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Date	: ……………………………………..

A LOAD SHEDDING FOR DG INTEGRATED ISLANDED POWER SYSTEM UTILIZING BACKTRACKING SEARCH ALGORITHM (BSA)

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

Faculty of Electrical Engineering
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I declare that this report entitle "A Load Shedding For DG Integrated Islanded Power System Utilizing Backtracking Search Algorithm (BSA)" is the result of my own research except as cited in the references. This report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : …………………………………..

Name : …………………………………..

Date : …………………………………..

To my beloved mother and father

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ABSTRACT

In a power system, when the distribution network that connected with distributed generation (DG) is islanded from main grid, there are several issues should be resolved. One of the main issues are in maintaining the voltage and frequency that disturbed and may lead to power collapse. Thus, the common practices to shed certain loads using load shedding scheme. This project proposed a development of an optimal load shedding scheme based on Backtracking Search Algorithm (BSA). To handle this optimization, a multiobjective function considering the linear static Voltage Stability Margin (VSM)as an indicator and also amount of load curtailment is formulated. Besides, it is also handle the load priority case. The performance of proposed load shedding scheme was evaluated through various islands created based on IEEE 69-bus system using MATLAB software. Furthermore, the effectiveness of the proposed scheme was validated and compared using existing optimization such as Genetic Algorithm (GA). The optimization results indicate that the proposed BSA method is more effective in determining the optimal amount of load to be shed in any islanded system with the shortest time which is average of 886.1319 seconds compared to GA with 1083.929 seconds.

ABSTRAK

Dalam satu sistem kuasa, apabila rangkaian pengagihan yang berhubung dengan penjana teragih (PT) telah dipulaukan dari sistem grid utama, terdapat beberapa isu yang perlu diperhatikan. Salah satu isu utama adalah dalam usaha mengekalkan voltan dan frekuensi yang terganggu dan boleh membawa kepada keruntuhan kuasa. Oleh yang demikian, jalan penyelesaian yang biasa adalah dengan menggugurkan beberapa beban pengguna dengan menggunakan skim tapisan beban. Projek ini mencadangkan penghasilan suatu skim pengoptimuman tapisan beban menggunakan Algoritma Carian Jejak Balik (ACJB). Untuk melaksanakan pengoptimuman ini, fungsi pelbagai objektif dengan mengambilkira Kestabilan Jidar Voltan statik (KJV) sebagai salah satu penunjuk dan jumlah pengurangan beban yang telah dirumuskan. Selain daripada itu, ia juga menangani kes keutamaan beban. Prestasi pengoptimuman bagi skim pengoptimuman tapisan bebas ini dinilai melalui beberapa kepulauan sistem kuasa yang telah diwujudkan berdasarkan IEEE sistem bas 69 dengan menggunakan perisian MATLAB. Tambahan pula, keberkesanan skim yang dicadangkan ini disahkan dan dibandingkan menggunakan skim pengoptimuman yang telah sedia ada seperti Algoritma Genetik (AG). Hasil kajian bagi skim pengoptimuman ini menunjukkan bahawa cadangan kaedah ACJB lebih berkesan dalam menentukan jumlah optimum beban yang perlu digugurkan di dalam mana-mana sistem kepulauan sistem kuasa dengan masa yang pantas, dimana purata masa adalah 886.1319 saat berbanding AG iaitu 1083.929 saat.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Figure 1.1 shows the maximum demand of the grid system in Malaysia provided by Suruhanjaya Tenaga (ST) [1]. According to the statistics provided, the demand of the electric power was increasing year by year from 1990 to 2013 with the average of 4.43% increasing. The figure shows that the increasing by 2.7% of maximum demand of Malaysia's grid system which is from 15,072 MW in 2010 to 15,476 MW in 2011 and then keep increased by 2.3% to 15, 826 MW in 2012. The latest statistics provided by ST shows that the increasing by 4.65% of maximum demand in year 2013 with the current value of 16,562 MW.

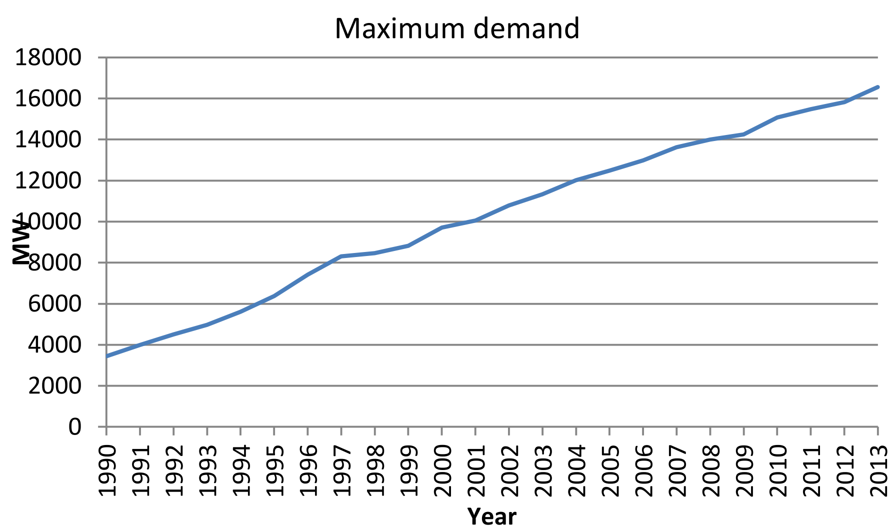


Figure 1.1: The maximum demand of the grid system in Malaysia [1]

Besides that, the Tenaga Nasional Berhad (TNB) report that the sales of electricity also increased year by year. Figure 1.2 shows the sales of electricity had increased to 93,640 GWh in 2011 compared to 90,770 GWh in 2010. Meanwhile, in 2012, the sales continuously increased by 3.8% to 97, 243 GWh.

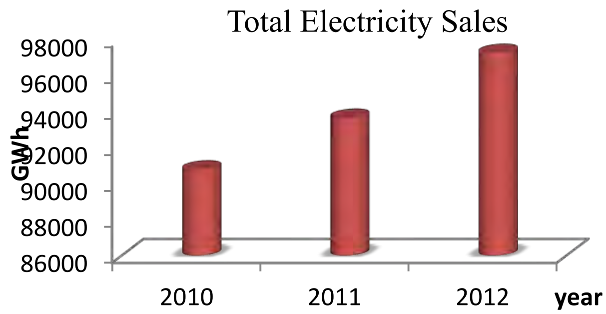


Figure 1.2: The total electricity sales (GWh) of TNB [1]

To meet the higher demand for electricity, TNB had to increase power generation from each power plant. With the current power plant had in Malaysia, the electricity demand hardly to be fulfilled. In order to overcome of the increment of maximum demand yearly, the distributed generation (DG) is introduced. DG is an alternative to conventional power system in generating electricity to the place where it is consumed such as in residential areas, industrial areas and commercial buildings. Moreover, DG system could increase the efficiency of the system and reduce line losses.

In power systems, the DG generally supplies electricity to the consumers is in balance system for sufficient generating and transmission capacities to meet the load demand requirements. However, several problems occur in the system when the distribution system that connected with DG is islanded from main grid electrically which is also called islanding system. If islanding occurs in a distribution system, some of the parameters are severely disturbed such as the voltage and frequency and may lead to power collapse. If it is happened, only a certain amount of electricity can be supplied to consumers. As the last option, in order to ensure the power supplies to the critical loads, some of consumer's loads need to be shed.

In general, load shedding also occurs in places where the total electrical load power demand exceeds the total power generated by the power generations. The whole power station would be automatically shut down by the generator's overload breakers if the load shedding was not done properly where the overload breakers operated in order to protect its alternators from bad damage occurs where it would be highly expensive to repair and would take a lot of time to do it. However, in optimal load shedding, the voltage stability is considered to ensure the system maintain its operation from voltage collapse.

Voltage stability is one of the biggest concerns of power system operators because it would cause several power system blackouts. Voltage stability refers to the ability of a power system to maintain steady voltages at all the buses in the system after being exposure to a disturbance from a given initial condition. System blackout is the state when the system or large areas of it may completely collapse [2].

Voltage instability, in particular, results from the inability of the combined transmission and generation system to deliver the power requested by loads [2]. It is a dynamic phenomenon largely drove by the load response to voltage changes. Load shedding is one of the effective method used to overcome the instability of voltage, especially when the system happened through an initial voltage drop that is too significantly to be corrected by generator voltages [2].

Therefore for many years, various load shedding schemes have been presented, where optimal load shedding using computational intelligence techniques is the most applicable techniques.

1.2 Problem Statement

Figure 1.3 shows the number of tripping transmission system in Malaysia from 2008 to 2011 where it is recorded that more than 50MW of load loss. There were six tripping incidents occurs without load shedding and no incident recorded with load shedding in 2008. In 2009, there were only two incidents of tripping without load shedding and no incident with load shedding. For 2010 to 2012, there were four incidents each year without load shedding and one incident with load shedding on 2011 while the two others were no incidents of tripping with load shedding. There are numeral reasons for the interruptions of electricity supply such as natural problems, equipment failures, overload, maintenance works and improper load shedding. If the interruptions occurred, action should be taken by the TNB or other electricity supply company in order to maintain the distribution system of the unaffected area. The company should reduce the interruptions as minimum as possible because the consumers are desired to have continuously electricity supplies without any problems. Therefore, the result also shows that the load shedding is one of the important ways in reducing the incidence of tripping and there is needed to develop more effective optimization technique to overcome improper load shedding scheme in islanded system.

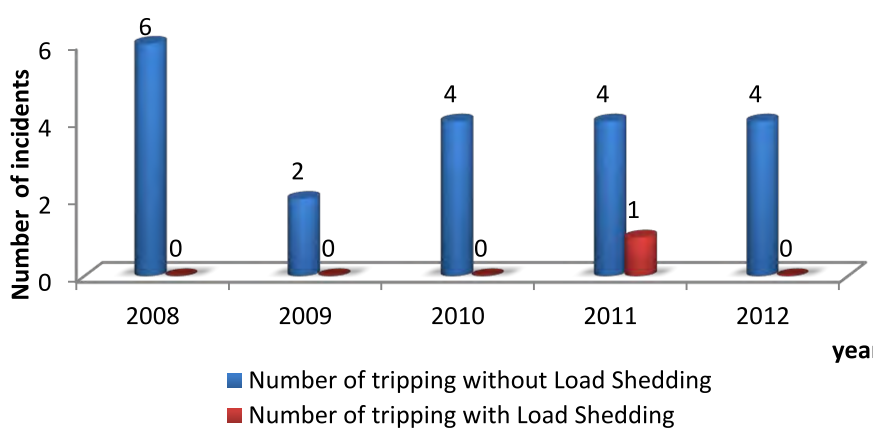


Figure 1.3: The number of transmission system tripping in Malaysia with a load loss of 50 MW and above [1]

Previous studies and researches had invented the optimal load shedding schemes such as fuzzy logic control (FLC), genetic algorithm (GA), particle swarm optimization (PSO), artificial neural networks (ANN), bacterial foraging optimization algorithm (BFAO) and etc. However, most of these methods are hard to converge and the amount of the loads to be shed are large with longer require computation time.

1.3 Objectives

The objectives of the project are as followed:

i. To evaluate the closeness of the system to voltage collapse in islanding condition
ii. To develop an optimal load shedding scheme to maintain the voltage stability in islanding condition.
iii. To validate the proposed load shedding scheme using an existing technique.

1.4 Scope of Work

The purpose of this project is to identify the load shedding scheme in an islanded power system. This load shedding scheme is developed to identify the priority based on the impact of the power system state. Therefore, this project will focus on the analysis of power system interruptions.

For this project, voltage stability margin (VSM) is used as an indicator to evaluate the maximum allowed loading of a transmission and distribution system. An effective optimization algorithm known as the Backtracking Search Algorithm (BSA) is one of the new methods that have been used in the load shedding scheme for an islanded power system. The methods consider numerals system constraint, such as priority load, voltage, and power generation limits.

To evaluate the formulated multi-objectives optimization problem, the MATPOWER Newton-Rapson based power flow algorithm in MATLAB software is used. In order to validate the performance of optimal load shedding scheme, various islands are created based on IEEE 69 bus system using MATLAB software. Moreover the performance of the optimal load shedding schemes is tested using other optimization technique such as genetic algorithm (GA).

1.5 Summary

This report consists of five chapters. **Chapter 1** describes the overview of the project, problem statement, objectives, scope and expected result of this project. **Chapter 2** provides an overview of load shedding scheme to maintain the stability of islanded system. **Chapter 3** explains the methodology of the project and will cover the methods and procedure that been used in carrying out the study project where VSM and BSA are used as the tools and methods in load shedding scheme development. **Chapter 4** highlights the results obtained from the experimental data collection, preparation and discussion performance of the projects that has been simulated. The result shows the value of the VSM for each feeder in the IEEE 69-bus radial distribution system. The results also show the performance of proposed load shedding scheme which is the convergence characteristic, load demand after optimization, and the voltage profile in the system. Lastly, **Chapter 5** is the conclusion of the achievement from the finding study that has been made using the MATLAB software.

CHAPTER 2

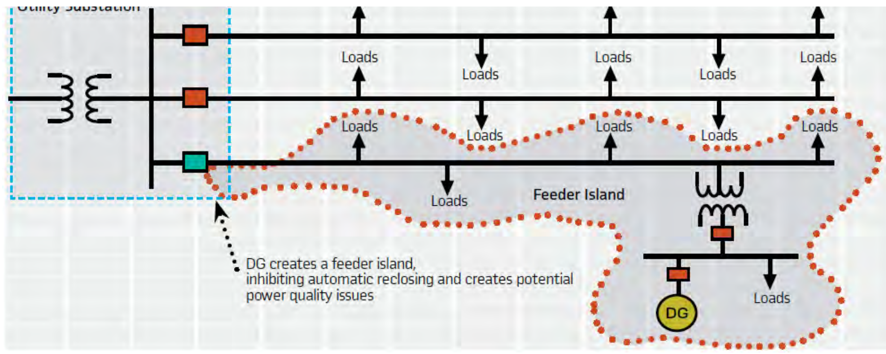
LITERATURE REVIEW

2.1 Introduction of Distributed Generation

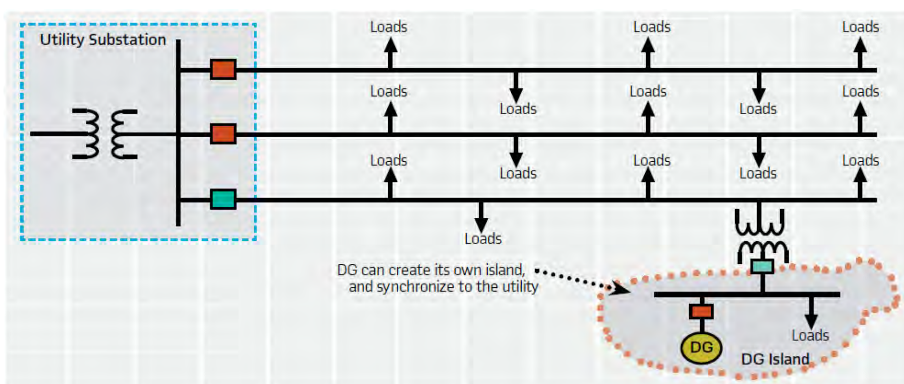
A power system is a network of electrical components used to generate, transmit and distribute electric power. Distributed generation (DG) generally refers to small power output of generators that produce electricity generally only 10 megawatts (MW) or less. It is located close to the load that DG serves. Meanwhile, conventional power stations, such as coal-fired, nuclear, hydroelectric, solar, and others power stations are centralized and often require electricity to be transmitted over long transmission line. By contrast, DG systems are decentralized and more flexible technologies [3, 4]. DG systems usually use renewable energy sources such as solar power, biomass, hydro power, wind power, and etc. DG system also plays an important role as the central generation for the electric power distribution system. The advantages of DG system are increased efficiency, reduce line losses, avoid capacity upgrade of transmission and distribution, and environmental benefits [5].

2.2 Islanding

When a DG disconnected from the power system, it generally cannot be islanded with external utility substation to the DG zone. DG normally cannot maintain the voltage, frequency and harmonics which are acceptable at utility loads external to the DG zone [4]. Reclosing back the system in order to restore the circuit is much complicated and the synchronizing equipments are required. DG can island with the local load at the DG zone and this kind of islanding is allowed because the islanding is invented where DG generation is enough to supply to local load at the DG zone as shown in Figure 2.1(b) [5]. Meanwhile, Figure 2.1(a) shows the not allowed islanding system where the DG generation cannot support the overall loads. However, load shedding may be required so that only critical loads are reserved for the DG.



(a)



(b)

Figure 2.1 (a) Not allowed DG islanding, (b) Allowed DG islanding [5]

In DG, there are several problems occur when the grid disconnects and forms an islanded system electrically. The most critical situation when islanding happened is to maintain the stability of the islanded system where the islanding could be either intentional islanding or unintentional islanding [4, 6]. The disadvantage of this islanding is the voltage and frequency stabilization are severely disturbed due to imbalance between generation and load demand. Besides, the system grid synchronization and power quality matters also effected due to the islanding [6, 7].

Intentional islanding can be defined as planned islanding which is caused by opening of the circuit breaker located at the point of common coupling. The purpose of this islanding is to create a power "island" during system disturbances which are presented because of the faults. If there are power quality sensitive loads in the island, the intentional islanding can prevent the loads from being damaged in case of significant variation of voltage or frequency [4, 6]. Meanwhile, unintentional islanding can be defined as undetected island or unplanned islanding. This unintentional islanding can cause several problems in term of power quality, safety, voltage and frequency stability, and interference [4, 6].

For the past 5 years, there are several techniques to detect the islanding had been studied and developed. Generally islanding technique can be classified into central (remote) and local techniques. Local techniques are based on the measure of some parameters which is voltage, current and frequency on the DG. Meanwhile, remote techniques are based on some kind of communication between the grid and the DG. Remote techniques are more dependable than the local techniques, but it is more expensive to implement than the local techniques [6]. Therefore, most of the researchers are move towards local technique

2.3 Load Shedding

Load shedding is defines as the deliberate switching off of electricity supplies to the electricity network which is then to the customers. Load shedding is rarely done in power systems but it is an importance techniques and issues of the electricity networks. Load shedding may cause the loss of some systems, but it is possible to keep the other systems or equipments or devices which are more important to operate [8]. Then, the system will operate as normal once the system has been restored.

In distribution system, load shedding is utilized to shed some of consumer's loads when the power system is in an unstable condition. Load shedding ensures that the electricity supplies to important or critical loads and make sure the system stable [8-10]. If not recovered properly, a large voltage and frequency variation may lead to power collapse and blackouts [9, 10]. Generally, there are two types of automatic load shedding, which is under-frequency load-shedding (UFLS) and under-voltage load shedding (UVLS).

The instability of the system frequency could affect the reactive power balance and voltage cannot be held and the overall system will collapse immediately [11]. Therefore, the under-frequency load-shedding (UFLS) scheme is to shed an appropriate amount of load for quick recovery of system frequency to its nominal value. The frequency response is much depends on the nature of disturbance. Hence, Omar, Y.R present that it is important to analyze the behavior of system frequency with different types of disturbance that may occur in the system [11]. Laghari J.A proposed a fuzzy based under frequency load shedding strategy to shed optimum loads where the Fuzzy logic load shedding controller (FLLSC) calculates the value of drop frequency and disturbance magnitude [12].

The unbalance and disturbances of voltage stability occurs because of the large value of power transmitted to long distances. Unstable voltage can cause the whole network system to significant voltage drop condition [13]. Therefore, in order to ensure the voltage stability and avoid low voltage condition, the under-voltage load shedding (UVLS) schemes are used. UVLS operates when there is a system disturbance and the voltage drops below a preselected level for a predetermined time. The aim is the voltage is stabilized or recovered to normal levels when sufficient load is shed [14]. Arief, A and Mollah, K. present that UVLS are used and studied to prevent instability voltage occurs [13, 14].

Compare with these two types of load shedding, UFLS is ineffective if there are instability or voltage collapse occurs within the island. Therefore, UVLS is the more effective load shedding because of the most common factor that contributes to power blackout is voltage instability.

2.4 Optimization

Optimization also known as constraint optimization or mathematical programming is defines in term of maximizing or minimizing some objective relative to some set often representing a range of choices available in a certain situation [15-20]. Optimization is a very important research area in applied mathematics. Optimization algorithms aim to find the best values for a system's parameters under various conditions. The problem is to determine the best combination of activity levels that does not use more resources than are actually available. The first step in solving an optimization problem is determining the objective function that states the relations between the system parameters and system constraints.

Optimization, and its most popular special form, Linear Programming (LP), has found practical application in most engineering studies, including the optimization in radial distribution power system. In distribution power system, the common practice of optimization is maximal voltage profile, maximal power load, minimal cost, optimal load shedding, and etc

2.5 Optimal Load Shedding

The most applicable method of optimal load shedding schemes is using computational intelligence techniques, such as fuzzy logic control (FLC), genetic algorithm (GA), particle swarm optimization (PSO), artificial neural networks (ANN), bacterial foraging optimization algorithm (BFAO) and etc.

Genetic algorithms (GA) are global search techniques invented by J. Holland in 1975, based on the mechanisms of natural selection and genetics. The genetic algorithm transforms a population of individual objects, each with an associated fitness value, into a new generation of the population using the Darwinian principle of reproduction [15-17]. M. Guichon presents that the study of the behavior of GA to optimally calculate the smallest amount of load that is necessary to disconnect from the power system after an instability system has occurred [16]. M.T. Hagh proposed multi-objective GA and was applied to power system during two critical