiation to which exposure should be minimized or avoided are X-rays (wavelength of a few nm), ultraviolet rays than cause sunburn (about 0.3–0.4 mm), but also microwaves (wavelength of about 12 cm).

Literature review

In recent years, due to technology advances human life are subjected to high level of Electromagnetic emission, Effects of the Electromagnetic Radiation (EMR) on the human's health is one most significant concern in the world. The present paper recognizes of the possible health hazard on the humanity by exposure of Electromagnetic radiations (EMR).

Potential of electromagnetic radiation can radiate through transmission lines which are very close to human's life. The effects of the radiations are classified to two main categories that are known as ionization and non-ionization radiation may have ionization radiations have high energy that impact on the atoms in the cells, and lead to change their natural status, however they can be too dangerous and lethal, and they will lead to cancer and other diseases.

On the other hand, non-ionization radiations that consist of electromagnetic radiation such as communication waves, microwaves, electrical waves. This kind of radiation cannot change structure of atom; they just impact on their manner that it can lead to irreparable hurts.

The International EMF project was established at the World Health Organization (WHO) in 1996 to provide a forum for a coordinated international response to health concerns raised by exposure to electromagnetic fields. This is a major project, the purpose of which is to establish one way or the other whether there is a health risk arising from exposure to electromagnetic radiation is on-going. While a number of interim reports are being produced, it is not expected that a final report will be available until the early years of the next century.

There are currently no legal limits in Ireland to limit exposure to workers or the public from non-ionizing electromagnetic radiation. There are, however, health and safety guidelines included in the 1996 Department of the Environment guidelines for the erection of mobile phone masts.

Until the early part of this century, exposure to electric and magnetic fields among the general public was very low. With the advances in energy production, energy distribution, telecommunications and broadcasting that have been witnessed throughout this cenrury, particularly in the last few decades, there has been a proportional rise in the exposure of the population to electric and magnetic fields associated with these technologies. The use of mobile phones, for example, has increased exponentially since they were first marketed in 1983 (Buffler, 1996).

While there are clear and obvious benefits to society from each of these forms of technology, there have been increasing concerns expressed about the safety of exposure to the electric and magnetic fields that they generate. There has been a considerable increase in research effort in keeping also with the increasing level of population concern about their use This research covers a number of different disciplines such as physics, engineering, biological sciences such as biochemistry, genetics and physiology, clinical medicine and epidemiology.

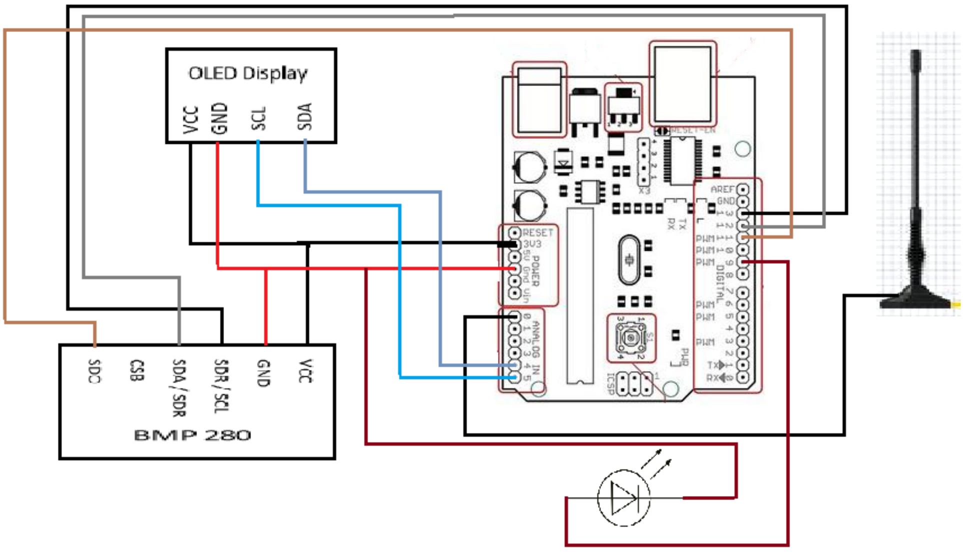

Fig. 5. Block Diagram of CANSAT for measurement of Electromagnetic Radiation

Methodology

A. Measurement Process

Objective: Executing the process to measure electromagnetic radiation in georeferenced mode called “drive test” through each zone selected according to the previous process. Technological systems and advanced tools are used to speed up the process and to reduce some critical error introduced by the instrument operator. Method steps are described below

1. Automatic taking of broadband measurement: The process of EMF broadband measurement has to be very autonomous and systematic, therefore computer systems of telemetry are used, which take advantage of modern information and communication technologies. At this stage it is necessary to: a) Set all systems to be used and b) Perform broadband EMF measurement by route, here it is important to consider the radiating region type in city streets; if the field region in the city is near and far field, the electric and magnetic fields are measured at all routes. If the far field predominates in the city, the electric field is only measured.

2. Frequency selective measurements for Hotpoints: Results of the broadband field measurement in all routes are compared with the most restrictive limit (MRL) of recommendation ITU-T K.52 by general public (28 V/m). If field value exceeds the MRL in one point, frequency selective measurements will be performed in each point found; these sites are named “Hotpoints”. A spectrum analyzer is used in this stage, in order to identify significant radiation and quantifies field contribution per frequency. The steps for frequency selective measurement are:

   a) identifying the radiation sources (antennas) nearer to measurement site (Hotpoint).
   b) Selecting the proper antennas to spectrum measurement, according to frequency range.
   c) Measuring for 6 minutes with spectrum analyzer and software of automatic spectrum measurement (Example: GeoSpectScanner).
   d) Saving the data.
   e) Sending to measurement web server. This process is repeated by each Hotpoint of the city.

3. Broadband EMF measurement by route: This procedure is included in sub process called “automatic taking of broadband measurement” and it indicates how to perform the broadband measurement by a route. This procedure has to be strictly used by each route of the city. EMF measurement software are utilized in order to achieve a process agile, efficient, systematized and minimum errors, the steps are described below.

   a. Set Measurement Plan by route: It is necessary to define reference of field meter and probes, amount of sites or points to measure, time of data capture by site, sampling rate, start time, component of electromagnetic field to measure (or electric or magnetic.
   b. Set measuring instrument according to Measurement Plan: Broadband Field meter and GPS are initialized; the setting parameters and the parameters of remote connection are adjusted in equipment (capture time, sampling rate, and field component to measure)

c. Place instruments in a site of the route: The equipment have to be installed on vehicle. Furthermore, the Broadband EMF meter has to be far over 20 centimeters from any metallic surface. The vehicle and instruments have to be motionless in site in order to avoid alterations and noise in the measurement; also, in this case each site of a route is located at the midpoint of each street block.
d. Capture and tabulate data from instruments: To take data from EMF meter and GPS as preset time marked in the Plan. The electromagnetic field and geographic coordinates are automatically captured by a computer with the measurement software at set times.
e. Check data: The data are reviewed in this step, the operator looks up that there are not errors in data, null data and the process has finished correctly. If the data are not correct, the measurement process will be repeated in site.
f. Send data to a database server: If there is Internet connection in site, data shall be send to a central measurement server so that the general public can access to this information.

B. Analysis Data Process

1) Statistic analyze of measurement: It performs the descriptive statistic to all data, average, maximum and minimum values, standard deviation, variance and uncertainty are calculated; probability distribution and accumulative probability graphs are realized in order to analyze EMF strength of all measurement sites and to compare them with limits for human exposure to electromagnetic field of recommendation

2) Performing of continuous radiation map of the city: A map of continuous radiation is performed through the measured data of electromagnetic field in each site which they are related with geographic coordinates. Then, advanced techniques of spatial interpolation are used.

Design and Implementation

Electromagnetic radiation consists of electromagnetic waves, which are synchronized oscillations of electric and magnetic fields that propagate at the speed of light, which, in a vacuum, is commonly denoted *c*. In homogeneous, isotropic media, the oscillations of the two fields are perpendicular to each other and perpendicular to the direction of energy and wave propagation, forming a transverse wave.

A. Ground Based Observation

Monitoring of the Sun and its activity is a task of growing importance in the frame of space weather research and awareness. Major space weather disturbances at Earth have their origin in energetic outbursts from the Sun: solar flares, coronal mass ejections and associated solar energetic particles. In this review we discuss the importance and complementarity of ground-based and space-based observations for space weather studies. The main focus is drawn on ground-based observations in the visible range of the spectrum, in particular in the diagnostically manifold Hα spectral line, which enables us to detect and study solar flares, filaments, filament eruptions, and Moreton waves and the electromagnetic waves. Existing Hα networks such as the GONG and the Global High-Resolution Hα Network are discussed. As an example of solar observations from space weather research to operations, we present the system of real-time detection of Hα flares and filaments established at Kanzelhöhe Observatory (KSO; Austria) in the frame of the ESA Space Situational Awareness programme. During the evaluation period 7/2013 - 11/2015, KSO provided 3020 hours of real-time Hα observations at the SWE portal. In total, 824 Hα flares were detected and classified by the real-time detection system, including 174 events of Hα importance class 1 and larger. For the total sample of events, 95\% of the automatically determined flare peak times lie within ±5 min of the values given in the official optical flares reports (by NOAA and KSO), and 76\% of the start times. The heliographic positions determined are better than ±5∘. The probability of detection of flares of importance 1 or larger is 95\%, with a false alarm rate of 16\%. These numbers confirm the high potential of automatic flare detection and alerting from ground-based observatories.

The BMP280 consists of a Piezo-resistive pressure sensing element and a mixed-signal ASIC. The ASIC performs A/D conversions and provides the conversion results and sensor specific compensation data through a digital interface. The pressure sensor (BMP 280) is connected to the circuit so that it helps us to calculate the temperature, humidity and pressure when the CANSAT is in the air. A set of oversampling settings is available ranging from ultra-low power to ultra-high resolution setting in order to adapt the sensor to the target application. The settings are predefined combinations of pressure measurement oversampling and temperature measurement oversampling. The BMP280 measurement period consists of a temperature and pressure measurement with selectable oversampling. After the measurement period, the data are passed through an optional IIR filter, which removes short-term fluctuations in pressure.

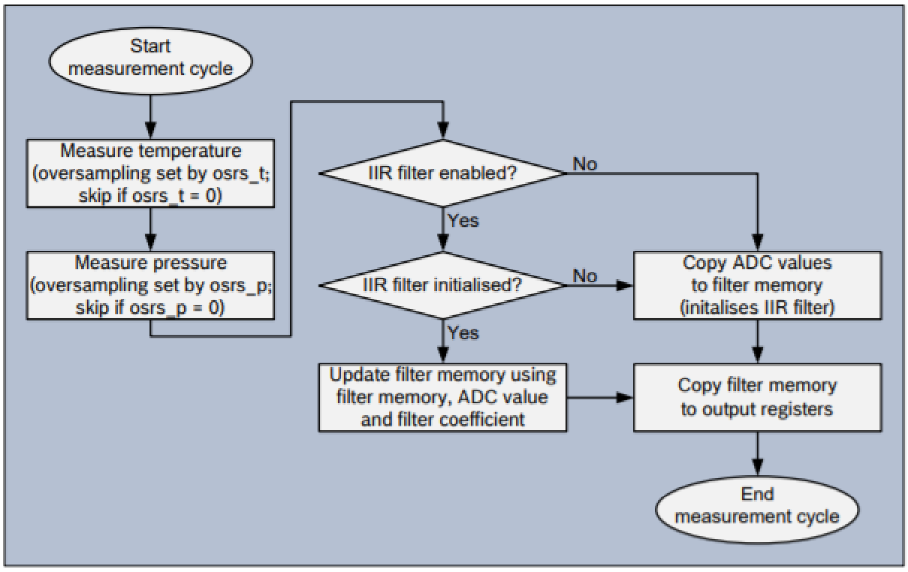

Fig. 6. Measurement of Temperature, Humidity and Pressure through BMP 280

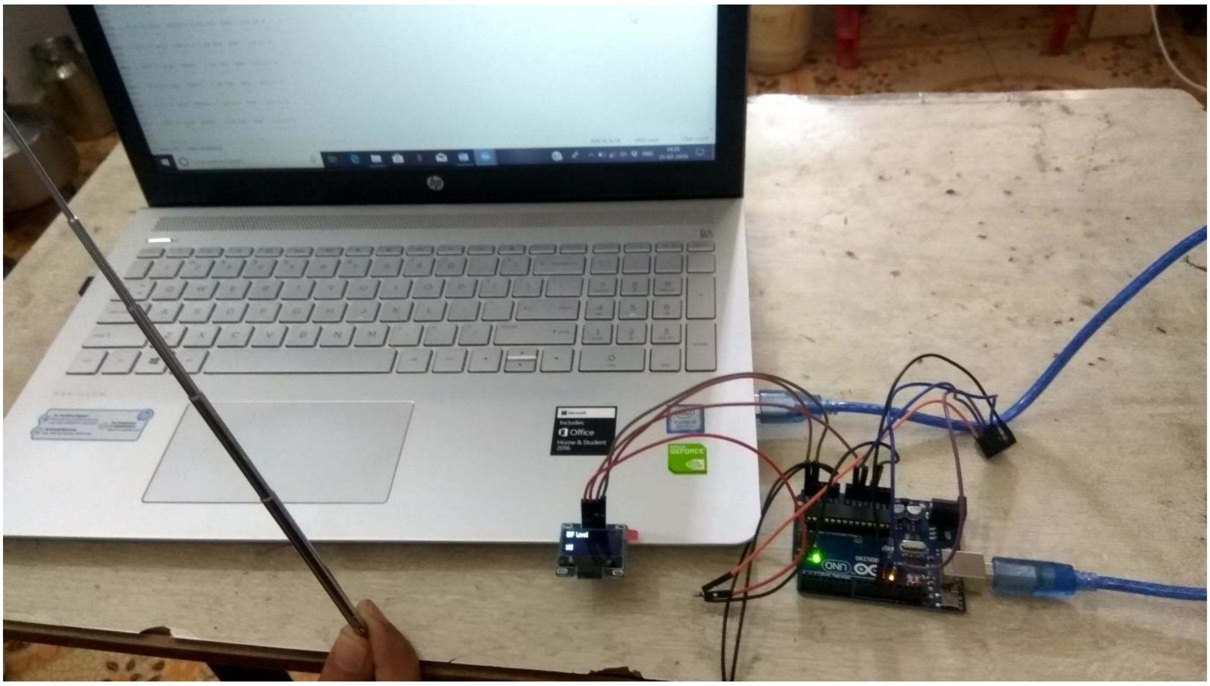

Fig. 7. Design and Implementation of Electromagnetic Radiation measuring CANSAT

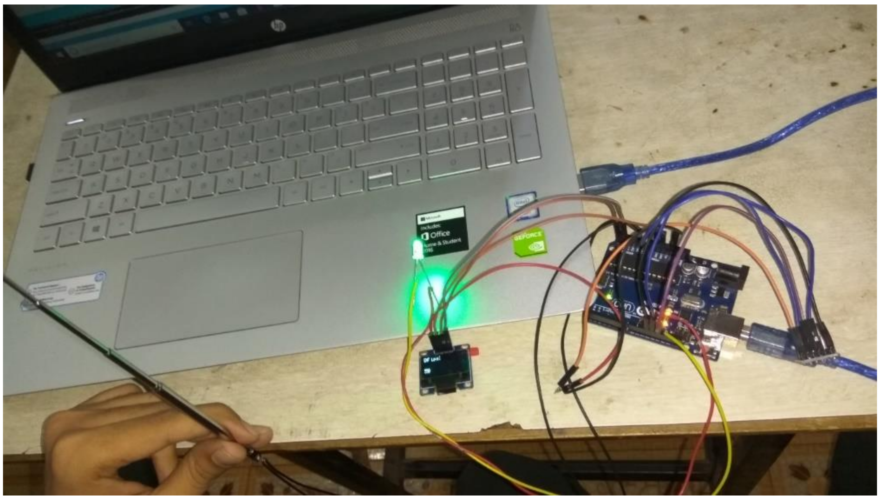

Fig. 8. Measuring of Electromagnetic Radiation

B. Arduino Code

```
#include <SPI.h>
#include <Wire.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>
#define OLED_RESET 4
Adafruit_SSD1306
display(OLED_RESET);
#define NUMFLAKES 10
#define XPOS 0
#define YPOS 1
#define DELTAY 2
#define LOGO16_GLCD_HEIGHT 16
#define LOGO16_GLCD_WIDTH 16
#include <Wire.h>

#define BME280_ADDRESS 0x76
unsigned long int
hum_raw,temp_raw,pres_raw;
signed long int t_fine;

uint16_t dig_T1;
 int16_t dig_T2;
 int16_t dig_T3;
uint16_t dig_P1;
 int16_t dig_P2;
 int16_t dig_P3;
 int16_t dig_P4;
 int16_t dig_P5;
 int16_t dig_P6;
 int16_t dig_P7;
 int16_t dig_P8;
 int16_t dig_P9;
 int8_t  dig_H1;
 int16_t dig_H2;
 int8_t  dig_H3;
 int16_t dig_H4;
 int16_t dig_H5;
 int8_t  dig_H6;

static const unsigned char PROGMEM
logo16_glcd_bmp[] =
{  B00000000, B11000000,
   B00000001, B11000000,
   B00000001, B11000000,
   B00000011, B11100000,
   B11110011, B11100000,
   B11111110, B11111000,
   B01111110, B11111111,
   B00110011, B10011111,
   B00011111, B11111100,
   B00001101, B01110000,
   B00011011, B10100000,
   B00111111, B11100000,
   B00111111, B11110000,
   B01111100, B11110000,
   B01110000, B01110000,
   B00000000, B00110000 };
//int emfLevel = 0;
int ledLevel = 0;
//int pin11= 11;
```

```
void setup() {
  Serial.begin(9600);
pinMode(9, OUTPUT);
display.begin(SSD1306_SWITCHCAPVCC, 0x3C);
display.display();
delay(2000);
display.clearDisplay();
display.setTextSize(1);
display.setTextColor(WHITE);
display.setCursor(0,0);
display.println("EMF Detector");
display.display();
delay(2000);
display.clearDisplay();
uint8_t osrs_t = 1;             //Temperature oversampling x 1
    uint8_t osrs_p = 1;             //Pressure oversampling x 1
    uint8_t osrs_h = 1;             //Humidity oversampling x 1
    uint8_t mode = 3;               //Normal mode
    uint8_t t_sb = 5;               //Tstandby 1000ms
    uint8_t filter = 0;             //Filter off
    uint8_t spi3w_en = 0;           //3-wire SPI Disable

    uint8_t ctrl_meas_reg = (osrs_t << 5) | (osrs_p << 2) | mode;
    uint8_t config_reg    = (t_sb << 5) | (filter << 2) | spi3w_en;
    uint8_t ctrl_hum_reg  = osrs_h;

    Serial.begin(9600);
    Wire.begin();

    writeReg(0xF2,ctrl_hum_reg);
    writeReg(0xF4,ctrl_meas_reg);
    writeReg(0xF5,config_reg);
    readTrim();
}

void loop() {
  int sensorValue = analogRead(A0);
  Serial.println(sensorValue, DEC);
 // tone(9, sensorValue);
   //analogWrite(pin11, sensorValue);
   //emfLevel = analogRead(A5);
ledLevel = map(sensorValue, 0, 1024, 0, 255);
double temp_act = 0.0, press_act = 0.0,hum_act=0.0;
    signed long int temp_cal;
    unsigned long int press_cal,hum_cal;

    readData();

    temp_cal = calibration_T(temp_raw);
    press_cal = calibration_P(pres_raw);
    hum_cal = calibration_H(hum_raw);
    temp_act = (double)temp_cal / 100.0;
    press_act = (double)press_cal / 100.0;
    hum_act = (double)hum_cal / 1024.0;
    Serial.print("TEMP : ");
    Serial.print(temp_act);
    Serial.print(" DegC  PRESS : ");
    Serial.print(press_act);
    Serial.print(" hPa  HUM : ");
    Serial.print(hum_act);
    Serial.println(" %");

    delay(1000);
if(sensorValue > 20){
   display.setTextSize(1);
   display.setTextColor(WHITE);
   display.setCursor(0,0);
   display.println("EMF Level");
   display.setCursor(0,20);
   display.println(sensorValue);
   Serial.println(sensorValue);
   display.display();
analogWrite(9, (ledLevel*5));
display.clearDisplay();
}
else {
   display.setTextSize(1);
   display.setTextColor(WHITE);
   display.setCursor(0,0);
   display.println("EMF Level");
   display.setCursor(0,20);
  display.println("0");
   display.display();
   analogWrite(9, 0);
   delay(100);
   display.clearDisplay();
}
delay(200);
}
```

```
void readTrim()
{
   uint8_t data[32],i=0;                    // Fix
2014/04/06

Wire.beginTransmission(BME280_ADDR
ESS);
   Wire.write(0x88);
   Wire.endTransmission();

Wire.requestFrom(BME280_ADDRESS,2
4);       // Fix 2014/04/06
   while(Wire.available()){
      data[i] = Wire.read();
      i++;
   }


Wire.beginTransmission(BME280_ADDR
ESS);    // Add 2014/04/06
   Wire.write(0xA1);                        //
Add 2014/04/06
   Wire.endTransmission();                  //
Add 2014/04/06

Wire.requestFrom(BME280_ADDRESS,1
);        // Add 2014/04/06
   data[i] = Wire.read();                   //
Add 2014/04/06
   i++;                                  // Add
2014/04/06


Wire.beginTransmission(BME280_ADDR
ESS);
   Wire.write(0xE1);
   Wire.endTransmission();

Wire.requestFrom(BME280_ADDRESS,7
);        // Fix 2014/04/06
   while(Wire.available()){
      data[i] = Wire.read();
      i++;
   }
   dig_T1 = (data[1] << 8) | data[0];
   dig_T2 = (data[3] << 8) | data[2];
   dig_T3 = (data[5] << 8) | data[4];
   dig_P1 = (data[7] << 8) | data[6];
   dig_P2 = (data[9] << 8) | data[8];
   dig_P3 = (data[11]<< 8) | data[10];
   dig_P4 = (data[13]<< 8) | data[12];
   dig_P5 = (data[15]<< 8) | data[14];
   dig_P6 = (data[17]<< 8) | data[16];
   dig_P7 = (data[19]<< 8) | data[18];
   dig_P8 = (data[21]<< 8) | data[20];
   dig_P9 = (data[23]<< 8) | data[22];
   dig_H1 = data[24];
   dig_H2 = (data[26]<< 8) | data[25];
   dig_H3 = data[27];
   dig_H4 = (data[28]<< 4) | (0x0F &
data[29]);
   dig_H5 = (data[30] << 4) | ((data[29] >>
4) & 0x0F); // Fix 2014/04/06
   dig_H6 = data[31];
// Fix 2014/04/06
}
void writeReg(uint8_t reg_address, uint8_t
data)
{

Wire.beginTransmission(BME280_ADDR
ESS);
   Wire.write(reg_address);
   Wire.write(data);
   Wire.endTransmission();
}


void readData()
{
   int i = 0;
   uint32_t data[8];

Wire.beginTransmission(BME280_ADDR
ESS);
   Wire.write(0xF7);
   Wire.endTransmission();

Wire.requestFrom(BME280_ADDRESS,8
);
   while(Wire.available()){
      data[i] = Wire.read();
      i++;
   }
   pres_raw = (data[0] << 12) | (data[1] <<
4) | (data[2] >> 4);
   temp_raw = (data[3] << 12) | (data[4]
<< 4) | (data[5] >> 4);
   hum_raw  = (data[6] << 8) | data[7];
}
```

```
signed long int calibration_T(signed long
int adc_T)
{

   signed long int var1, var2, T;
   var1 = ((((adc_T >> 3) - ((signed long
int)dig_T1<<1))) * ((signed long
int)dig_T2)) >> 11;
   var2 = (((((adc_T >> 4) - ((signed long
int)dig_T1)) * ((adc_T>>4) - ((signed long
int)dig_T1))) >> 12) * ((signed long
int)dig_T3)) >> 14;

   t_fine = var1 + var2;
   T = (t_fine * 5 + 128) >> 8;
   return T;
}

unsigned long int calibration_P(signed
long int adc_P)
{
   signed long int var1, var2;
   unsigned long int P;
   var1 = (((signed long int)t_fine)>>1) -
(signed long int)64000;
   var2 = (((var1>>2) * (var1>>2)) >> 11)
* ((signed long int)dig_P6);
   var2 = var2 + ((var1*((signed long
int)dig_P5))<<1);
   var2 = (var2>>2)+(((signed long
int)dig_P4)<<16);
   var1 = (((dig_P3 *
(((var1>>2)*(var1>>2)) >> 13)) >>3) +
((((signed long int)dig_P2) *
var1)>>1))>>18;
   var1 = ((((32768+var1))*((signed long
int)dig_P1))>>15);
   if (var1 == 0)
   {
      return 0;
   }
   P = (((unsigned long int)(((signed long
int)1048576)-adc_P)-(var2>>12)))*3125;
   if(P<0x80000000)
   {
     P = (P << 1) / ((unsigned long int)
var1);
   }
   else
   {
      P = (P / (unsigned long int)var1) * 2;
   }
   var1 = (((signed long int)dig_P9) *
((signed long int)(((P>>3) *
(P>>3))>>13)))>>12;
   var2 = (((signed long int)(P>>2)) *
((signed long int)dig_P8))>>13;
   P = (unsigned long int)((signed long
int)P + ((var1 + var2 + dig_P7) >> 4));
   return P;
}

unsigned long int calibration_H(signed
long int adc_H)
{
   signed long int v_x1;

   v_x1 = (t_fine - ((signed long
int)76800));
   v_x1 = (((((adc_H << 14) -(((signed
long int)dig_H4) << 20) - (((signed long
int)dig_H5) * v_x1)) +
           ((signed long int)16384)) >> 15) *
(((((((v_x1 * ((signed long int)dig_H6)) >>
10) *
           (((v_x1 * ((signed long
int)dig_H3)) >> 11) + ((signed long int)
32768))) >> 10) + (( signed long
int)2097152)) *
           ((signed long int) dig_H2) +
8192) >> 14));
  v_x1 = (v_x1 - (((((v_x1 >> 15) * (v_x1
>> 15)) >> 7) * ((signed long int)dig_H1))
>> 4));
  v_x1 = (v_x1 < 0 ? 0 : v_x1);
  v_x1 = (v_x1 > 419430400 ? 419430400
: v_x1);
  return (unsigned long int)(v_x1 >> 12);
}
```

Prior Art Search

This is a very large field of research as considering the effect of electromagnetic radiation on humans as well on other living beings as well as electric and electronic devices. There are many small devices developed which are used for checking the radiation by mobile.

But there is no development of CANSAT for checking the electromagnetic radiation level. So we are developing the system which measures the required data and sends it to the ground station.

CONCLUSION

A radiation monitoring method was designed and tested during measurement campaigns at city urban zones by covering 70% of Bucaramanga city area; it was registered around 52 points per Km2 for a total amount of 564 measured points. An iterative and agile process was explained and accomplished into a practical and semi-automatic way to record field strength of electromagnetic waves by using both broadband field meter and spectrum analyser in order to establish whether regulation norms are being met and to know which factors are contributing to radiation level increasing by means of a spectral view. Also a telecommunications service was developed to measure, send and request on-line for measured data in real time and integrated into a Geographic Information System supported by RadioGis R&D Group with a web platform of Telecommunication services.

The non-ionizing radiation measurement results have proved that there are no violations of Colombian Decree law 195 of 2005 in Bucaramanga, although the electromagnetic contribution of Cellular antennas is relative high, the maximum electric field of the city is below 10% of the strictest electric field limit recommended by ITU-T K52 and average is 1.92% respect to this limit. The probability of not exceeding an electric field of 0.9767 V/m is 90%. A radiation level map was generated by using a interpolation method called Kriggin in order to get a continuous surface that shows the characteristics of electric field in a better way to analyse it. This result shows that residential and educational zones and four main hospitals of the city present a values range of low level, whereas business district and shopping areas (commercial zone) at old city show a relatively medium level of radiation strength between 0.8 and 1.5 V/m. Finally, there was found a high level spot located around the Court house, City Hall and around 2 important shopping centers with radiation levels over 2.0 V/m.

ETHICAL CONSIDERATIONS

We commit ourselves to abide by the ethical code laid down by the IEEE. A few considerations specific to our product are outlined below.

1. Safety may be of concern, if this product will be used in areas of high radiation density. To this effect, we will implement a safety mechanism to ensure that currents do not exceed normal levels.

2. Many Electromagnetic Field Detectors are marketed as Ghost Hunting Devices. As no evidence is currently available to us regarding the viability of this application, we clearly state that our product is not intended for detecting paranormal activity.

3. Developing this product for a doctoral student in the neuroscience program requires that the team not promise to deliver a product that may not meet specifications or may be excessively costly.

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