CHAPTER 6

CONCLUSION / RESULTS AND FUTURE SCOPE OF WORK

In the first phase of this thesis finite model for two layer soil was developed using MATLAB GUI. In the next phase empirical formula was developed for two layer soil resistivity model & this was run in the MATLAB GUI. Finally the parametric analysis was carried out to examine the impact of each designing parameters of grounding system on the optimization of grounding grid design of the substation. A computer program named RPDGS was developed using MATLAB GUI for optimization of grounding system design & soil modeling of the substation.

6.1 Summary of Work Done:

1. Four pin wenner method of resistivity measurement was used to measure the resistivity of soil in the field. These data were arranged & analyzed. The data so obtained were used as input for soil Modeling Module of RPDGS to obtain the two layers soil resistivity model. Also Data from literature were also taken to validate the results obtained by RPDGS.

2. Empirical formulas for apparent resistivity to be assumed for designing of grounding system with two layer soil resistivity model for both positive and negative reflection factor were developed. Many case studies were carried out to validate the developed empirical formula with established Auto-grid pro software.

3. Experiments were carried out using scale model of grounding system for both single layer (Uniform layer) soil model and two layer soil resistivity model to examine the impact of resistivity of soil of both layers, size of earth mat, number of electrodes, location of electrodes etc. both on the substation resistance & GPR.

4. Parametric Analysis was also carried out to examine the impact of change of any parameters on complete design of grounding system with uniform layer as well as two layer soil resistivity model using MATLAB GUI developed program RPDGS.

6.2 Conclusion (Findings of Work)

1. Accurate measurement of the soil resistivity and proper interpretation of the data is very important for proper modeling of soil structure. Both infinite & finite expressions for Wenner apparent resistivity calculation for two layers have been used to develop the two layer soil model of the High Voltage substation. Developed software RPDGS with the help of MATLAB GUI has been used for two layer modeling and the same has been tested / validated for a number of combinations of soil resistivity measurement data.

2. The importance of soil resistivity in the designing of grounding system of any substation cannot be ignored. The soil properties need to be analysed and computed properly using accurate method of soil resistivity measurement as the resistivity may vary over a wide range i.e. few ohm-m to few thousand ohm-m. The soil properties changes with seasonal variations, structure type etc. It is pertinent to mention here that neither the very low resistivity nor the very high resistivity represents the worst case for human safety during fault in the power system.

3. The computed apparent resistivity for two layer soil model depends on resistivity of top layer, resistivity of lower layer, depth of the upper layer, reflection factor (K) and distance between electrodes of earth tester/ resistivity measuring device.

4. The various parameters like grid area, soil resistivity, conductor length, and depth of the buried grid, number of meshes and diameter of the grid conductor play an extremely vital role in the calculation of substation grounding grid resistance. Therefore, these parameters should be observed and measured carefully, so that substation grounding grid resistance can be calculated accurately. The substation grounding grid resistance affects the ground potential rise.

5. For the two layer soil resistivity model where the resistivity of upper layer is more than resistivity at bottom layer (negative K) i.e. $\rho 2 < \rho 1$, increase in depth of grounding decreases the mesh voltage, step voltage, grid resistance & GPR which enhance the safety of operating person .

6. As soon as depth of grounding grid touches the boundary of two soil layers, there is remarkable decrease in step potential, mesh potential, grid resistance and GPR for (negative K) i.e. $\rho 2 < \rho 1$.

7. The phenomenon is reverse in positive K i.e. $\rho 2 > \rho 1$ i.e. for the two layer soil resistivity model where the resistivity of upper layer is less than resistivity at bottom layer .

8. For positive reflection factor i.e. $\rho 2 > \rho 1$ as the 'H' i.e. height of upper layer increases all parameters GPR Em & Es decrease. It is pertinent to mention here that all designing parameters i.e GPR, Em, Es and resistance will decrease further with the use of electrodes / rods.

9. For negative reflection factor i.e. $\rho 2 < \rho 1$ phenomenon is reverse.

10. The increase in number of meshes and use of ground rods of varying length with horizontal grid makes the surface potential distribution more favorable for the personal safety and also decreases the grid resistance and ground potential rise which enhances the reliability of protection devices.

11. Empirical formulas developed for calculation of parameters of design

of grounding system for two layer soil model can be useful for accurate designing of grounding system for design engineer who do not have software for designing of grounding system. The accuracy of developed software RPDGS may be improved by analysing more data of substation grounding design especially for two layer soil resistivity model.

6.3 Future Scope of Work

1. For large substations the soil model with multilayer may be derived for optimal designing of substation grounding system.

2. Step and touch potential may be computed for each and every point in the substation at the time of fault in the substation.

3. Impact of EMI (Electromagnetic Interference) may be done for GIS.