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# Measurement of Electric and Magnetic Field Strengths under 765 kV UHVAC Single Circuit Transmission Line

**P. Rajamani*, K. A. Aravind, Pradeep M. Nirgude**

UHV Research Laboratory, Central Power Research Institute, Hyderabad – 500098, Telangana, India;
rajamani@cpri.in, aravind@cpri.in, pmnirgude@cpri.in

## Abstract

Transmission line corridors of developing countries are increasingly dense and expensive with construction of new ultra-high voltage (UHV) transmission lines. Right of way of transmission line in the corridor, construction cost of transmission lines including towers, is directly influenced by electric and magnetic field strength emission (EMF) of that line. In UHV range, emission of electric and magnetic field strength in the vicinity of lines is of great public concern, as are likely to have hazardous effects to human being when their exposure level exceeds specified limits. Higher the transmission voltage and stronger the electric field. Though the results on effect of EMF on human being is inconclusive, to create awareness to common public and working professional, it is mandatory to measure the emission level of EMF in lateral and longitudinal profile. This paper reports experiences of EMF emission measurement of 765 kV UHVAC quadruple ACSR bundled conductor single circuit transmission line in India. Measurement results of EMF with vegetation is reported.

**Keywords:** EMF Measurement, Electric Field Strength Measurement, Magnetic Field Strength Measurement and 765 kV Transmission Line

## 1. Introduction

Now a days, the land resources in developing countries, particularly in transmission corridors, have become increasingly dense with construction of large transmission lines. It is not economical to build new transmission line corridors. On the contrary, ever increasing in power demand posing a challenge to mandatorily examine the possibilities of increasing power handling capabilities of existing transmission lines or construct a new line with different design criteria. This economical requirement made the power utilities to utilize the existing transmission line corridors with higher voltages, viz. Ultra-High Voltage (UHV) or Extra High Voltage (EHV) transmission level. In this UHV/EHV voltage level, emission of electric and magnetic fields in their vicinity is likely to have hazardous effects on human beings, plants and animals when their exposure level exceeds specified limits. Based on the guidelines set by International Commission on non-Ionizing Radiation Protection (ICNIRP), countries have their own limits for exposure to electric and magnetic fields[1].

In case of AC power lines, electric field at ground levels is mainly due to capacitive coupling between the conductors and the living beings at ground level. Strength of electric field depends upon voltage associated with electric charges. Higher the voltage and stronger the electric field. UHV lines produces stronger electric field than that of low voltage lines. Magnetic fields are created by moving charges. A stream of charges moving in the same direction constitutes an electric current. Same as that of electric strength, greater the current, the stronger the magnetic field.

The possibility of biological effects due to AC electric and magnetic fields generated by transmission lines have been a source of public concern. Results of research on effect of electric and magnetic fields on a human being health is inconclusive, the public opinion is remains in

*Author for correspondence

opposition to increase the transmission voltage level. Although, the results of numerous scientific studies performed in many countries around the world have so far failed to prove that they are hazardous to health, doubts still persist in this regard. To solve this important public concern regarding health issue, it is mandatory to measure the electric and magnetic fields in transmission line vicinity.

International Commission on Non-Ionizing Radiation Protection (ICNIRP) has published guidelines for limiting the exposure to time varying electric and magnetic fields (1 Hz to 100 kHz)[1]. As per ICNIRP guidelines 2010, the reference levels for general public exposure to time varying electric and magnetic fields are 5 kV/m and 200 μT respectively and for occupational exposure to time varying electric and magnetic fields are 10 kV/m and 1000 μT respectively. Hence, to create awareness to general public, on interest of power utilities, Central Power Research Institute has performed measurement of electric and magnetic fields on 765 kV single circuit transmission line in India. As per IEEE Std. 644, the measurement is to be carried out in flat surface. However, in developing countries like India, where the agriculture is the backbone of economy, getting such measurement sites without any vegetation and irregularities is challenging. In this paper, the field strength measured with those irregularities are reported.

## 2. Details of Measuring Sites

Electric and magnetic fields are measured along or near the transmission line at height of 1 m above the ground level. As stated in IEEE Std.644, it is preferred that the measurement site shall be relatively flat and free, as much as possible, from trees, fences, vegetation, tall fences, another electric power transmission line and other irregularities[2]. Considerable influence of effect of vegetation on electric field measurement is reported. Particularly, the water content on top of isolated vegetation has more influence on field perturbation.

As per the requirement of power utilities, electric and magnetic field strengths are measured near five spans of energized 765 kV ACSR Moose quadruple bundle single circuit transmission line. Remarkably, none of the measuring sites on the six spans were flat. In particular, the measurement site had different vegetation, viz. cotton fields with different height of cotton plant, orange field with metallic fence, tress, cannel, open well, single room cement shed with metallic sheet roof top, etc. Photograph

**Figure 1.** EMF measured in 765 kV S/C transmission lines in cotton field.

**Figure 2.** View of orange garden near 765 kV S/C transmission lines were EMF measured.

**Figure 3.** EMF measured in 765 kV S/C transmission lines near open well and isolated metal roof shed.

of two measuring sites is shown in Figures 1 and 3. Though it is not meeting the guidelines as in IEEE Std. 644, influence of various factors in actual electric and magnetic field measurement were reported.

## 3. Method of Measurement of Electric and Magnetic Field Strength

Electric and magnetic field strength of 765 kV single circuit quadruple ACSR Bersimis conductor is measured both in lateral and longitudinal profile as per IEEE Std.644. To make it convenient for measurement, the measuring sensor is placed on top of 1 m telescopic stand. For lateral profile, the measurement is carried out normal to the line as shown in Figure 4. As on Figure 4, at first, EMF is measured at location Y0, then subsequently, EMF is measured at 5 m distance from Y0. This measurement is continued in a suitable interval of distance upto 50 m distance from outer phase of transmission line. EMF strengths parallel to the transmission line are measured for longitudinal profile as shown in Figure 5. Measurement is performed in the entire span between the two towers.

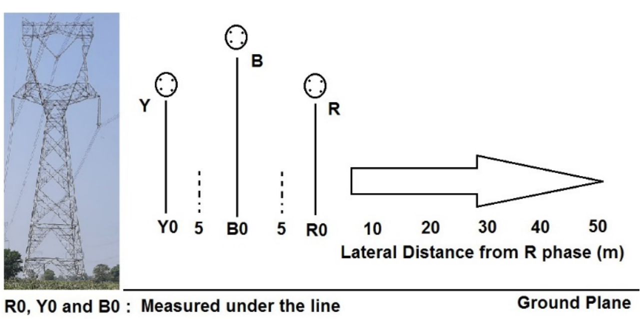


**Figure 4.** Schematic representation of lateral profile of 765 kV S/C transmission line.

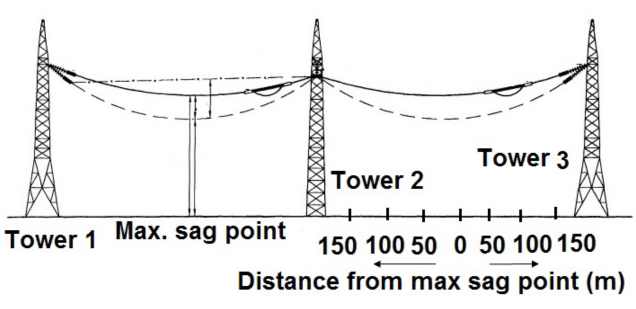


**Figure 5.** Schematic of longitudinal measurement of EMF strength of 765 kV S/C transmission line.

During longitudinal profile also the first measurement starts at maximum sag point and continued in both the directions independently in suitable interval of distance till next tower. Longitudinal measurement is carried out between towers under the transmission (parallel to) lines, whereas, the measurement is performed perpendicular to the line for lateral profile.

## 4. Equipment used for Electric and Magnetic Field Strength Measurement (EMF)

EMF near 765 kV single circuit transmission lines were carried out using M/s. Narda Safety Test Solutions, Italy make Compact Field Analyzer with optical interface to personal computer. EHP-50 TS software, Version 2.09, is used for measurement, control, front end display and evaluation software EMFS measured[3]. EPH -50 is a free-body type meter. It is suitable for field measurement because it does not require any known ground reference, allows measurement above ground plane at required distance and portable. Photograph of EHP-50 compact field analyser along with control software is shown in Figure 6.

## 5. Measurement Results and Discussions

### 5.1 Measurement Site 1- Span between Tower 1 (A+0) and Tower 2(A+6)

Lateral profile of electric and magnetic field strength measured in the span between tower 1 and tower 2 is shown in Figure 7. Ambient atmospheric conditions and other transmission line parameters during EMF measurement at this site are given in Table 1, this

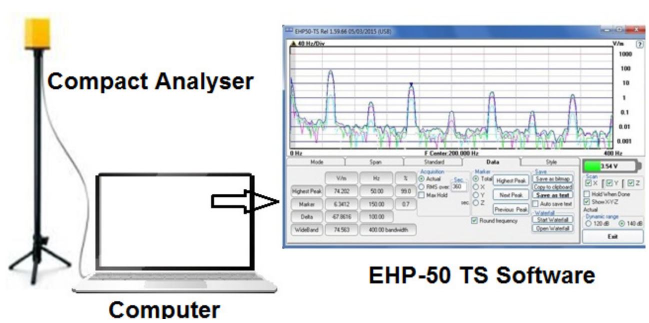


**Figure 6.** EHP-50 Compact Field analyser.

information are provided by utility. Tower 2 is 6 m taller than tower 1. The span between the towers is covered by cotton fields, including right of way. The lateral profile places of measurement locations of interest are covered by uneven surfaces, in some places small sand mountains also observed. Moreover, there was a Nala of 1.5 m depth under R phase line at the place of measurement. Because of Nala, lowest value of electric field was measured at location R0. The longitudinal profile of EMF strengths measured at site 1 shown in Figure 8. The profile was recorded under Y phase, as there was an isolated low tension metallic electric supply pole was there near R phase side. More or less smooth longitudinal profile was recorded under Y phase.

**Table 1.** LINE parameters during measurement at site 1

| Sl. No. | Parameters | Particulars |
|---|---|---|
| 01 | Span Length | 370 m |
| 02 | Line voltage | 758 kV |
| 03 | Line load | 1050 MW |
| 04 | Bundled conductor height at max. sag point | 20 m |
| 05 | Ambient Conditions | Td:34˚C, Tw:24˚C and P:728 mm of Hg |

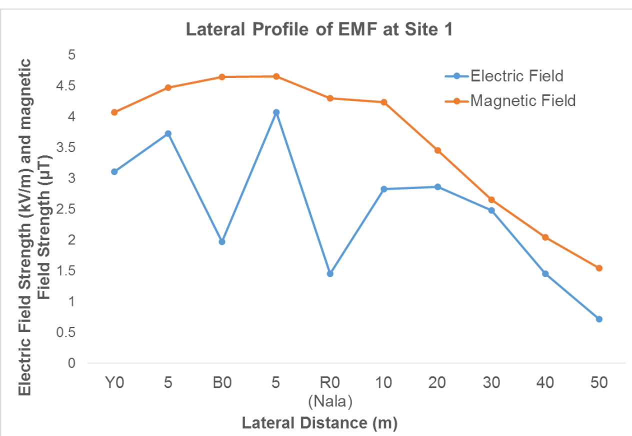


**Figure 7.** Lateral profile of EMF at measuring site 1.

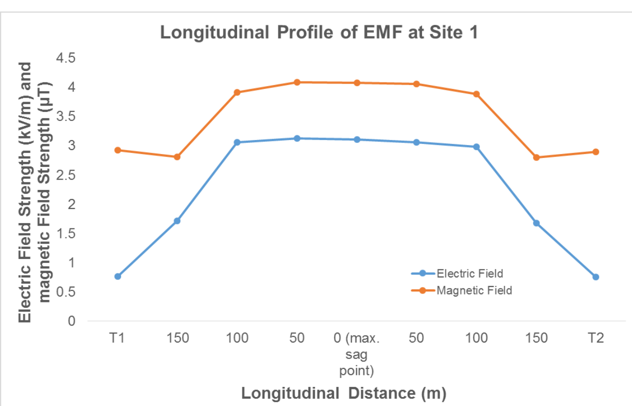


**Figure 8.** Longitudinal profile of EMF at site 1.

## 5.2 Measurement Site 2- Span between Tower 2 (A+6) and Tower 3(A+3)

In measurement site 2, the entire span of lateral and longitudinal profile of EMF measurement locations of interest are covered by cotton plants of approximately half meter height, i.e., lower than the height of compact field analyser. Tower 3 is shorter than tower 2 by 3m. Ambient atmospheric conditions and transmission line parameters during measurement are given in Table 2. The lateral and longitudinal profile of EMF strengths is shown in Figures 9 and 10. Highest electric field strength recorded at location R0, 6.11 kV/m, which is more than ICNIRP limits for common public. In this span the conductor height at maximum sag point is 17 m, which is 3 m shorter than conductor height at previous measurement site 1. This may one of the possible reasons for recording higher value of electric field strength at R0. In longitudinal measurement also the electric field exceeded the ICNIRP limits at maximum sag point and at 50 m distances.

## 5.3 Measurement Site 3- Span between Tower 4 (A+3) and Tower 5(A+3)

Ambient atmospheric conditions and transmission line parameters during this measurement as provided by the utility are given in Table 3. Both the towers are at same height and measurement location of interest is fully covered by chickpeas plants. Height of chickpeas plants are approximately 0.2 to 0.35 m, which is lower than height of compact field analyser. Lateral and longitudinal

**Table 2.** Line parameters during measurement at site 2

| Sl. No. | Parameters | Particulars |
|---|---|---|
| 01 | Span Length | 430 m |
| 02 | Line voltage | 759 kV |
| 03 | Line load | 1049 MW |
| 04 | Bundled conductor height at max. sag point | 17 m |
| 05 | Ambient Conditions | Td:34˚C, Tw:24˚C and P:728 mm of Hg |

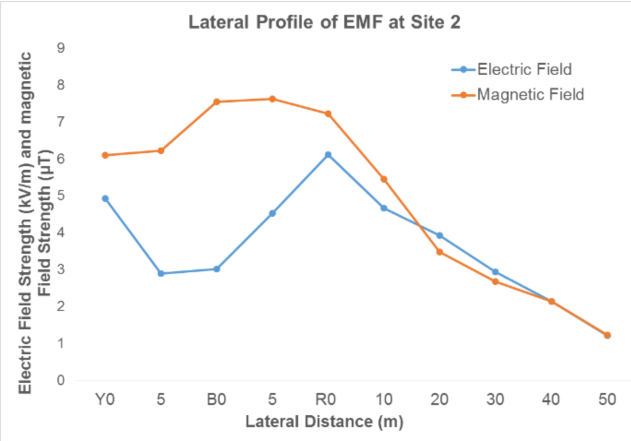


**Figure 9.** Lateral profile of EMF at site 2.

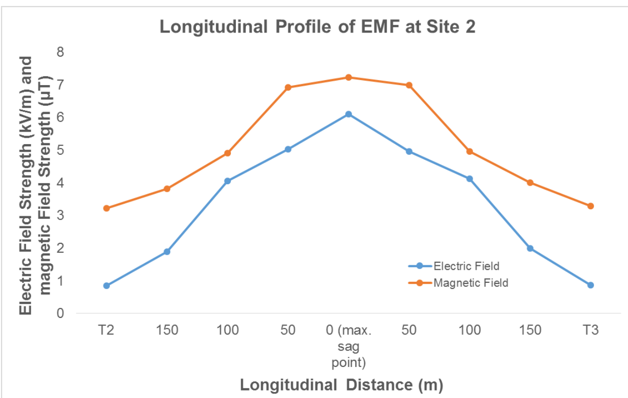


**Figure 10.** Longitudinal profile of EMF at site 2.

profile of electric and magnetic field measured is shown in Figures 11 and 12. During lateral profile measurement, maximum value of electric field strength is recorded are locations Y0 and R0, as 4.41 kV/m and 4.45 kV/m, respectively. Both are lesser than ICNIRP limits. Height of bundle conductor at maximum sag point is 16 m. Magnetic field strengths measured are much lower than the ICNIRP limits specified for common public and working professional. Longitudinal profile is measured along Y phase conductor.

## 5.4 Measurement Site 4- Span between Tower 5 (A+3) and Tower 6(A+6)

In this location, tower 6 is 3 m taller than tower 5 and the height of conductor at maximum sag point is 22 m. Among the measurement sites, height conductor height from ground level is recorded in this span. In this span also the measurement area is covered by cotton fields as

**Table 3.** Line parameters during measurement at site 3

| Sl. No. | Parameters | Particulars |
|---|---|---|
| 01 | Span Length | 430 m |
| 02 | Line voltage | 759 kV |
| 03 | Line load | 1049 MW |
| 04 | Bundled conductor height at max. sag point | 16 m |
| 05 | Ambient Conditions | Td:34˚C, Tw:25˚C and P:729 mm of Hg |

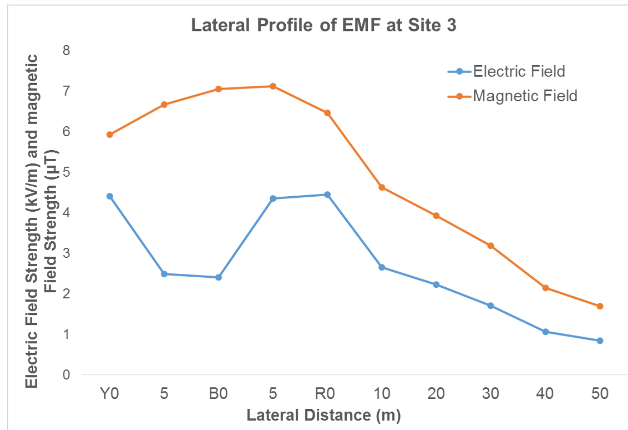


**Figure 11.** Lateral profile of EMF at site 3.

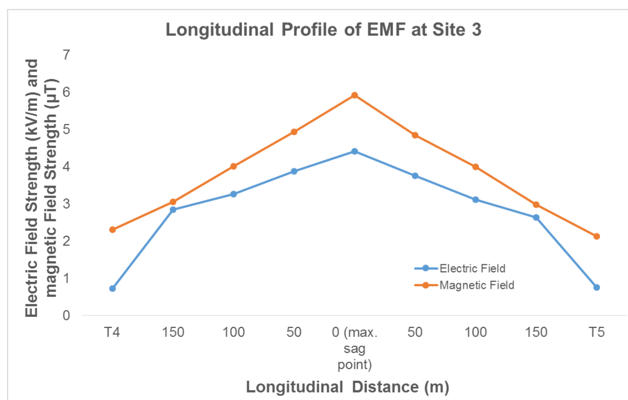


**Figure 12.** Longitudinal profile of EMF at site 3.

shown in Figure 1. Height of the cotton plant is comparable with height of the compact field analyser, i.e., around 1 m. Moreover, there was a cement room with Galvanized Iron roofing was also there nearby measurement point. Table 4 shows ambient atmospheric conditions and other transmission line parameters during the measurement. Lateral and longitudinal profile of electric and magnetic field strength is shown in Figures 13 and 14. It is evident from Figures 13 and 14, though conductor is at 22 m

**Table 4.** Line parameters during measurement at site 4

| Sl. No. | Parameters | Particulars |
|---|---|---|
| 01 | Span Length | 370 m |
| 02 | Line voltage | 760 kV |
| 03 | Line load | 1050 MW |
| 04 | Bundled conductor height at max. sag point | 22 m |
| 05 | Ambient Conditions | Td:35˚C, Tw:25˚C and P:729 mm of Hg |

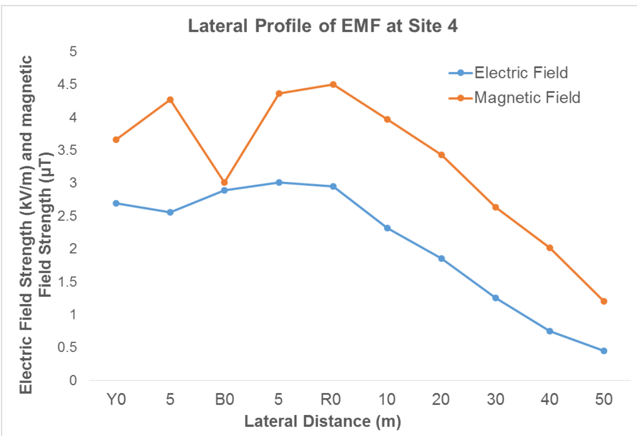


**Figure 13.** Lateral profile of EMF at site 4.

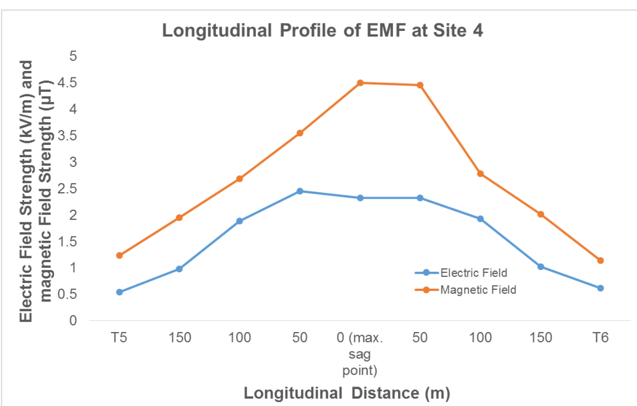


**Figure 14.** Longitudinal profile of EMF at site 4.

height, due to the effect of other ground objects, much lower value of electric field was recorded as compared to the other measuring sites have comparable transmission line parameters.

## 5.5 Measurement Site 4- Span between Tower 40 (A+0) and Tower 41(B+0)

This measurement site is fully covered with orange garden and with metallic fencing. Moreover, tall trees and open

**Table 5.** Line parameters during measurement at site 5

| Sl. No. | Parameters | Particulars |
|---|---|---|
| 01 | Span Length | 305 m |
| 02 | Line voltage | 773 kV |
| 03 | Line load | 1043 MW |
| 04 | Bundled conductor height at max. sag point | 20 m |
| 05 | Ambient Conditions | Td:27˚C, Tw:23˚C and P:730 mm of Hg |

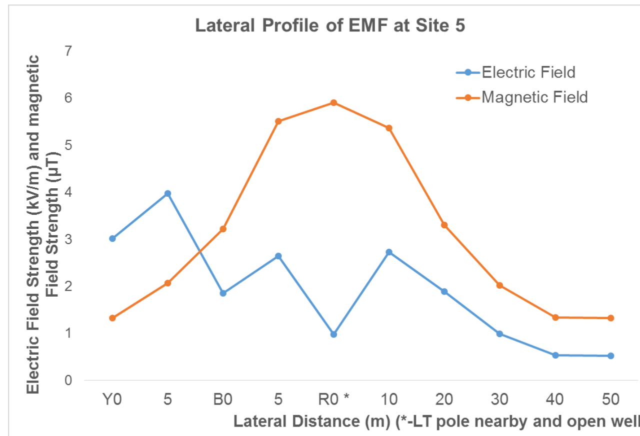


**Figure 1** Lateral profile of EMF at site 5.

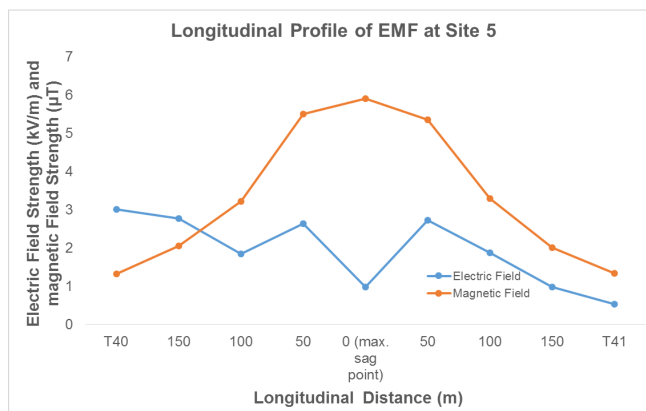


**Figure 16.** Longitudinal profile of EMF at site 5.

well, one shed cement / coconut leaf room with galvanized iron roofing sheets, as shown in Figures 2 and 3, is also spotted near the location of measurement interest. Lateral and longitudinal profile of electric and magnetic field is strengths measured is shown in Figures 15 and 16. Due to the effect of irrelevant objects and uneven surfaces, there may be lots of disturbances in the measurement. Though the recorded values of field strengths are lesser than ICNIRP guidelines, this may not be considered within the limits because of irregularities in the measurement location. Ambient conditions and other transmission line parameters recorded during the measurement are given in Table 5.

## 6. Conclusions

The measured values of electric field are greatly affected by the presence of other power lines, towers, trees, fences, vegetation, flatness and other irregularities of the location of measurement. Not much influence of these parameters was observed on the measured magnetic field strengths. The maximum values of electric field strength and magnetic field strength were measured near span between tower numbers Tower 2 and Tower 3 as 6.11 kV / m and 7.63 μT, respectively. Though these values are exceeding the ICNIRP limit, due to the irregularities in the measuring site, decision is inconclusive. However, it is advisable to take necessary steps to mitigate the electric field strength. Moreover, all these measurements are to be repeated without any vegetation for compliance to ICNIRP guidelines.

## 7. Acknowledgment

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## 8. References

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