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ELECTRIC AND MAGNETIC FIELD MANAGEMENT

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ABSTRACT

Natural earth processes and thus climate and human environment are influenced by the Sun–Earth-Moon system which encompasses the atmosphere, hydrosphere and the lithosphere [1]. An accelerated charged particle produces electromagnetic field. In other words, artificial electrical facilities produce power frequency electromagnetic fields. The present article presents that those power frequency fields may disturb working of sensitive electronic equipment, human's biological system. Here it is discussed that the non-ionizing Extremely Low frequency Electromagnetic Fields (ELF EMF) produced due to electrical utilities affects the environment. The influence of ELF EMF around power frequency sources has been evaluated in history & at present, as well and it is found that they have significant effect on technical and health aspects. However, professional organizations like Electrical Power Research Institute of India (EPRI) are also carrying out the field management research. Several research programmes have been initiated on long run to identify exact association of power frequency fields with electrical and electronic instruments and human civilization. The objective of present article is to examine and identify methods to reduce the contact level to electromagnetic fields around the electrical utilities, electronic devices and environment. In the present study, an attempt has been made to analyse the different Maxwell's equations and their applications, effects as well as EMF MGT in different electrical, electronic and biogenic systems. Present article deals almost all the possible issues in concern to power frequency ELF EMF management.

Keywords: *Electromagnetic, Field, Frequency, Management, Environment.*

I. INTRODUCTION

This is a well established fact that the Electrical facilities produce power frequency electromagnetic fields of a range of 10 to 100Hz and these power frequency fields may disturb working of sensitive electronic equipments. Further, human's biological system is reported to be sensitive to this non- ionizing ELF EMF. Now, technical as well as health effects of ELF EMF in the vicinity of power frequency sources has become a history but still its study is a matter of great importance and several researchers are continuing the same. In spite of several studies common and uniform applicable results are not decided technically or clinically. However, professional organizations like EPRI have started their efforts towards field management research. Several research programmes has been initiated on long run to identify exact association of power frequency fields associated to

the impacts made by instruments, humans and environment. The objective of these programmes is to examine and identify the pathways to reduce the level of exposure to electric and magnetic fields around the electrical utilities viz. transmission and distribution lines, substations, electrical utilities and electronics devices as well as environment. EPRI and World Health Organization's (WHO) [2] research programme provides the common platform to all the efforts concentrated towards effects of ELF EMF. It avoids the duplication of work as well as helps to test and evaluate the most promising ideas in this concern so that they can be adopted technically. According to EPRI [3], "EMF management" is to manage the affects of field through its management rather than reduction. The activities such as communication programs, EMF measurement and assessment, research programs, design of power system components with low EMFs, modification of power system to reduce EMF, tracking ground and net current flows, shielding the sources of EMF and the areas occupied by people or sensitive equipments and reduction of exposure to EMF by selective use of space and time are the key factors for the required considerations for the field of EMF management [4].

II. ELECTROMAGNETIC SPECTRUM

Electric and magnetic fields or EMF are weak, invisible fields of energy that exist around anything that carries or uses electric power. The strength of these fields quickly decreases as one move away from the source as per inverse square law [5].

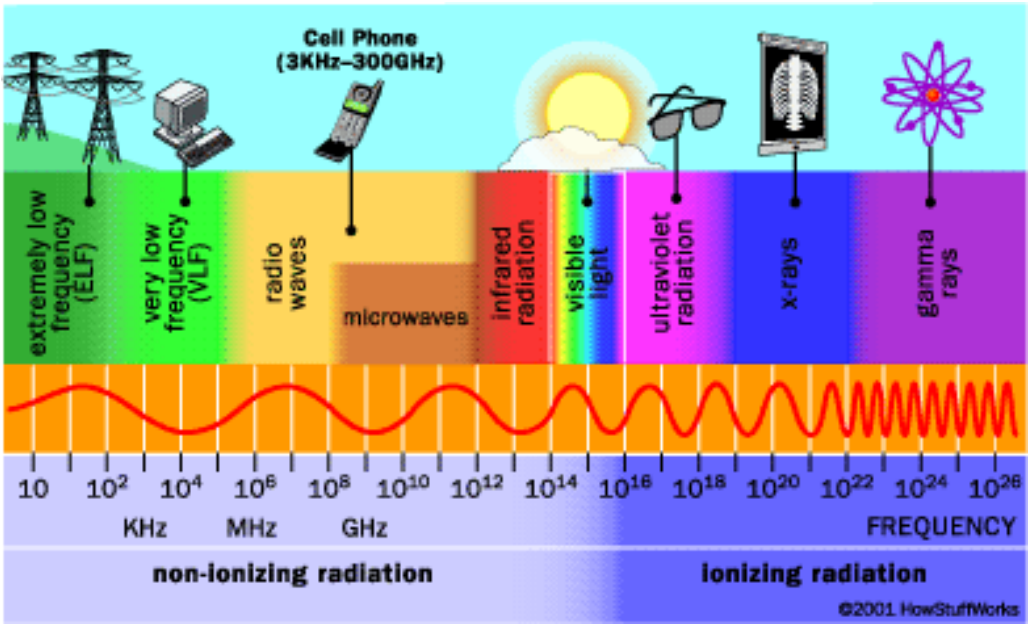

Fig. 1 Dirty Electricity from 2 kHz-150 kHz (transient bursts).

III. EMF MEASUREMENTS & CALCULATIONS

Generally, EMFs are generated by generation plants, electric & electronic equipments, transmission & distribution lines and cables. Electric field is produced by voltage, whereas magnetic field is a result of flow of charge.

The IEEE has set a detailed set up for measurement of electric and magnetic fields [6]. Today, due to the development pace of the all over the world, the High voltage transmission lines of voltage level beyond 132kV to 1500kV have become inside the cities. The magnetic radiation near high voltage transmission lines is very important issue that both the researchers and the population are worry about due to its health & environmental effects. Many previous work states that, it is dangerous not only to people but even to our creatures and children [5]. It had been developed some equations and Matlab Graphic User Interface for double circuit 132kV vertical configuration base on Bio-Savart's law and Maxwell's equations, to make easy for the researchers to calculate the magnetic field, It was applied the superposition method of multiple conductors. Moreover, the measurement was done by using Electric and Magnetic Field Digital Exposure System to collect data in Johor, Malaysia. Based on the conclusions, a good number of parameters were obtained from the measurement of electric and magnetic field that control the magnetic field; the current magnitude, the height of the conductor above the ground and the space between the conductors. The correct phase arrangement can reduce the magnetic field up to 91.5% and the increment of 8m in the height will reduce 79% of magnetic emission.

EMF calculations: In the last few decades, concern about the health effects of EMFs has increased rapidly worldwide. Therefore, the main purpose of calculating the electric and magnetic field sources, such as distribution lines, overhead transmission lines, transmission cables, substations, and residential as well as commercial and industrial sector is to minimize the impact of their dangerous effects. The electric field can be calculated near the power line at 1metre above from ground is essentially vertical along the route of the power line. On the other hand, magnetic fields may be calculated 1metre above from ground is essentially both vertical and horizontal components. The various calculations formulae can be obtained from the well known Maxwell's electro magnetic equations as under [7]:-

I. Gauss' Law of electrostatics

$$\nabla.D(r) = \rho_v$$

II. Gauss' Law of magnetostatics

$$\nabla.B(r) = 0$$

III. Faraday's Law of electromagnetic induction

$$\nabla x\ E(r) = -\frac{\partial B(r)}{\partial t}$$

IV. Ampere's Law

$$\nabla x\ H(r) = J + \frac{\partial D}{\partial t}$$

The EMF may be calculated by determining working voltage of equipment or line, diameter of conductor, number of conductors per bundle, stringing of conductors & string efficiency, distance between phases, distance of conductors from the ground, clearance of the power lines above the buildings, guard wire thickness etc.

IV. HEALTH EFFECTS OF ELECTROMAGNETIC FIELDS

While the term electrical pollution is not a scientific term, there has been a lot of research and case studies done to understand the connection between electromagnetic field radiations and human health. Few of them are the wire and transformers are the carrier of dangerous high frequency currents alongwith circulation of power supply. The high frequency currents emitted by computers and other electronic devices affect home and office environments. Some of the health problems being attributed to electrical pollution include asthma, attention deficit disorder, chronic fatigue syndrome, diabetes, migraine headaches, fibromyalgia and multiple sclerosis, reduction in blood glucose levels, multiple sclerosis, higher PH (reduced acidity), reduction in insomnia, increased cancer incidence, chills, fever and dry throat, reduction in sleeping etc.

Due to some internal factors such as electronic equipment that distorts 50Hz power when the dc power has created ac power. A distorted 50Hz wave is a normal 50Hz current polluted by high frequency voltages and currents [8].

The increasing demand for electricity and the proliferation of computers and other electronic devices have remarkable increase in our exposure to electrical and magnetic fields. These phenomena are a ubiquitous presence in our lives, albeit invisible and odourless. One of the most potent contaminants is electrical and magnetic fields in form of radio-frequency radiations.

Radio-frequency radiations: Dirty current is created by numerous devices and is conducted nearly everywhere. The wiring in the buildings then acts as antennae for the current silently and insidiously assaulting those who play and work nearby. So, the wires that deliver electricity have also become conduits for high frequency radiations, a form of electromagnetic field that has largely escaped attention by the medical community. The increased prevalence of these radio-frequency currents has coincided with an alarming increase in the prevalence of ailments as explained above. Various symptoms of exposure to radio wave sickness had already been seen in the human body such as Neurological, Cardiac, Respiratory, Dermatological, Ophthalmologic and others such as digestive problems, abdominal pain, enlarged thyroid, testicular/ovarian pain, dryness of lips, tongue, mouth and eyes, great thirst, dehydration, nosebleeds, internal bleeding, altered sugar metabolism, immune abnormalities, redistribution of metals within the body, hair fall, pain the teeth, deteriorating fillings, impaired sense of smell, ringing in the ears etc.[9]

A filter and a meter have been created to measure and control the radio frequency radiations. The filters provide a low impedance path for high frequency currents from the hot wire(s) to the neutral wire path bypassing the customer loads. The Graham-Stetzer (GS) meter and GS filters are the most common tools to measure and reduce electrical radiations. Filter frequency ranges from 4kHz to 100kHz provide optimal results for cleaning the electricity. Any frequencies above 100kHz or below 4kHz are hard to detect by the filters.

RMS meters do measure the amount of electricity present, but the GS meters have demonstrated their ability to measure the amount of harmful electricity present. Electrical current enters the body more readily at higher

frequencies, and body current at those higher frequencies can be harmful. The GS meter measures currents at those higher frequencies by measuring the sum of the frequencies above 60Hz.

V. ELECTROMAGNETIC FIELD MANAGEMENT

1. EMF Management for Transmission Lines: Among all the sources of EMF, overhead transmission lines produce the greatest EMF. Nowadays, extra high voltage (EHV) is transmitted through overhead transmission lines. The installations and distribution of EHV transmission line produce the highest electric field near the ground surface. Overhead transmission lines (OHTL) produces extremely low frequency (ELF) EMF, which requires reducing to minimum level. In the age of electrification, the evaluation of EHV, people are used to stay around ELF field sources, which may further lead to responsible for biological effects of human as well as living beings. Electric and magnetic field management of overhead transmission lines require different factors such as line designing, Right of way (ROW), shielding, grounding and techniques for reduction of EMF. Electric field is reducing to extremely low values using ground grids of densely spaced wires and the magnetic field of these EHV OHTL can be significantly reduced with voltage upto 115kV or by using loops cancellation method [10].

2. EMF Management for Transmission Cables: EMF is an issue that concerns overhead transmission lines. Concern about possible health effects due to EMF overhead transmission lines is replaced by underground transmission lines (UGTL) as the solution of EMF problem. In UGTL, above the surface of the ground, the electric field is eliminated, but the magnetic field is not, because the soil around the underground cable has practically the same permeability as air. Thus, near the surface of ground MF from underground transmission line is higher than that of overhead transmission lines [11].

3. High Temperature Superconductors (HTSrs) in Power Cables: Leading challenges in power T&D system will be solved by the High Temperature Superconducting (HTSing) technology where HTSing cables are highly capable to wear large J_c under cryogenic conditions (77K) with zero resistance, low impedance, zero electromagnetic radiation and free from hazardous cooling oil than conventional power cables and wires. Underground AC/DC power T&D network of HTSrs use inexpensive and environmentally safe LN_2 cooling core which provides cooling to the material to maintain the superconducting state. In addition, the installation cost of underground and overhead power cables can be reduced more than 20%. In conventional overhead Cu based power T&D cable system, about 50kW/km of electrical energy is dissipated due to high resistance of conductor can be reduced by HTSrs (table 1) [12]. For transportation of 5GW power with 75kV overhead AC lines require 600ft wide ROW and 130ft high pole & whereas 5KW with 200kV underground DC HTSrs cable require about 3ft diameter pipe and 25ft ROW according to American Super conductors.

Sr. No.	Description of cable specifications	Conventional conductors AC cables	HTSing AC cables	HTSing DC cables
1.	Power transmission capacity (MVA)	1500	1500	1500

2.	Power transmission voltage	275kV rms	66V rms	130kV
3.	Power transmission current	1kA rms/phase	3.3kA rms/phase	12kA/phase
4.	Cable type and diameter size (cm)	Single phase XLPE (14cm)	3 in one (13.5cm)	3 in one (13.5cm)
5.	No. of cables	9	4	1
6.	Transmission cables (kW/km)	740	200	20
7.	CO2 emission and reduction	778	210,562	21,757

Table 1: Comparison of HTSing and conventional cables

High superconducting cable, characterized by high current densities and low transmission loss, shows promise as a compact low-capacity power cable that exhibits several environmental advantages such as energy and resource conservation as well as no external electromagnetic fields. HTS DC cable takes maximum advantage of the characteristics of superconductivity.

HTS DC cable is a large-capacity, compact, energy-saving & environmentally-friendly cable. Moreover, further improvements in performance & declines in price are likely to give rise to greater economic efficiency. Due to these advantages, HTS AC cable demonstration projects are being planned and promoted [13]. The zero resistance of HTS material is observed only in DC current, while the transmission loss is generated in AC current. Moreover, it is necessary to take measures to solve the problems to HTS AC cables such as protection against short circuit current and solution to avoid unbalanced AC current in each HTS conductor.

Basic Structure of HTS DC cables (EMI free): In HTS AC cables, superconducting wires are used for shielding with both ends shorted. In this manner, the current in the reverse phase form the conducting current flow can be induced to carry through the superconducting shielding layer. This induction cancels the magnetic field outside the shielding layer to create a state that is purely free of electromagnetic interference (EMI) allowing no leakage of any electric field. An EMI-free state can also be created in HTS DC cable by flowing the return current through the shielding layer in monopolar transmissions and by carrying the positive and negative currents side by side in bipolar transmissions.

HTS DC cable applications: In view of the above advantages and superiority of HTS DC cable, the major applications can be as under:-

I. Ultra-high voltage substations.
II. Primary substations.
III. Relay substations.
IV. Distribution substations.
V. From back-to-back to interconnection applications and other applications.

1. Distribution Lines EMF MGT: Overhead distribution lines generate an electric field around its vicinity that influences the environment in the space as well as located on the ground surfaces. Normally,

distribution lines electric fields are so small that they do not produce any effect on the environment for example production of spark discharge has extremely low frequency to affect the human body. The management for magnetic field produced by the distribution system may create two special challenges. First one is associated with the large societal cost of an overall change in distribution system. The second one is related to the different techniques that are required to reduce the magnetic field caused by phase and net current in the distribution system.

2. EMF Management in Substation: The substation having mainly major components as transmission lines, step-up/ step-down transformers, substation buses, sub-transmission feeders and generating circuits. The EMF produced by substations may expand outside the substation perimeter, where residential and commercial activities take place. Management of EMF near the substation is very complex issue. Sources of electrical field in the substation are the substation buses and HV equipments. Electric field can be controlled by design of buses and their geometry and also be reduced by increasing the space between ground and buses.

On the other hand, sources of magnetic field around the substation are substation buses, incoming and outgoing cables, capacitor banks etc. Management of MF around a substation has mainly two purposes, (i) association with the field level inside the substation to ensure the safety of workers and (ii) to minimize the MF outside the perimeter of substation where residential and commercial settlements are found. This can also be required for modelling of conductors and buses.

6. Residential EMF Management: EMF is also produced near the residential area due to HV transmission lines cross over in case of urban areas. People spent most of time in their houses in which the desirable and non-desirable EMF were produced by the various devices. Electric field in the home is relatively small and insignificant as compared to magnetic field. Computers and accessories, unsuitable electrical wiring, electrical appliances, electronic devices, overhead power transmission lines, ground connections at electrical subpanels and grounding system of the residence are the main sources of magnetic fields in residential areas. It has been a concern because a number of epidemiological studies have indicated to some dangerous diseases- such as leukemia, breast cancer, miscarriage etc.

7. School, Commercial and Industrial EMF management: The main purpose of management of electric and magnetic fields in schools, colleges, universities, commercial and industrial premises is lowering the exposure to EMF. According to survey of EPRI, the magnetic field sources in school, colleges, commercial more or less similar to those used in residential areas [14]. EMF values in the industrial areas are higher than the residential and commercial areas. Sources of MF in industrial areas are mainly the electrical machinery and equipment that are used in electrical transmission and distribution systems [15]. So, need for management of their EMFs is very important. Their harmful effects include breaking of the bones & tissues and many more.

VI. CONCLUSION

The present study indicates that exact association of power frequency fields with instruments and humans is still being evaluated. There are various health concerns associated with Electromagnetic emissions experienced by various personnel and obtained the significant effect of EMF radiations on various parts on human body and remedy methods are to be obtained by use of GS filter. Electric and magnetic fields around transmission and

distribution lines, substations and other electrical HV equipments/ utilities can be reduced by various technical approaches. Communication programmes, EMF measurement and assessment, research programmes, design of power system components with low EMFs and use of High Temperature superconducting equipments, modification of power system to reduce EMF, tracking ground and net current flows, shielding the sources of EMF, shielding the areas occupied by people or sensitive equipment and reduction of exposure to EMF by selective use of space and time are the steps that are used for EMF management. Hence it is a need of the time to use very carefully all the resources causing electro-magnetic field dangerous to the mankind and different approaches are to be invented for its management. Efforts are going on worldwide.

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