

# Electromagnetic and Electrostatic Study in High Voltage Switchyard

R. Devanathan<sup>1</sup>, B. Mutum<sup>2</sup>, L. Obiroy<sup>2</sup>, C. Manivannan<sup>3</sup>, R. Malarvizhi<sup>3</sup>

<sup>1</sup>Hindustan University, Rajiv Gandhi Salai, Padur (via) , Kelambakkam, Chennai , India

<sup>2</sup>Hindustan University, Rajiv Gandhi Salai, Padur (via) , Kelambakkam, Chennai, India

<sup>3</sup>L & T Constructions, Power Transmission & Distribution, Chennai, India

## Abstract

Safe electromagnetic radiation levels for long term exposure of humans have been specified. The project reported in this paper is to check whether the limits specified are exceeded in a 765 kV, 2000 MW switchyard so to protect the human operators working in the yard.

Due to the complexity of the geometry of switchyard, a practical approach to the solution of the problem is to carry out Finite element (FEM) analysis using COMSOL Multiphysics software® and the AC/DC Module. The main challenge was in terms of having to cope with a large range of dimensions starting from 0.04 m diameter of conductors to the 200-250m length of transmission lines.

We took advantage of the symmetry of the switchyard geometry to reduce the dimensional problem of modeling the transmission lines. Also, auxiliary elements, such as, circuit breakers, isolators etc. on the ground are simply modeled as geometrical objects with a metallic enclosure. Figure 1 shows the geometrical structure simulated.

The switchyard modeled is then meshed using COMSOL Multiphysics. The result is the finite element space as in Figure 2. The electric circuit, electric current and magnetic field physics are used in the project. At 50 Hz, the electric and magnetic fields are essentially decoupled and could be separately studied. Iterative linear solvers are used for the study.

The results are displayed in the form of field distribution along a horizontal cross- section of the switchyard at a height of about 1.8 m above ground (corresponding to the typical maximum height of a human operator). The electric field in many locations exceeded the prescribed limit of 10 kV/m as per regulations. To rectify this situation, 4 grounded wires per bay are placed at critical locations. With grounded wires placed at appropriate locations, the simulation showed that it was possible to bring down the electric field below the limiting value at all the locations (see Figure 3).

The value of the magnetic field along the plane mentioned above is always below 10 mG (see Figure 4). The regulatory limit is far above this value at 5000 mG. So, clearly, for the electric current levels provided, no risk is perceived through magnetic field.

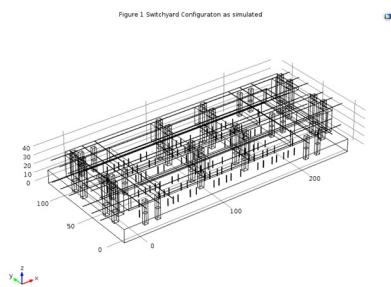
In conclusion, it is found that the magnetic field in the switchyard is far below the specified level for human exposure. The electric field, however exceeded the specified limit at certain regions. Again, after placing grounded wires at critical locations at a height of 8 m above ground level, the COMSOL Multiphysics simulation showed that the electrical field was within the specified

limits at all locations at 1.8 m above ground level. The simulation results have also been largely verified using actual field measurements of electric and magnetic fields at selected locations in the switchyard using a power frequency survey instrument.

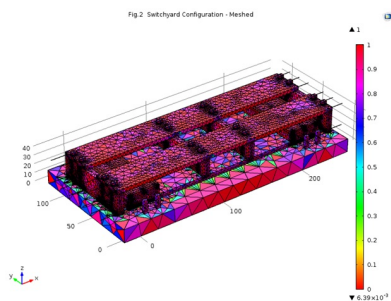
## Reference

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2. COMSOL, “Introduction to COMSOL Multiphysics”, COMSOL 5.1.

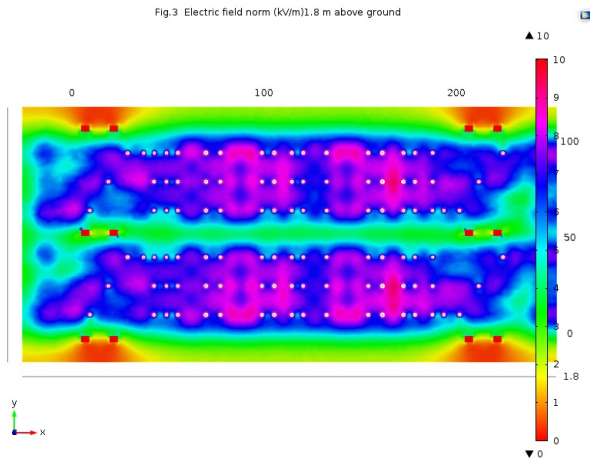
## Figures used in the abstract



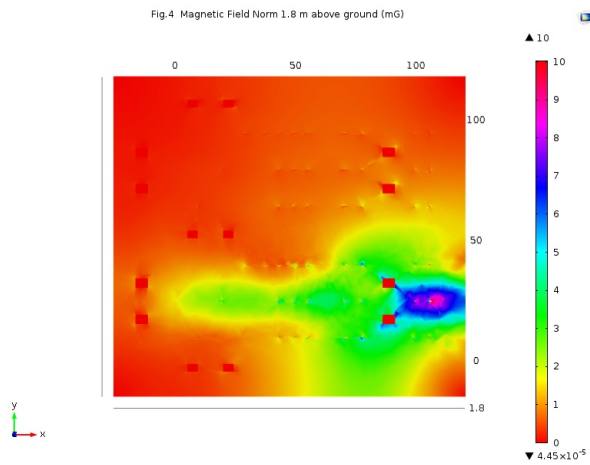
**Figure 1:** Switchyard Configuration as simulated.



**Figure 2:** Switchyard Configuration - Meshed.



**Figure 3:** Electric Field Norm (kV/m) 1.8 m above ground.



**Figure 4:** Magnetic Field Norm 1.8 m above ground (mG).