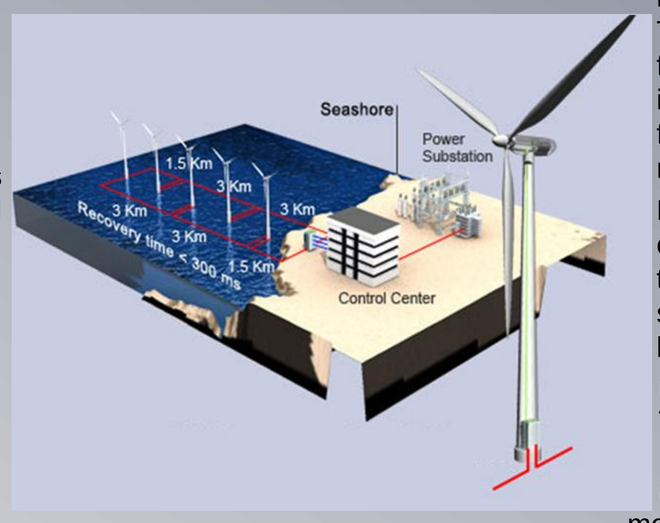
“Grounding system analysis of large electrical installations, using multi-layer soil modeling based on genetic algorithms”

Off-Campus Module Leader: Professor Samarakou Maria
Supervisor of Dissertation: Professor Moronis Antonios
Created by: MSc Student Georgiadis Panagiotis

Abstract
Last decade large amount of money from research programs and many work hours have been spend for applications relative to Grounding Systems. The concept of Grounding systems includes –first of all– the protection of human life, and the protection of the equipment (electrical or no). Of course the protection is the main target. Many projects also take into account the cost. On the other hand this dissertation set as a target the grounding of a large installation with a wind farm in Greece. This wind farm includes about 15 wind turbines.
By considering carefully the pro mentioned problem we will realize that there are many sub problems which we ought to consider and face them. I realized that in my country (Greece) there are many problems which they come up during the design of wind farm grounding system. Generally the main difficulties are relative to land–planning and topographical limitations. There are also many difficulties to achieve the appropriate distances between electrodes. The use of genetic algorithm is necessary to solve the above problems. Software may be used for genetic algorithm calculations. At the section of Literature Review you may see the above sub problem and other –less difficult– sub problems as well. You may also see a well organized way to face all the sub problems and the references which help me to get there.

Aims and Objectives
The main aim is to realize the problem, and divide it into sub problems.
For each sub problem I search for ways to face it. My strategy includes sub problems facing and detailed analysis with the aim is to solve the general problem. The main sub problems which I described before are:

1. What technique will be used for grounding measurement
2. What is the most appropriate analysis of N–layer structure
3. Choose of a sufficient genetic algorithm
4. Facing the special requirements and distinctiveness
5. Design of a grounding system sufficient to our purpose



Background
The most widely used methods are Wenner & Schlumberger methods. The former method has less accuracy (compared with the latter) at cases of inductance conductions [1], [2]. On the other hand the former is not so depended from the noise signals, than the latter [1], [2], [3] . Hence Between the above methods the best choice is the former [1], [2].
Most authors use two or three layered analysis. There is no point to do calculations for more layers. We should mention that the most widely spread way to obtain soil parameters is to assume that the actual soil has a two-layer structure. But calculations are very difficult and risk of inaccuracy is very high. A better two layered analysis presented at paper [1] because this analysis is based in a genetic algorithm.
The greatest advantage of those algorithms is that, they have the ability to Process large amount of data in very short time. One of most wide spread applications is the calculation of earth structure parameters. Especially article [26] mention more details about genetic algorithms A good genetic algorithm can be used by the software “RESAP” [25] of CDEGS. This software is considered as reliable. This is a software just for our purpose.

Project Description
Intro
We should note that each of the above sub problems can be divided –until a point– into more sub problems. I would also like to let you know that after the meeting which I had with my supervisor we decided that –until the printing of this document– my dissertation would be bibliography based. Hence I will not do experiments, but I will probably use a software sufficient for my purpose.

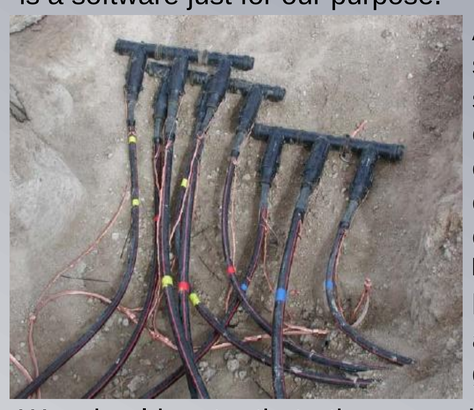
✓ 1. The technique will be used for grounding measurement
Briefly we have two methods: Wenner & Schlumberger. Those two methods are the most widely spread. Despite this I will search more because I should find out if it is exist another more accurate method. Until the time of printing this document I decided that Wenner method is better choice (compared with Schlumberger).

✓ 2. What is the most appropriate analysis of N–layer structure
By abstract is not mentioned clearly the number of layers of the soil structure. I know that first of all I will study about the single layer soil. After that I will try to learn about, tow or thee layer structure of the soil, analysis. Some steps will probably change during the summer when I will deeply into my dissertation. By take into account the references [4], [7], [10], [8], [16], [27], [25], [1], [2], [32], [33], [26], I believe that more important for my purpose, are papers [7], [25], [1], [2], [32]. This is fundamental problem but it can be faced easily. Many writers write for 2 or 3 layer earth structure.

✓ 3. Choose a sufficient genetic algorithm
Genetic algorithm is a necessary tool. We need this tool to process all the existed data. There are many algorithms. A good genetic algorithm which can be used, is the software “RESAP” [25], [7] of CDEGS Company. I believe that this is a reliable solution and it is widely used from National Technical University of Athens (NTUA) for various experiments and Dissertations. Until the time of printing this document I believe that the algorithm which is more sufficient for this purpose, described best by paper [7]. This is an algorithm exclusively for wind farm grounding systems.

✓4. Facing the special requirements and distinctiveness
The factors and the standards for the correct distances between electrodes are mentioned clearly in a very reliable guide [32] of IEEE. All the data about measurements should be during for summer months. By working based in those months means that we work will the worst case/scenario with the simple reason that during this time we have the maximum value of earth resistivity. Maximum earth resistance means minimum protection of the occupants life (first of all), and equipment which is placed close to electrical installation. If we manage to design a grounding system which operates successfully in the worst conditions then we can say that our system achieved its purpose. The problems are usually due to the land-planning and topographical limitations. As a result of this there are many difficulties to achieve the appropriate distances between grounding electrodes. Also the each resistivity of Greek wind farms is usually high due to the structure of the earth

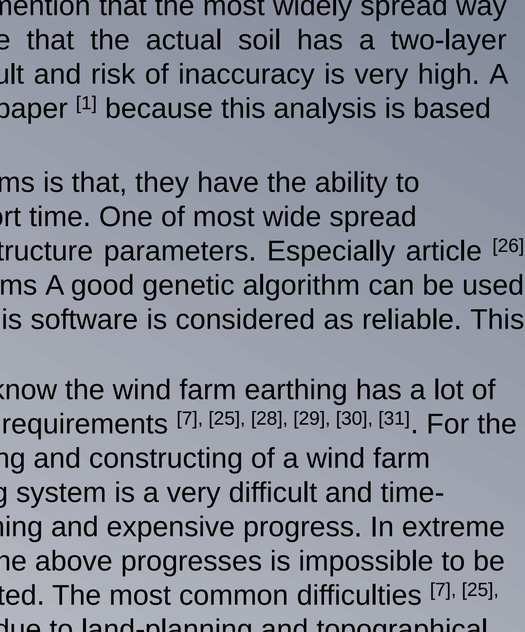
✓ 5. Design of a grounding system sufficient to our purpose
The sub problem 5 can not be solved –until appoint– if we firstly do not solve the sub problems 1 to 4. By taking notice all the presented difficulties of the previous sub problem, it is sufficient to follow the common technique 25] for large installations. In conformance with –almost- all the writers, large grounding systems is better to be faced as many separate independed sub grounding systems. As I mentioned before I will not do experiments. Hence many steps of this method may be replaced from assumptions. (more details will be mention at the point of layer analysis).



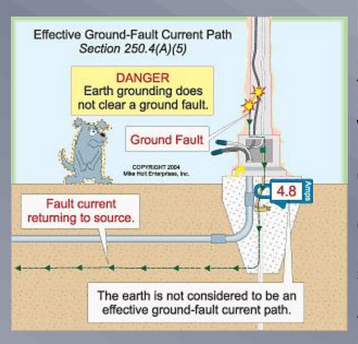
As we know the wind farm earthing has a lot of special requirements [7], [25], [28], [29], [30], [31]. For the sketching and constructing of a wind farm earthing system is a very difficult and time-consuming and expensive progress. In extreme cases the above progresses is impossible to be completed. The most common difficulties [7], [25], [28] are due to land-planning and topographical limitations. There are also many difficulties to achieve the appropriate distances between grounding electrodes.
We should note that, the grounding systems which we will design should be sufficient for our purpose. Especially I believe that more important for my purpose, are papers [1], [2], [7], [25], [31]. From the pro mentioned references the most useful are [7], [25] because they are mention very useful information especially for wind farm earthing systems. This methodology had been widely used for several measurements of wind farms in Greece. Large institutes such as NTUA and International CLEIS have widely mentioned the use of this method at their papers.

Project Plan

	Task Name	Duration	Start	Finish
1	Dissertation	159 days?	Mon 2/2/09	Thu 10/9/09
2	Portfolio Preparation	50 days?	Mon 2/2/09	Fri 10/4/09
9	Main Part of Dissertation	85 days?	Fri 15/5/09	Thu 10/9/09
10	General Searching	16 days?	Fri 15/5/09	Fri 5/6/09
11	Sub problem 1	16 days?	Fri 15/5/09	Fri 5/6/09
12	Appropriate technique for measurement	16 days?	Fri 15/5/09	Fri 5/6/09
13	more literature searching	16 days?	Fri 15/5/09	Fri 5/6/09
14	consideration & comparison for each method	16 days?	Fri 15/5/09	Fri 5/6/09
15	Write my thoughts	16 days?	Fri 15/5/09	Fri 5/6/09
16	Sub problem 2	23 days?	Fri 15/5/09	Tue 16/6/09
17	Optimal technique for N-layered analysis	23 days?	Fri 15/5/09	Tue 16/6/09
18	Find the appropriate technique of layer analysis	4 days?	Fri 15/5/09	Wed 20/5/09
19	consideration & comparison for each method	3 days?	Fri 5/6/09	Tue 9/6/09
20	Write my thoughts	4 days?	Thu 11/6/09	Tue 16/6/09
21	Sub problem 3	22 days?	Fri 15/5/09	Mon 15/6/09
22	Genetic algorithm	22 days?	Fri 15/5/09	Mon 15/6/09
23	try to achieve access in NTUA lab.	4 days?	Fri 15/5/09	Wed 20/5/09
24	Be familiar with the appropriate software	4 days?	Thu 21/5/09	Tue 26/5/09
25	Use the software	4 days?	Thu 21/5/09	Tue 26/5/09
26	Discuss my findings	4 days?	Wed 27/5/09	Mon 1/6/09
27	Write my thoughts	10 days?	Tue 2/6/09	Mon 15/6/09
28	Sub problem 4	33 days?	Wed 10/6/09	Fri 24/7/09
29	Wind farm special requirements & distinctiveness	33 days?	Wed 10/6/09	Fri 24/7/09
30	Search for special requirements and distinctiveness	7 days?	Wed 10/6/09	Thu 18/6/09
31	Search for literature appropriate for my purpose	9 days?	Mon 15/6/09	Thu 25/6/09
32	Find way to face the distictivities	6 days?	Fri 26/6/09	Fri 3/7/09
33	Discuss my findings	6 days?	Mon 6/7/09	Mon 13/7/09
34	Write my thoughts	6 days?	Fri 17/7/09	Fri 24/7/09
35	Sub problem 5	25 days?	Mon 27/7/09	Fri 28/8/09
36	General idea of grounding system	25 days?	Mon 27/7/09	Fri 28/8/09
37	Summarize all the above thoughts of sub problems	15 days?	Mon 27/7/09	Fri 14/8/09
38	Following the 17 steps method	15 days?	Mon 27/7/09	Fri 14/8/09
39	Comments on my work	15 days?	Mon 27/7/09	Fri 14/8/09
40	Write my thoughts	10 days?	Mon 17/8/09	Fri 28/8/09
41	Final processes	7 days?	Wed 2/9/09	Thu 10/9/09
42	Presentation	1 day?	Wed 2/9/09	Wed 2/9/09
43	Final printing	1 day?	Thu 10/9/09	Thu 10/9/09



Expected Outcomes
- Special requirements and distinctiveness which a grounding system of a wind farm may have, should be taken into account
- Special characteristics of the soil structure in Greece must be taken into account.
- A reliable software –appropriate for this purpose– should be found.
- Small period of adjustment with the above software, and well consideration of windings
- Design of a sufficient grounding system which it will be able to provide protection both at apparatus and occupants.



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