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Signature	: ....
Supervisor's name	: MISS NUR HAZAHSHA BINTI SHAMSUDIN
Date	: 24/06/2015

DISTRIBUTION NETWORK RECONFIGURATION (DNR) RESTORATION FOR MINIMIZING LOSSES IN CONSIDERATION OF DISTRIBUTED GENERATION (DG) INSTALLATION USING IMPROVED GENETIC ALGORITHM (IGA)

NABILAH BINTI ISZHAL

A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2015

I declare that this report entitle "*Distribution Network reconfiguration (DNR) Restoration for minimizing losses in consideration of Distributed Generation (DG) installation using Improved Genetic Algorithm (IGA)*" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree

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Name : NABILAH BINTI ISZHAL

Date : 24/06/2015..

To my beloved mother and father

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ABSTRACT

Fault is a type of disturbance that affecting the continuity of the power supply to loads. Therefore, it is essential for a distribution power system to have a flexible, stable and more reliable load restoration system. The aim of the load restoration in this project is to restore as many loads as possible through the network reconfiguration while minimizing the power losses after the occurrences of fault. Distribution network reconfiguration (DNR) is applied to determine the best combination of open switches that acts as the best route to optimize the reduction of power losses during load restoration process. The reconfiguration process of the network is performed with distributed generation (DG) and being operated simultaneously to reduce power losses by using an algorithm. An improved genetic algorithm (IGA) is proposed in this project. This method is based on IGA expressions to obtain the optimal size of four different distributed generations (DG) at the optimal location on the network. The algorithm proposed is tested and validated on 69 IEEE bus using MATLAB software. A detail analysis is performed to demonstrate the effectiveness of IGA. The proposed method is applied and the effects of method on the power losses are examined. Results show that IGA method for load restoration via DNR and DG is more effective as compared with genetic algorithm (GA) solution.

Keywords: *Load Restoration. Fault Occurrences, Distributed Generation (DG), Distribution Network Reconfiguration (DNR), Power Losses Reduction, Reconfiguration, Genetic algorithm (GA), Improved Genetic Algorithm (IGA), Uniform Crossover (UC)*

ABSTRAK

Gangguan elektrik adalah sejenis gangguan yang menjejaskan keberterusan bekalan kuasa untuk beban. Oleh itu, adalah penting bagi sistem pengagihan bekalan kuasa untuk mempunyai sistem pemulihan beban fleksibel, stabil dan lebih dipercayai. Tujuan pemulihan sistem pengagihan di dalam projek ini adalah untuk memulihkan sebanyak mungkin beban melalui konfigurasi semula rangkaian dan pada masa yang sama ianya meminimumkan kehilangan kuasa apabila berlakunya gangguan elektrik. Konfigurasi semula rangkaian pengagihan (KRP) digunakan untuk menentukan kombinasi pengsuisan terbaik yang bertindak sebagai laluan yang terbaik untuk mengoptimalkan pengurangan kehilangan kuasa semasa proses pemulihan sistem pengagihan. Proses konfigurasi semula rangkaian dilakukan dengan generator teragih (GT) yang dikendalikan secara serentak untuk mengurangkan kehilangan kuasa dengan menggunakan algoritma. Peningkatan algoritma genetik (PAG) dicadangkan dalam projek ini. Kaedah ini adalah berdasarkan kepada ungkapan PAG untuk mendapatkan saiz yang optimum bagi empat generator teragih (GT) yang berbeza di lokasi yang optimum pada rangkaian. Algoritma yang dicadangkan diuji dan disahkan pada 69 bas IEEE menggunakan perisian MATLAB. Analisis terperinci dilakukan untuk menunjukkan keberkesanan PAG. Kaedah yang dicadangkan digunakan dan kesan kaedah keatas kehilangan kuasa akan diteliti. Hasil kajian menunjukkan bahawa kaedah PAG untuk pemulihan beban melalui KRP dan GT adalah lebih berkesan berbanding dengan penyelesaian algoritma genetic (AG).

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Continuity of power supply is very importance for human because electricity is one of the biggest contributors in their daily life. The power supply came from power plant and distributed in the form of electrical energy to any electrical devices in the country through substations. There are two types of the power breakdown which are permanent breakdown and temporary breakdown. The permanent power breakdown referred to disconnection of the power supply for a long period. This type of breakdown will take awhile to be repair and usually involving a major correction in the power supply system. Meanwhile the temporary power breakdown is contrast to permanent breakdown. It is a non-continues situation that occurs in the system which is not lasting or permanent. Breakdown is closely related to disturbance and fault is one form of disturbance received by power supply system. Fault is considered as unusual electric current that exist in an electric power system caused by equipment failures. There are several elements that can be affected by the disturbances of the continuity of the power supply such as product production, financial, jobs opportunities and country economic. For an example, the disturbance of power supply could paralyze sector involved in massive production of products. This is because in the process of product productions, continuity of power supply is important as it will ensure the whole process went smoothly. Without it, the productions of the products are stopped and this could give a huge impact to the company financial. The unstable financial of a company could lead to reduction of workers since job to be done are reduced. If these situations occur at many companies, the economics of the country will be affected as well. In short, the reliability between power utility and consumer need to be emphasis more to ensure the balancing of economic for both companies.

Load restoration is a response of the power system due to fault where the system attempt to restore network back to normal. Fault occurs due to various reasons such as weather condition, equipment failure, human error or smoke of fire. In order to protect the satisfaction of customer restoration of the system is necessary once fault occurs. Priority in the load restoration is to recover as many load as possible by minimizing the faulted areas through the network reconfiguration. Furthermore, reconfiguration of distribution network is significant in maintaining the power supply after fault occurs. The continuity of the power supply throughout the system after the restoration of load is ensured by the radial configuration of the network topology.

Radial structure of the network can be retained by using network reconfiguration. Thus, the number of the open switches should always be equal to the number of the tie-switches .The reconfiguration network holds customers satisfaction and service reliability. Reconfiguration of network also known as a basic of avoiding overloads aside from minimizes the resistive losses. For the future smart grid electricity networks, it is important to have a fully automatic and efficient configuration network. Another option in reducing power losses is the installation of Distributed Generation (DG) where a small scale generator used to provide an alternative to enhance the power system. DG is a self generated power supply that produced and distributed electricity without any help from other source supply. The fault occurrences lead to power failure in several areas. Here, the placement of DGs played an important role in supplied power to affect loads immediately. However, the successes of implementation of DG to the power system are depending on the location and sizing of DG itself.

Both radial structure and placement of DG in distribution network can be achieved through numerous methods such as Tabu Search (TS), Simulating Annealing (SA), and Genetic Algorithm (GA). These methods are commonly used to allocate the perfect combination of switches in the distribution network reconfiguration (DNR) system [1-2]. GA is a calculation adjustment system that used research-based approaches direct binary coding. The principle used in the GA is evolution by natural selection, which uses a population of individuals who undergo selection in the presence of operators like mutation and crossover. The fitness function used to evaluate individuals, and reproductive success varies according to fitness. The improvement of GA leads to a new method called improved genetic algorithm (IGA). The IGA consists of the same main idea as the GA but some improvement is done either at selection, crossover or mutation of the genetic operators. Implementation of these methods will reduce the power losses after fault occurs.

1.2 Problem Statement

The most common problem for normal operation of load restoration after fault occurrences is the increasing of the power losses. This could be due to high current flows during the fault occurrences and less effective of the load restoration management. Most conventional method is usually performed without distributed generation (DG) installation. By using improved genetic algorithm technique in load restoration making the distribution of power becomes more effective and reliable. Load restoration using improved genetic algorithm via distribution network reconfiguration (DNR) and DG installation contributed to higher power losses reduction compared to conventional method.

1.3 Objectives

The objectives below need to be successfully achieved in order to meet all requirement of minimizing the power losses of distribution network system.

1. To determine the best combination set of open switches and the best location and size of distributed generation (DG) for load restoration.

2. To compare the reduction of power losses between the load restoration via DNR and load restoration via DNR and DG simultaneously.

3. To compare results in term of reduction of power losses between the GA method and IGA method.

1.4 Scope

A 132kV/11kV of 69 IEEE buses of radial distribution network with selections of tie switches based on the faulted areas is tested. These selections of ties switches are normally in open condition used for configuring the best status switches during faulted condition to reduce losses. There are four distributed generations (DGs) at optimum location installed in the system with different size of each. IGA is used to find the optimum size of distributed generation (DG) applied to the distribution network system. MATLAB software is used to implement the proposed algorithm

1.5 Expected project outcome

At the end of this project, the load restoration of distribution network is expected to be able to reduce power losses after fault occurrences via network reconfiguration (DNR) and DNR with distributed generation (DG). The 69 IEEE bus systems represent the distribution network system. The installation and location of the DG will help reducing power losses. This system uses the method of Improved Genetic Algorithm (IGA) to reconfigure the system to radial and reduce the power losses as well as to determine the optimum size of the DG.

1.6 Significance of project

With the reconfiguration of 69 IEEE busses distribution network as tested system, a better optimization of power delivering and improving the minimizing of power losses is provided. An improved genetic algorithm is used as an evolutionary search engine to accomplish the objective of the reconfiguration.

1.7 Report outline

This report will be divided in five chapters such as introduction, literature review, research methodology, preliminary results and conclusion. In chapter 1, introduction is about the research background, problem statement, objectives, scope, expected project outcome, significant and report outline. Chapter 2 is the literature review that discussed about the theory and basic principle that will be used in the project. There are also related works and studies and research paper that reviewed as the references. Chapter 3, methodology discusses about the operations, techniques and methods to do this project. The tested system is also presented in this chapter. In chapter 4, discussion on the result of the project outcome is made in terms of the comparison between the two methods used which are the GA and IGA method. Lastly, chapter 5 is discussed on the conclusion of the gathered results for both methods.

CHAPTER 2

LITERATURE REVIEW

2.1 Theory and basic principles

Based on the problem statement, objective and scope in the chapter 1, a study on the theory and basic principle is done in order to fully understand the project. All necessary theories on the fault restoration, distribution network reconfiguration (DNR), distributed generation (DG), genetic algorithm (GA) and improved genetic algorithm (IGA) are included in this chapter. All these theories and basic principles are used in the project.

2.1.1 Fault Restoration

In the fault restoration process based on [3, 4, 5], fault management played an important role in processes of managing the fault occurs. Therefore, the most crucial factor is the fault detection. The fault management processes started with the occurrences of fault and followed by tripping of the protection mechanism. The fault is detected due to the opening of circuit breaker of the feeder. All of the description above described the short circuit fault operation. It is completely opposite with the earth fault operation. In earth fault operation, fault detection is based on the alarm in the relay protection or due to the tripping of the earth fault protection which lead to a less reliable protection of the earth fault operation.

Recently the implementation of automatic distribution is used to ensure the process of distribution of power supply effectively and efficiently. However, the limitation of information of network topology and fault indication with protection alarm had delimitated human capability to solve the occurrences of fault even with the help of automatic distribution.

Besides than automatic distribution, self healing control of power grid is introduced as a solution to fault problem. This self healing comes together with an emergency control agent, restorative control agent, corrective control agent and preventive control agent. The occurrences of fault will trigger protective mechanism of emergency control to isolate the fault. Self healing control will then received a return signal from an emergency control and started to read the latest data from database before activating the restorative control agent while covering the faulted area. Once the faulted area is recovered, restorative agent will immediately send clear mission to self healing control agent.

According to [3], there are three types scheme of self healing fault detection, isolation and restoration schemes. The first scheme is the reclosers that will detect the voltage losses and closed it back after a preprogrammed time. No telecommunication is needed for this scheme and possible to detect fault. The second scheme solved the fault detecting problems but required an advanced GOOSE technology and telecommunication. The third scheme is the combination of substation computer application and SCADA/DMS. The computer application used to make restoration plan according to the information of the feeders. Meanwhile SCADA/DMS will make the switching action decision based on the restoration plan and other information from the network.

2.1.2 Distribution of network reconfiguration (DNR)

Reconfiguration of radial distribution system network is the basic power restoration after fault occurrences to maximize the reduction of power losses. It is necessary to do the reconfiguration of distribution network to retain the power supply during the maintenance of network or while restoring the power after fault occurs. According to [1], some approaches had been proposed to overcome reconfiguration problem such as integer linear programming, Tabu search, fuzzy variable, genetic algorithm, simulated annealing, ant colony systems and other evolutionary techniques. Hence the idea of having a larger loss reduction is come from closing of an open switch with a larger voltage differences between tie switches and the two node voltages of each tie switch is stated in [2]. Therefore a switch needs to be opened to maintain the radial structure of the network using a simple heuristic rules by identifying an effective switch status configuration of distribution system for the minimum loss reduction.

2.1.2.1 Mesh Configuration

A mesh configuration of a distribution system consists of a number of inter-connected ring systems [6]. It has more than one route of power supply and very flexible in transferring the loads. Even a fault occurs on a feeder, there will be no interruption in the process of supplying the power because the faulted areas are immediately isolated. The disadvantages of the mesh configuration of the distribution system are this configuration is more expensive compared to ring and radial configuration network and it is extremely difficult in grading of protection relays. Figure 2.1 below shows the mesh configuration of distribution system.

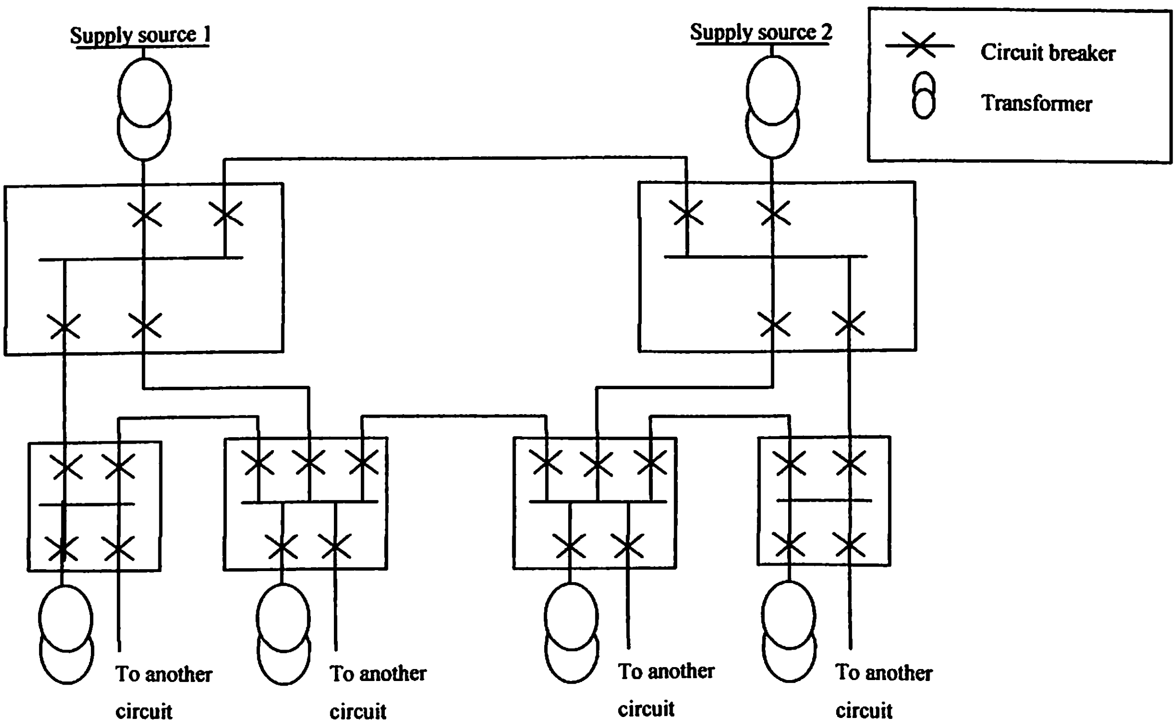

Figure 2.1: Mesh configuration of distribution system.

2.1.2.2 Ring Configuration

For a distribution system with a ring configuration according to [6], it has two or more supply sources. Due to that, the system can provides two or more separated route of power supply to any load. When a fault occurs at a feeder, the faulty feeder can be easily disconnected and the faulted area can be supplied back with power. The disadvantage of the ring configuration is it costs more than a distribution system with radial configuration with the same number of secondary substation and serving the same loads. Besides that, the coordination of protection relay is also difficult compared to a radial configuration. Figure 2.2 below shows the ring configuration of distribution system.

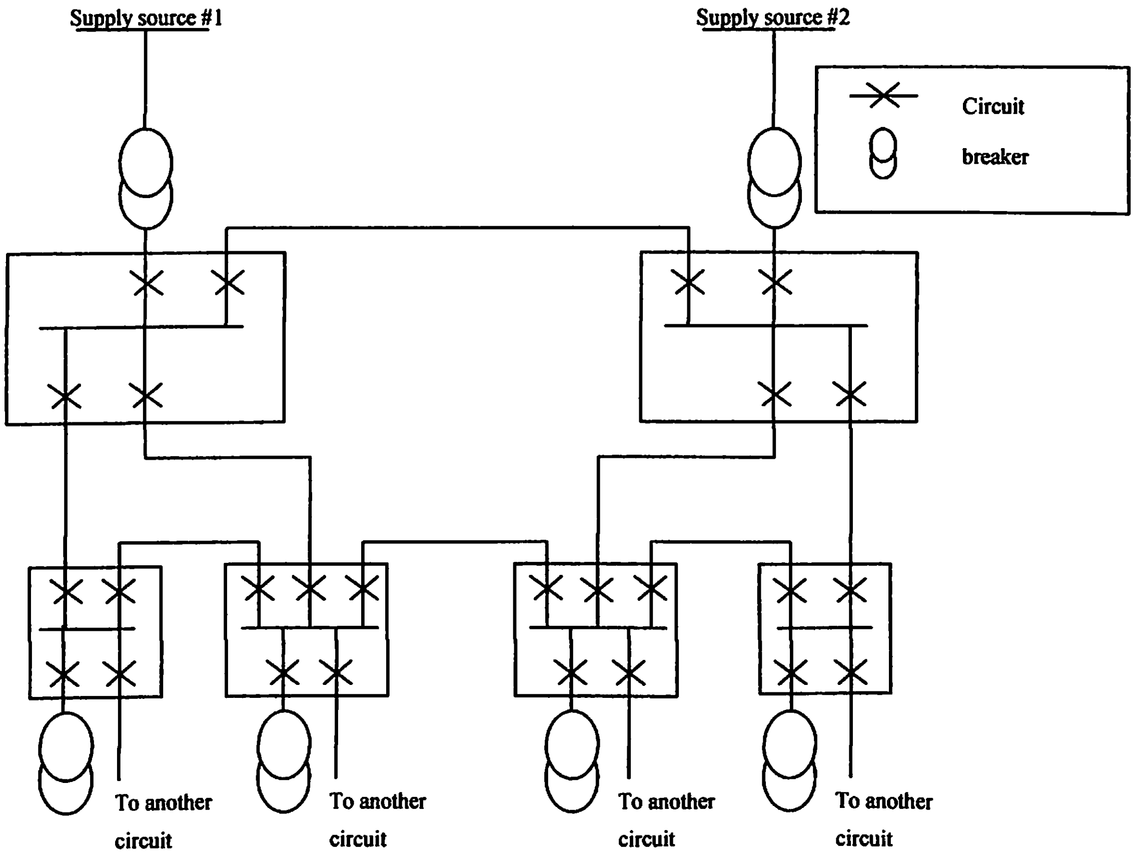

Figure 2.2: Ring configuration of the distribution system.

2.1.2.3 Radial Configuration

A power distribution system that used radial configuration is a system that has only one supply and feeds a number of loads [6]. There are several advantages of radial configuration such as it is simple to design and making the load estimation and sizing of components are relatively easy. Besides that, with this configuration the estimation of fault level and grading of protection are easy to make. Radial configuration of distribution power system only has one disadvantage which is that it does not provide an alternative route to the customer to supply the power. A power outage will occur if fault is on a feeder. Figure 2.3 below shows the radial configuration of distribution system.

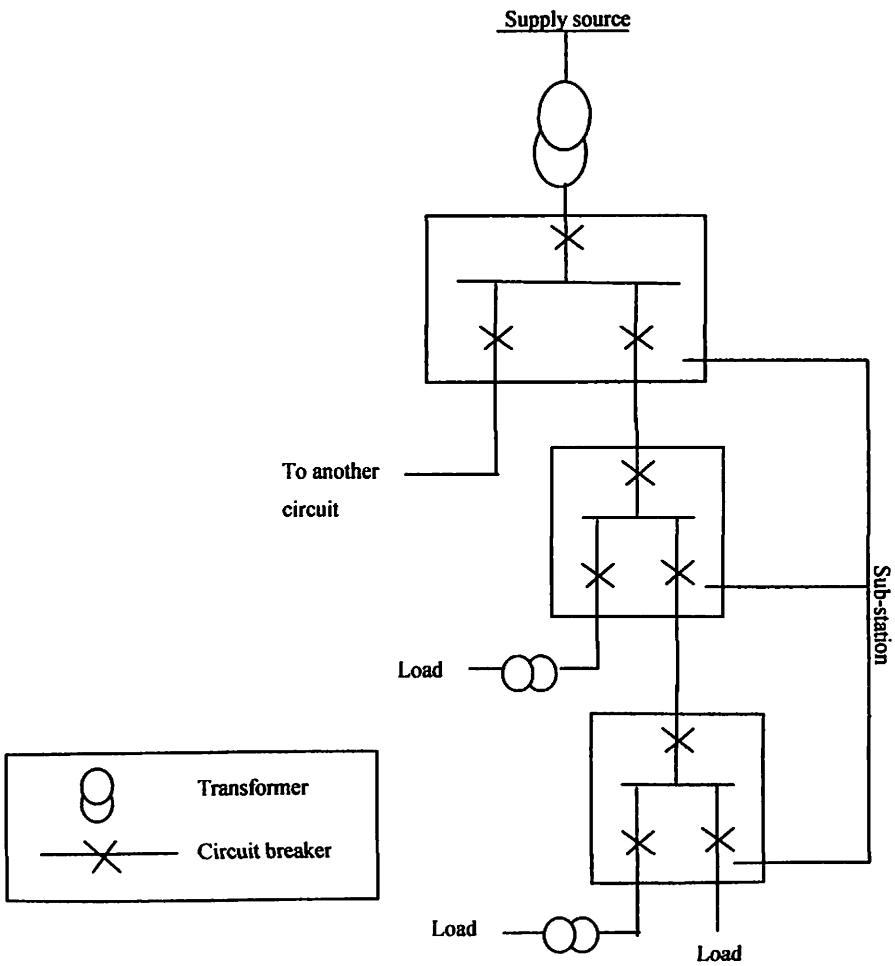

Figure 2.3: Radial configuration of distribution system

2.1.3 Distributed generation (DG)

There are several different types of distributed generation (DG)'s resources and technologies that can be used such as wind, solar, fuel cells, hydrogen and biomass. The implementation of DG in a network operation and planning practices lead to a greater benefits. The benefits of DG are classified into two groups which are technical and economics such as loss, voltage profile, reliability of supply, maintenance costs, and network connection reinforcement costs. The implementation of DG to distribution system can significantly impact the flow of power and voltage conditions at customers and utility equipment. These impacts may be either positively or negatively depending on the distribution system operating characteristics and the DG characteristics.

Distributed generation is described as an electrical power resource that directly connected to the distribution network based on [7]. According to [8, 9], due to their intermittency and fluctuating characteristics, the distribution system is imposing a new challenge with the DG over centralized predictable production. To enhance reduction in power losses, power transfer capability, increase system quality and reliability, the optimal size and location DG can be used. However, the system losses can be increased if the inappropriate installations of DG are made at haphazard locations.

2.1.3.1 Optimum sizing of the DG

According to [10], the total loss of power to the power injected is a parabolic function and the minimum loss rate of change with respect to the power loss is injected is zero.

$$\frac{\partial P_L}{\partial P_i} = 2 \sum_{j=1}^{N}\left(\alpha_{ij} P_j - \beta_{ij} Q_j\right) = 0 \tag{2.1}$$

It follows that

$$\alpha_{ii} P_i - \beta_{ij} Q_j + \sum_{j=1\, j\neq i}^{N}\left(\alpha_{ij} P_j - \beta_{ij} Q_j\right) = 0 \tag{2.2}$$

$$P_i = \frac{1}{\alpha_{ii}}\left[\beta_{ij} Q_j + \sum_{j=1\, j\neq i}^{N}\left(\alpha_{ij} P_j - \beta_{ij} Q_j\right)\right] \tag{2.3}$$