# MSc in Energy

# "Investigation of the Performance of various Load Flow Solution Methods in Electric Power Systems"

**STAMELOS GEORGIOS**

## INTRODUCTION

Load flow (or power flow) analysis is a very useful and fundamental aspect of the investigation of any electrical power system. Under normal conditions electrical power systems operate in their steady state condition. Load flow analysis is a tool which is used for the calculation and determination of the various characteristics of the system under this steady state mode.

## BACKGROUND

In their survey, Sasson and Jaimes denote that the main problem in a power flow study consists in the quantities that are known in the beginning of the analysis. In their study, they stated that each bus is characterized by four quantities, magnitude and phase angle of voltage, real and reactive power. According to the type of the bus, two of these quantities are known while the other two are unknown. Thus, a nonlinear set of equations arises.

The most preferable among all the techniques for solving non linear equations are: The Gauss-Seidel method, the Newton-Raphson method, the fast decoupled Newton-Raphson method and the "dc load flow" method.

In order to make a comparison of all the above numerical solutions, it is necessary to built algorithms, for each method. These algorithms will be digitized through computer software.

According to articles [3] and [5], the Gauss – Seidel algorithm is an iterative numerical procedure for solving the load flow problem by successive estimation of the node voltages. Furthermore, it is stated in these articles that the generalized algorithm for the solution of the load flow problem is

$$V_K^{i+1} = \frac{1}{Y_{KK}} * \left( \frac{P_K - jQ_K}{\left(V_K^i\right)^*} - \sum_{n=1}^{N} Y_{Kn} V_n^i \right)$$

According to papers [3], [4] and [6], the Newton – Raphson method is an iterative technique for solving a set of simultaneous non-linear equations in an equal umber of unknowns. At a given iteration point, each function is approximated by its tangent hyperplane. According to these articles the generalized algorithm of the Newton – Raphson method is

$$F(x) = -J\Delta x$$

According to [9] and [11], the fast decoupled method is based upon the fact that there is a strong interdependence between active powers and bus voltage angles and between reactive powers and voltage magnitudes. The main idea behind this method is to solve separately the equations for real power and phase angles and reactive power and voltage magnitudes. The following general equations express the fast decoupled method

$$\Delta P = B' * \Delta\theta$$

$$\Delta Q = B'' * \Delta V$$

According to [12] the dc load flow analysis is a technique which is used only for the calculation of the real power within an electrical power system In a paper published by Purchala et al [13] it is stated that the DC load flow analysis is a simplification of a full AC power flow analysis. It is a method which neglects voltage support, reactive power management and transmission losses. Hence is a linear method.

## EXPECTED OUTCOMES

Conclusions will be extracted concerning the efficiency of each method. Furthermore the experimental implementation of each method, to the same network will lead to the analytical bases, computational requirements, and comparative numerical performances of each method.

## AIMS AND OBJECTIVES

### Aim of the project

The aim of this study is to present a survey which will include a theoretical and experimental approach of the various load flow solution methods for the load flow problem. Furthermore, in this study a comparison will be attempted between the selected methods with reference to the accuracy of the final values of voltages and power flows and to the convergence rate.

### Objectives of the project

1) Investigation of the basic methods for solving the load flow problem
2) Investigation of the suggested improvements upon the basic methods
3) Development of the algorithms for each of the selected load flow solution methods. The algorithms will be developed for a particular electrical network.
4) Implementation of the algorithms in digital form. The selected software for digitalize the algorithms is FORTRAN 90.

Finally the performance of each method will be presented and a comparison will be conducted among them

## PROJECT DESCRIPTION

This study will present a survey of the various load flow solution methods. Mainly there are four load flow methods that will be examined 1) the Gauss-Seidel method 2) the Newton – Raphson method 3) the fast decoupled Newton – Raphson method 4) the "dc load flow" method.

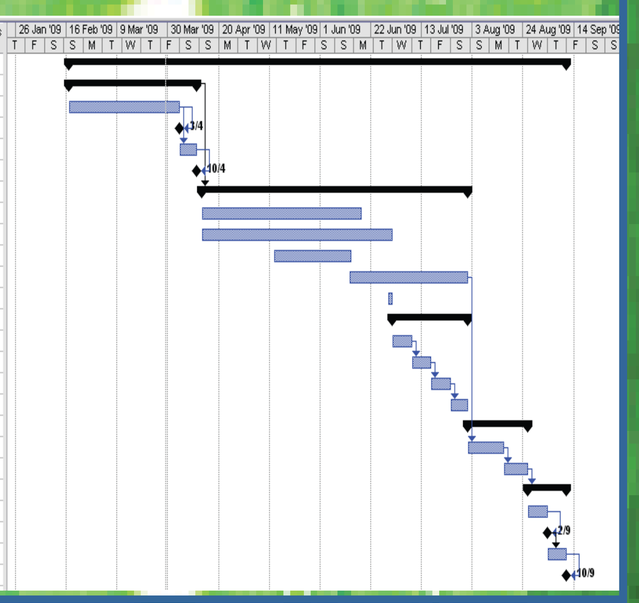
After the exact formulation of the load flow problem, a typical small power system will be selected for the experiment. The various solution methods will be applied on that typical small power system through simplified digital algorithms. The computer software which will be used for the construction of the digital algorithms will be FORTRAN 90.

The primary goal of the load flow study will be to obtain complete voltage angle and magnitude information for each bus in the specified power system for specific load and generator real power and voltage conditions. Once this information is known, real and reactive power flow on each branch as well as generator reactive power output can be analytically determined.

The results obtained by the implementation of each of the above numerical methods to the same network are compared with reference to the accuracy of the final values of voltages and power flows and to the convergence rate.

## Gantt chart

| | Task Name | Duration | Start | Finish | Predecessors |
|---|---|---|---|---|---|
| 1 | **Dissertation** | **159 days?** | **Tue 17/2/09** | **Thu 10/9/09** | |
| 2 | **Critical analysis and research preparation** | **41 days?** | **Tue 17/2/09** | **Fri 10/4/09** | |
| 3 | portoflio preparation | 35 days? | Tue 17/2/09 | Fri 3/4/09 | |
| 4 | hand in portofolio | 0 days | Fri 3/4/09 | Fri 3/4/09 | 3FF |
| 5 | poster preparation | 6 days? | Sat 4/4/09 | Fri 10/4/09 | 3 |
| 6 | hand in poster | 0 days | Fri 10/4/09 | Fri 10/4/09 | 5FF |
| 7 | **Preliminary study** | **86 days?** | **Mon 13/4/09** | **Fri 31/7/09** | **2** |
| 8 | literature review (continue) | 50 days? | Mon 13/4/09 | Wed 17/6/09 | |
| 9 | Data consolidation | 61 days? | Mon 13/4/09 | Tue 30/6/09 | |
| 10 | Familirazation with FORTRAN 90 | 24 days? | Wed 13/5/09 | Sat 13/6/09 | |
| 11 | start writing | 41 days? | Sat 13/6/09 | Fri 31/7/09 | |
| 12 | Selection of network | 2 days? | Mon 29/6/09 | Tue 30/6/09 | |
| 13 | **Constructing the experiment** | **25 days?** | **Wed 1/7/09** | **Fri 31/7/09** | |
| 14 | development of algorithms | 7 days? | Wed 1/7/09 | Wed 8/7/09 | |
| 15 | writing the program | 6 days? | Thu 9/7/09 | Thu 16/7/09 | 14 |
| 16 | evaluating the results | 6 days? | Fri 17/7/09 | Fri 24/7/09 | 15 |
| 17 | conclusions | 6 days? | Sat 25/7/09 | Fri 31/7/09 | 16 |
| 18 | **Writing up** | **20 days?** | **Sat 1/8/09** | **Tue 25/8/09** | |
| 19 | Concluding the writing | 12 days? | Sat 1/8/09 | Sat 15/8/09 | 11 |
| 20 | Possible additional work | 8 days? | Sun 16/8/09 | Tue 25/8/09 | 19 |
| 21 | **Evaluation of dissertation** | **12 days?** | **Wed 26/8/09** | **Thu 10/9/09** | **20** |
| 22 | Presentation preparation | 6 days? | Wed 26/8/09 | Wed 2/9/09 | |
| 23 | Oral presentation | 0 days | Wed 2/9/09 | Wed 2/9/09 | 22FF |
| 24 | Final corrections | 6 days? | Thu 3/9/09 | Thu 10/9/09 | 23 |
| 25 | Hand in dissertation | 0 days | Thu 10/9/09 | Thu 10/9/09 | 24FF |

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