

Modelling of Electric and Magnetic Fields Around 132kV Transmission Line

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Abstract: Exposure to natural and manmade extremely low frequency (ELF) electromagnetic fields (EMF) have been a concern during previous years. Schumann Resonance (SR) phenomenon is the source of natural ELF EMFs. High voltage (HV) Transmission Lines is one of the major sources of manmade ELF EMFs. Staying around or close to transmission lines have reported to cause ill effects on human health. The health effects can be analyzed by measuring the external and internal fields. The main objective of this study is to do exposure assessment around high voltage alternating current (HVAC) transmission line and model the same using a program developed in MATLAB. A double circuit 132kV, 50Hz transmission line was selected for this purpose. ELF EMFs around HV line were measured using a low frequency analyzer ME 3830B. Measured external field levels were modelled using Regression Analysis, Support Vector Machine (SVM), Neural Network (NN) and Hybrid Technique. Finally comparative analysis of all modelling techniques was presented.

Keywords: *extremely low frequency, electric and magnetic fields, neural network, support vector machine, hybrid technique*

1. Introduction

Living body on earth is exposed to ELF EMF from inception to death. ELF EMF is produced by natural phenomenon as well as manmade technological developments too. Tropical thunderstorms are the source of natural ELF EMFs, which are also called as SR signals [1]. Electric power generating stations, distribution lines, HV lines and almost all appliances operating on power frequency are the source of manmade ELF EMFs. Living bodies during their life span exposed to both types of ELF EMFs. Bio activeness of ELF EMF was agreed by fraternity of scientist since last few decades. Detrimental effects of ELF EMF were also reported. Exposure to natural ELF EMFs is the million million years old phenomenon as compared to exposure to manmade ones.

During evolution process, natural defending mechanism or process could have been developed in biological bodies, against natural ELF EMF. However, for the life on earth, exposure to manmade ELF EMF is a recent phenomenon, which is attracting the researchers worldwide.

With the increased demand for electric energy, the number of power generating stations, high voltage transmission lines and utilization of electrically powered machinery and household equipments have been increased to a large extent. Peoples are continuously exposed to ELF EMF produced by these sources at their workplace as well at the place of residence [2]. There is a growing concern among the public about exposure oriented health effects especially due to high voltage transmission lines and electrically powered equipments and machines. The first scientific study to attract serious interest in the issue came in 1979. An epidemiological study by Wertheimer and Leeper [3], showed an association between the type and proximity of electricity supply cables outside the home and the incidence of childhood cancer. The association increased risk of cancer with conductive plumbing was also reported [4]. This study had a major impact both on the general public and on the scientific community and stimulated much subsequent research. Various international agencies have recommended exposure limits for both residential as well as occupational exposure. Efforts to address bioeffects and potential adverse health effects carried out since then were reported in [5, 6].

Exposure assessment is usually done in three steps. First step involves measuring the external EMF generated by the specific source. This field interacts with the living body. Interaction with external EMF induces internal fields in body. So, measuring internal fields stands as second step. The internally induced field may lead to certain biochemical change in body which may further lead to effect on specific organ depending upon the dielectric properties of that organ [7-9]. Measuring the initiated biochemical changes stood to be third step to arrive at conclusive effect of any exposure assessment.

The paper is organized as: Section 2 describes the background, section 3 will give details about the instrument used for measurement, section 4 will deal with the site selection and measured readings of EMF field, section 5 will show the modelling results and section 6 concludes the paper.

2. Background

As a matter of fact most of the scientific studies have been conducted for the occupationally exposed persons consisting of adults who are trained to be aware of the potential risk and to take appropriate precautions, while the untrained general public comprises of all ages and of varying health status and may include particularly susceptible groups or individuals. Also the period of exposure of these general public living nearby the transmission line is much more than the occupational exposure [10-12].

The main purpose of this study is to measure and model the external ELF EMF around the double circuit 132kV, 50Hz high-voltage transmission line. The data obtained during this survey is used to model the electric and magnetic fields, by using

various functions such as Regression Analysis, Support Vector Machine (SVM) and Neural Network. An innovative Hybrid Technique is also developed which is the combination of SVM and NN. Finally comparative analysis of all the modelling techniques was presented. Comparatively best performance was judged according to closed approximation to the calculated values. The procedure is explained with the help of flowchart shown in figure 1.

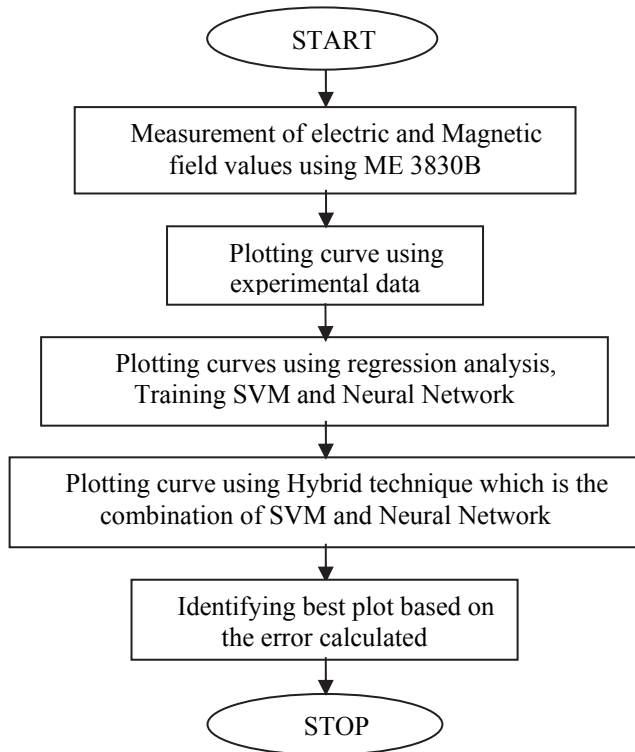


Figure 1. Flowchart of the Proposed System

3. Site selection and Measurement

A double circuit 132kV, 50Hz HVAC transmission line was selected, spanning from Deepnagar to Pachora in Jalgaon region of Maharashtra, India. Figure 2 shows the photograph of the site at which measurements of both the electric and magnetic fields were taken. Measurements were carried out along the span at a distance 15m from the centre of tower (ground line) at every 5 meters.



Figure 2. Site Selected for Measurement of Electromagnetic Field Emanating from Double Circuit 132 kV Transmission Line

Both electric and magnetic field intensities were measured using Gauss/Tesla meter ME 3830B [9].

4. Modelling the ELF EMF fields

4.1. Objective

Exposure assessment deals with measurement of external fields manually (with available Gauss/Tesla meters) and calculating internally induced fields in reference to measured external fields. The intensity of the internally induced fields varies according to intensity of external fields, and other electrical properties of living body. Each organ has different electrical properties such as, conductivity, permeability and permittivity. Fields induced internally will vary according to distance from source too, since the values of external fields vary as we move away from source of power frequency fields.

Since there is no direct method for measurement of internally induced fields, different models and modelling techniques are used for calculation of internal fields. These models and techniques seeks the perfect values of external fields which will be operated along with conductivity, permeability and permittivity values of specific organs to calculate organ specific induced fields. The accuracy of internal dosimetry depends upon proper selection of electrical properties and the exact input values which is to be operated as input. These input values are nothing but the external fields measured along the path of exposure assessment at different locations and distances. In external exposure assessment there are chances that external field readings may be deteriorated due to manual handling of the measuring instruments, which may lead to loss of smoothness and significance in measured values at particular locations. So there is always need to determine graph of best fit which represents best possible readings at that particular exposure location or path. This can be done by Regression Analysis, SVM and Neural Networks.

The objective of the modelling done in this paper is to generate the best dataset representing the external field values. These values will be operated to calculate organ

specific internal fields and current density at the point of interest from power frequency source.

4.2. Electric field

External field values obtained during survey functions as input to the MATLAB program. Modelling was done using Regression Analysis, Neural Network, SVM and Hybrid Technique (HT). HT is the combination of NN and SVM. The graph of the actual measurement data is shown in fig. 3.

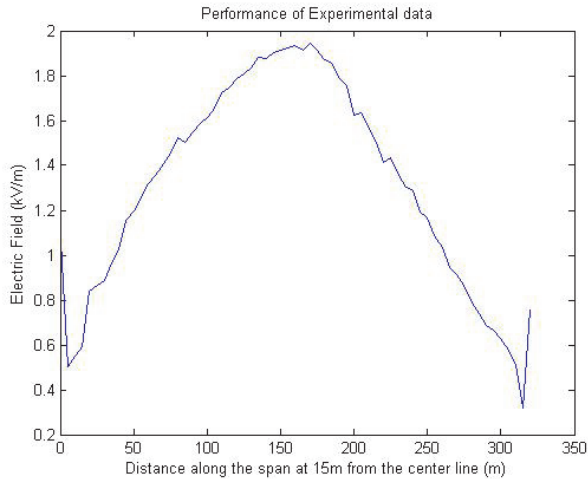


Figure 3. Graph of Experimental Data of Electric Field vs Distance Along the Span at 15 m from the Centre Line (m)

From the experimental data graphs are plotted using Regression Analysis for various degrees. Regression Analysis is used for modelling and analyzing several variables. It gives the relationship between a dependent variable and one or more independent variables. In present study the dependent variable is the electromagnetic field which is dependent on the position of the meter, *i.e.* distance from the center of the structure and distance along the line in meters.

Once MATLAB program plots the graphs for various degrees using Regression Analysis, it finds the graph which gives least errors by comparing the Regression Analysis graphs at various degrees with the experimental data. The Regression Analysis for 9th degree has given close approximation to the actual experimental data, so the graph for 9th degree was selected as the performance of the Regression Analysis as shown in fig. 4. Taking the dataset obtained by Regression Analysis for the 9th degree, the error value obtained is 2.2507.

The error value provides an overall measure of how well the model fits the experimental data. The error value becomes smaller when the data points are closer to the line. Readings generated by modelling techniques with least error value will be served as best dataset of external field values. Smaller error values are good because it indicates that modelled field values are closer to the measured once.

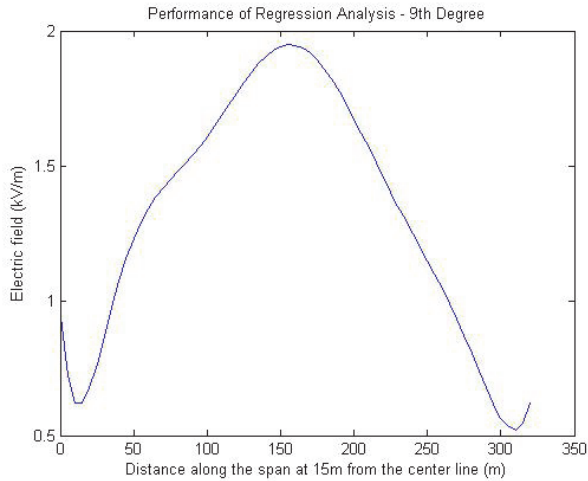


Figure 4. Performance of Regression Analysis Based on the Least Error

SVMs are powerful machine learning techniques for classification and regression. In our proposed method SVM was used for the modelling of electric and magnetic fields for different distances along the transmission line. The SVM is classified into two different types i.e. binary classifier based SVM and multiclass classifier based SVM. In proposed method more than two classes are used, so multiclass SVM classifier is used. A new dataset generated by SVM, with error value obtained as 2.696. The performance of SVM technique is shown in fig. 5.

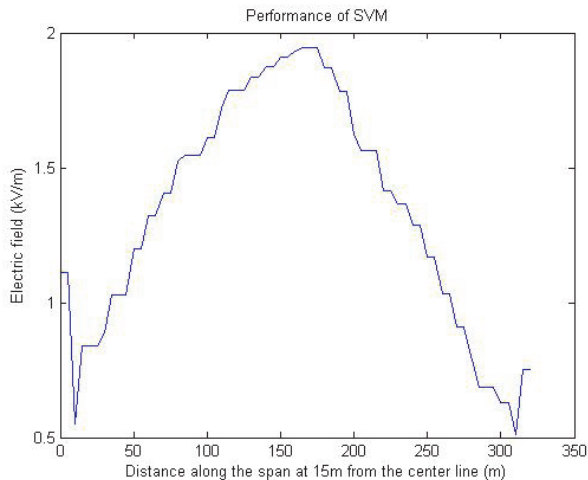


Figure 5. Performance of SVM for Electric Field vs Distance Along the Span at 15 m from the Center Line (m)

Neural Network was used for modelling of electric and magnetic field. Usually Neural Network consists of two stages namely; training stage and testing stage. In the

first stage, Neural Network was trained by using the training dataset and in the second stage; the graphs of electric field and magnetic fields were generated. For the training purposes of Neural Network back propagation algorithm is used. A new dataset was generated by training Neural Network, which gives error value of 4.8342. The graph obtained by training of Neural Network is shown in fig. 6.

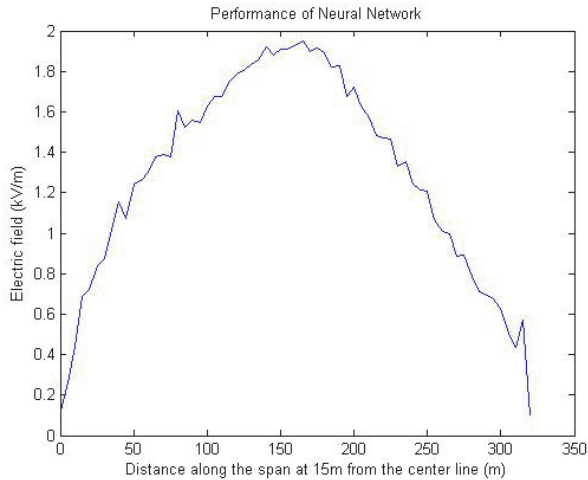


Figure 6. Performance of Neural Network for Electric Field vs Distance Along the Span at 15 m from the Center Line (m)

After training Neural Network and SVM individually the data was combined by using Hybrid Technique, which gives the average of the two data. The error value of 3.3999 was generated. The graph obtained for the Hybrid Technique is shown in fig. 7.

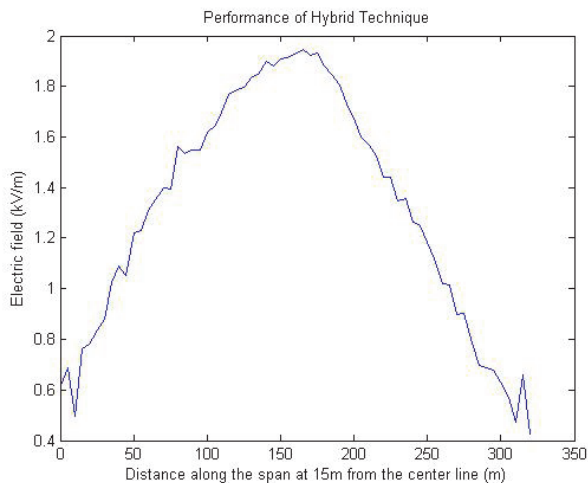


Figure 7. Performance of Hybrid Technique for Electric Field vs Distance Along the Span at 15 m from the Center Line (m)

4.3. Magnetic field

Measured values of Magnetic fields were treated as input to the MATLAB program. Modelling using Regression Analysis, NN, SVM and HT was carried out in the same manner as that of electric field modelling.

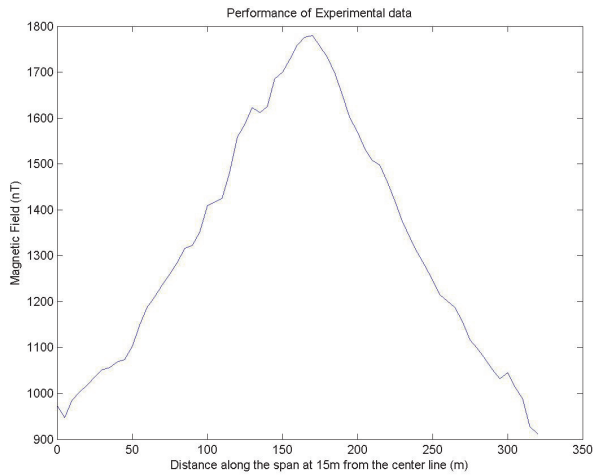


Figure 8. Graph of Experimental Data of Magnetic Field vs Distance Along the Span at 15 m from the Center Line (m)

The Regression Analysis of 10th degree had given close approximation to the experimental data. Error value of 921.772 was generated for the new dataset, using Regression Analysis for the 10th degree. The performance of Regression Analysis is shown in fig. 9.

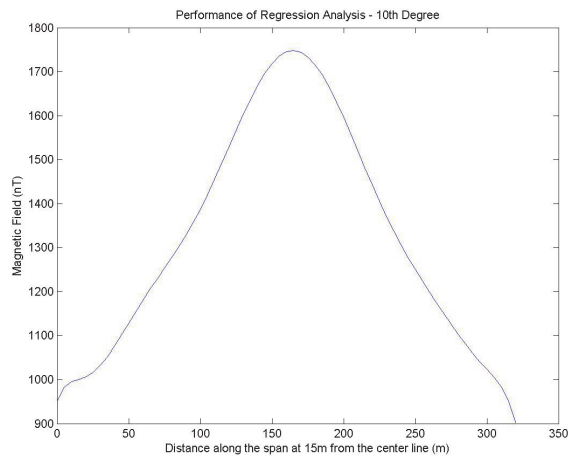


Figure 9. Performance of Regression Analysis Based on the Least Error

The new dataset obtained by the SVM had given error value of 847. The performance of SVM is shown in fig. 10.

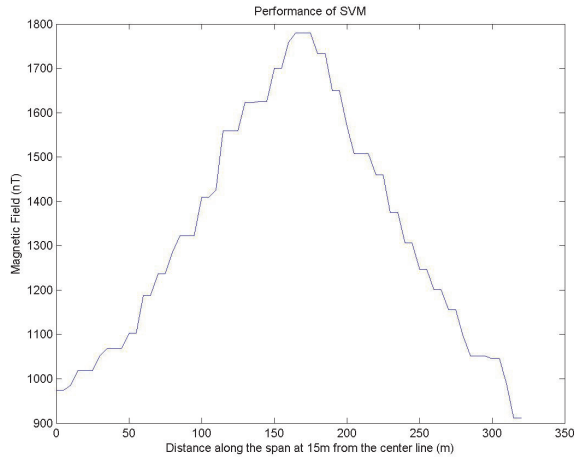


Figure 10. Performance of SVM for Magnetic Field vs Distance Along the Span At 15 m from the Center Line (m)

The error value of 1356.64 was generated for the Neural Network, whose performance shown in fig. 11.

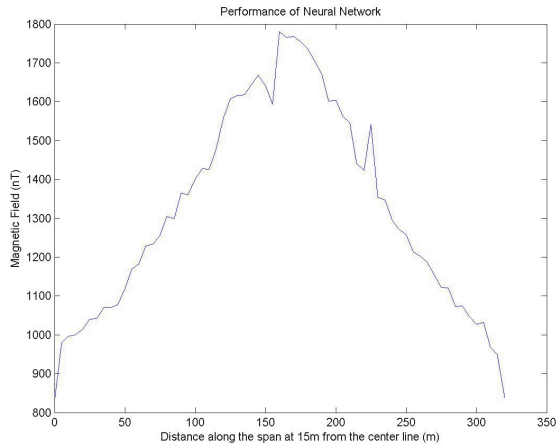


Figure 11. Performance of Neural Network for Magnetic Field vs Distance Along the Span at 15 m from the Center Line (m)

New dataset generated for Hybrid Technique with error value of 940.96, performance is shown in figure 12.

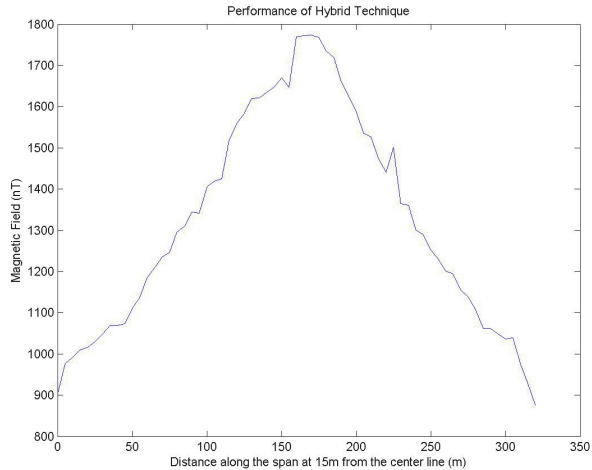


Figure 12. Performance of Hybrid Technique for Magnetic Field vs Distance Along the Span at 15 m from the Center Line (m)

5. Conclusions

External exposure levels are measured with low frequency analyzer. The maximum values of Electric and Magnetic field were obtained at the point of sag. The Electric and Magnetic fields measured at the sag were 1.947 kV/m and 1780 nT respectively. These positions will need maximum attention while calculating internal induced electric field and induced current densities.

The modelling was carried out by a program developed in MATLAB using Regression Analysis, SVM and NN. Regression Analysis was performed for various degrees and then these graphs were compared together to find the least error model, which was taken as the Regression Analysis model. After training SVM and Neural Network individually the data was combined by using Hybrid Technique which was a combination of Neural Network and SVM. Finally the models obtained from Regression Analysis, Neural Network, SVM and Hybrid Techniques have been compared to find the approximation with the experimental data.

The results obtained by these modelling techniques give close approximation with the measured dataset.

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