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FINAL YEAR PROJECT REPORT

MODELLING AND ANALYSIS FUEL CELL WITH BATTERY STORAGE MICROGRID SYSTEM BASED ON GREEN ENERGY

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2015

"I hereby declare that I have read through this report entitle "Modelling and Analysis of Fuel Cell with Battery Storage Microgrid System Based on Green Energy" and found that it has comply the partial fulfillment for awarding the Degree of Bachelor of Electrical Engineering (Industrial Power)"

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Date : 10^{th} of June 2016

MODELLING AND ANALYSIS OF FUEL CELL WITH BATTERY STORAGE MICROGRIS SYSTEM BASED ON GREEN ENERGY

NOR ATHIRA BINTI ALI OSMAN

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

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2016

I declare that this report entitle "*Modelling and Analysis of Fuel Cell with Battery Storage Microgrid System Based on Green Energy*" is the result of my own research except as cited in references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : Nor Athira Binti Ali Osman

Date : 10th of June 2016

I dedicate this report to my parents. Without their pray, understanding, support and most of all love, the completion of work would not have been possible.

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A major research project like this is never the work of anyone alone. The contributions of many different people, in their different ways, have made this possible. I would like to extend my appreciation especially to the following.

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Finally, I would like to thank my parents. They are very understanding with my busy schedule and give moral support to ensure me completing this paper.

ABSTRACT

Nowadays, the implementation of distribution generation(DG) are increasing per day to find out the most convenient and available alternatives from the several choice of DG. Fuel Cell technology is considered to be one of the most reasonable DG that is free from any climatic changes. Normally traditional grid is used to supply the electricity to the consumer but through this project two types of DG are connected to main grid. This type of connection is called Microgrid(MG) system. The two types of DG that connected to main grid are fuel cell and battery storage. There will be two designed which are first is fuel cell is connected to main grid and the second design is battery storage connected to main grid. These circuit are designed by using MATLAB Simulink Software and the simulation results are indicated the output data for power, three phase voltage and three phase current.

ABSTRAK

Pada masa kini, perlaksanaanpemasangan Generator Pengagihan(DG) semakinmeningkatsetiaphariuntukmengenalpastialternatif yang paling sesuaidanmudahdidapati. Teknologiselbahanapidianggapsalahsatudaripada DG yang paling berpatutan yang bebasdaripadaapa-apaperubahaniklim. Biasanya grid tradisionaldigunakanuntukmembekalkantenagaelektrikkepadapenggunatetapimelaluiproje kiniterdapatkelebihanpada grid utamaiaituduajenis DG disambungkankepada grid utama. Sambunganjenisinidipanggilsistem “Microgrid”(MG). Kedua-duajenis DG yang bersambungdengan grid utamaadalahselbahanapidanpenyimpananbateri. Di sanalahakanterdapatduarekaanlitariaitu yang pertamaadalahselbahanapidisambungkanke grid utamadanrekabentuk yang keduaialahpenyimpananbateridisambungkanke grid utama. Litarinidirekadenganmenggunakanperisian MATLAB Simulink dankeputusan data simulasi yang ditunjukkanialahkeluarankuasa, tigafasavoltandantigafasaaruselektrik.

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LIST OF ABBREVIATIONS

DG	-	Distribution Generation
MG	-	Microgrid
PCC	-	Point of Common Coupling
SD	-	Separation Device
AFC	-	Alkali Fuel Cell
PEMFC	-	Proton Exchange Membrane Fuel Cell
PAFC	-	Phosphoric Acid Fuel Cell
BMS	-	Battery Management System
MGCC	-	Microgrid Central Controller
PV	-	Photovoltaic
BESS	-	Battery Energy Storage System
VRLA	-	Valve-Regulated Lead Acid
UPS	-	Uninterruptible Power System

LIST OF SYMBOLS

H_2 - Hydrogen gas

H^+ - Hydrogen ion

e - Electron

O_2 - Oxygen gas

O - Oxygen ion

V - Voltage

I - Current

kW - Kilowatt

RMS - Root Mean Square

Vp-p - Voltage phase to phase

DC - Direct Current

AC - Alternate Current

P - Active Power

Q - Reactive power

CHAPTER 1

INTRODUCTION

1.1 Motivation

In developing countries, the usage and demand for energy is increasing rapidly due to the increase of human population and improvement in standard living. The necessity of technology in urban area helps the power consumption to increase respectively. The use of the fuel cells as a new alternative is the best solution to accommodate this situation.

Fuel cells has the advantage that is can be installed anywhere since it did not need large space. Constant supply of hydrogen supply as the fuel is the only thing needed to power up the fuel cells. Through this project, this two types of DG that is fuel cell and battery storage are used in connecting with MG.

MG is a power system that consists interconnected load and DG, which operates in high voltage or low voltage [1]. MG is greater than traditional grid this is due to the ability of the system to operate on its own when fault happens to the main grid. Hence, the source of power to the consumers would not be interrupted since it has backup system.

1.2 Problem Statement

Combining DG into the existing network can help improve the consistency of the system. A common problem in industries when using traditional grid is the grid is only one way of flow electricity and communication. Instead of using the traditional grid, in this project, MG is used to replace the traditional grid. However, MG operations have to satisfy quality requirements in terms of the frequency and voltage. To overcome this problem, energy storage systems for short and long term storage are used with MG. Fuel cell is implemented in DG so that the system can work functionally.

The MG is used to ensure there is no interruption happened as in traditional grid if fault happen. DG implemented in MG will be the backup to supply the power to the load if the power source from the grid is not functioning.

1.3 Objectives

The objectives of this project are;

i. To study the operation of DG, MG and battery storage in the three phase system network.

ii. To design the circuit of fuel cell, battery storage and MG system by using MATLAB Simulink software.

iii. To analyse the performance of fuel cell and battery storage system of microgrid by using MATLAB Simulink Software

1.4 Scope

The modelling and analysis of the fuel cell along with battery storage connected to MG are all carried out by using MATLAB, Simulink. This project research will cover the purpose on the operation of fuel cell and battery storage The observation of the changing voltage, current and power are all discussed by taking out the simulation of the graphs.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

To overcome the environmental issues and rapidly increasing power demand, various renewable and non-renewable energy sources getting attention. One of it is fuel cell system. The advantages of fuel cell are pollution free and high efficiency technology for MG distribution systems. In this section, all the main part such as fuel cell, MG and battery storage will be discussed. The design, configuration and operation of the MG, fuel cell and battery storage will be explained.

2.2 Microgrid

MG is a system that connect houses, factories and other buildings to power central sources [2]. A normal grid or traditional grid will connect to the houses, factories or other building but when there is maintenance work need to be done, all of the connected building will be cut off from receiving the supply. This is a situation that can be corrected by connecting the building using MG.

2.2.1 Microgrid Design

MG is a system that have low voltage or medium voltage distribution network that surround by DG, energy storage systems and loads, operating as a single controllable system [3]. Basically MG can be power on in case of emergency such as lightning strike or storms, without disturbing the supply to the loads. This is due to the connection of the load with the DG. DG is a used for capacity support, voltage support and regulation, and line loss reduction [3].

DG usually made of many new technologies such as fuel cell, photo-voltaic systems and several kinds of wind turbines. This DG will be the backup whenever the load is cut off from the main grid.

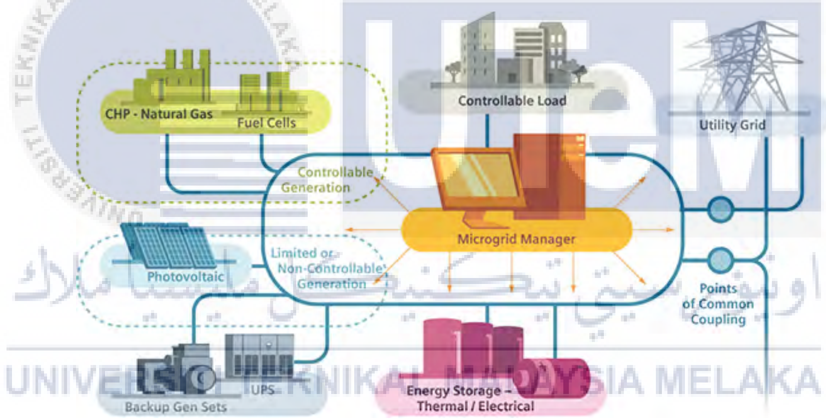

Figure 2.1: A microgrid overview[3]

2.2.2 Microgrid Operation

Figure 2.2 shows the MG operation. In the figure, it shows a group of feeders connecting to each other. There is a single point of connection to the main distribution utility called point of common coupling (PCC). PCC is the point in the electric circuit where a MG is connected to a main grid [4]. There is also a point called SD that is Separation Device which can disconnected MG immediately whenever fault happens in the distribution grid. The figure below shows in feeders 1 and 2, it has local generation which is require because it have sensitive loads. There is also loads that do not have any local generation that is traditional load, connected to Feeder 3[4].

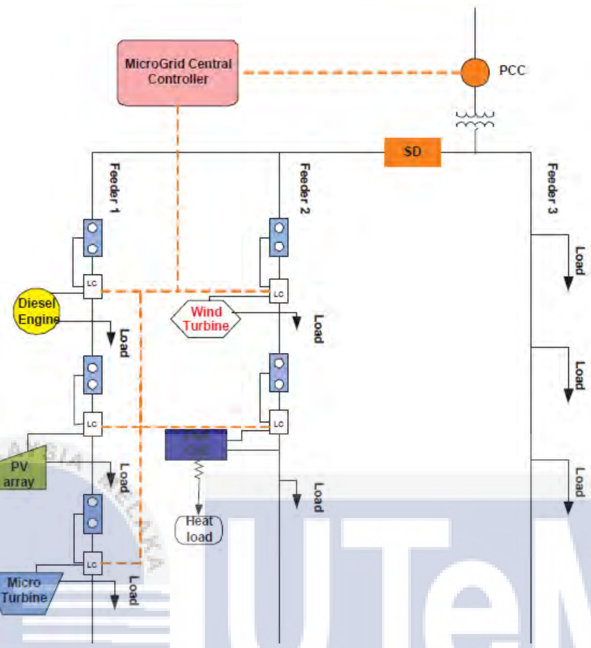

Figure 2.2: Operation of microgrid

2.3 Fuel Cell

Fuel cell is a device that converts chemical energy from fuel into electricity. Electricity was form through a chemical reaction of positive charged hydrogen ions with oxygen or other oxidizing agent [5]. Fuel cells was first invented in 1838, but, the world only know its existence until more than a century later through NASA space programs which to generate power for satellites and space capsules. Ever since then, fuel cells were broadly used in many applications which focused as a primary and backup power for industries, residential and commercial buildings. The ability to be installed in remote and inaccessible areas makes it possible for the used in powering vehicles such as forklift, buses, boats, submarines, automobiles and motorcycles.

2.3.1 Fuel Cell Modelling

Fuel cells have variety of different types. Each of it consist of an anode, a cathode and electrolyte which allow positive charged hydrogen ions to move between the two sides of fuel cell. To generate positive hydrogen ions and electrons, each anode and cathode contain catalysts which caused the fuel to oxidized. After the oxidation reactions, the hydrogen ions are drawn to the electrolyte. Simultaneously, through an external circuit, electrons are also drawn from the anode to the cathode. This helps produced a direct current electricity. Hydrogen ion, electrons, and oxygen reacts with each other at the cathode to form water[6].

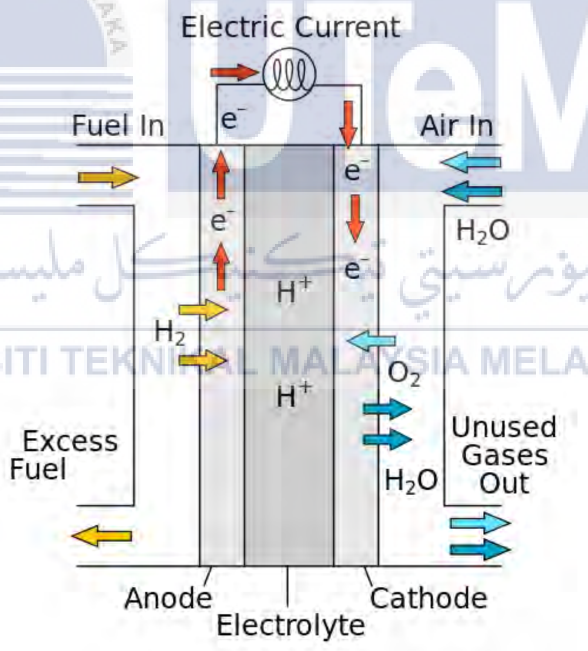

Figure 2.3: Construction of fuel cell

The two half reaction occur in the fuel cell are:

At anode: $H_2\,(g) \rightarrow 2H^{+} + 2e^{-}$ (2.1)

At cathode : $\frac{1}{2} O_2\,(g) + 2H^{+} + 2e^{-} \rightarrow H_2O$ (2.2)

Overall reaction: $H_2\,(g) + \frac{1}{2} O_2\,(g) \rightarrow H_2O$ (2.3)

2.3.2 Fuel Cell Characteristic

There are many types of fuel cell line such as Alkaline Fuel Cell (AFC), Proton Exchange Membrane Fuel Cell (PEMFC) and Phosphoric Acid Fuel Cell (PAFC). These fuel cells generate direct current. According to the power rating, there are numerous way of a fuel cells was chosen. 1KW fuel cells has the output voltage range 25-50V while 30KW and above of fuel cells can have output voltage range 200-400V. Fuel cells are in a development stage as stated in [7]. Below are the assumptions about the operating characteristics:

1. Fuel cell with type of PEMFEC has low temperature and have partial oxidation, it takes minor time to start-up while a high temperature fuel cell will takes 3 to 4 hours to start up. This show that fuel cell with low temperature is more suitable for start-stop operation since the start up time takes small amount of time.

2. Although fuel cell can do nearly instant load changes, it has a limit in the fuel processing system which has a certain time of lag due to the chemical reactions occur.

3. As the number of moving parts are low, fuel cells have the potential for high in reliability. Life length of fuel cells is given as 40000 h for the stack and at least twice the number of hours for the system.

2.4 Battery Storage

In recent years, due to large integration of Renewable Energy Sources like microturbine and fuel cell unit into the MG, the supplication of Battery Storage (BS) has surge greatly. The BS has considerable interest and advantages in the MG-based applications such as short term power supply, power quality improvement, facilitating integration of Renewable Energy Sources and providing necessary support to the primary activities service [8].

2.4.1 Operation of Battery

From the article in [9], it said that the battery is initially charged with the help of DG and Battery Management System (BMS). The article [9] explained the operation of the battery storage by using photovoltaic(PV), one of type of DG, as the source for charging. In the figure shown below, BMS is used for observing the charging and discharging level of the battery. Therefore, the battery span time can be lengthen. By using three levels of universal bridge inverter, a power electronics converter interfaces the energy storage unit with MG and the communication line between the Microgrid Central Controller (MGCC) and Battery Energy Storage System(BESS) management. The MGCC is also one of the observing blocks, which monitors the grid voltage and frequency. The power generated by PV system is not sufficient to meet the local load means the load will import the power from the MG and the battery is charged because the inverter act as converter. If the power generated is in excess, PV system export the power to the MG. If the grid voltage is in abnormal condition, local load is disconnected from the MG and it operates as island mode.

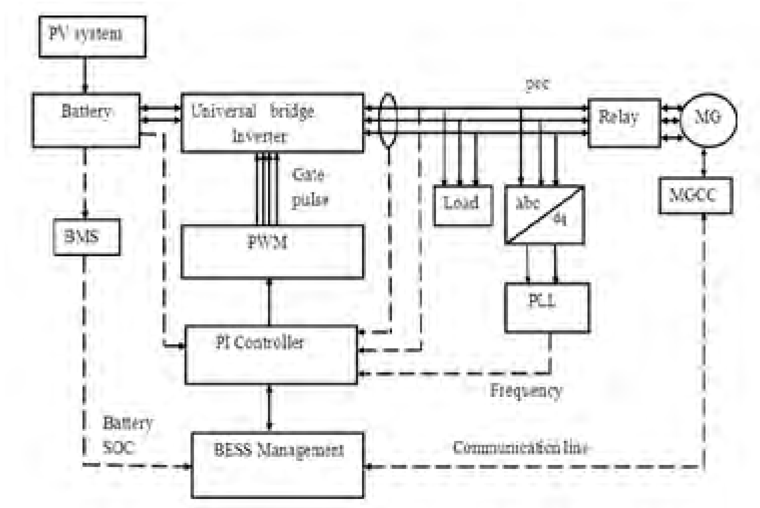

Figure 2.4 Structure of battery storage

2.4.2 Types of Battery Storage

The first battery in market was the flooded lead-acid battery which was used for establish, centralized applications. The valve-regulated lead acid (VRLA) battery is the current commercially convenient option. Other lithium-based batteries are under progression[10]. Batteries are produced in a wide assortment of capacities ranging from less than 100watts to modular configurations of several megawatts.

A. Lead-Acid Battery

Lead Acid batteries are barely economic but they have big space and maintenance necessity. The usage of battery below than 30% will drain the charge quickly. This results in the reduction of energy density amounting to increased capital costs. They are commonly installed in uninterruptible power supply (UPS) systems as well as in renewable and distributed power systems.

B. Valve Regulated Lead Acid Battery (VRLA)

VRLA use the same basic electrochemical technology as flooded lead-acid batteries, but these batteries are closed with a pressure regulating valve, so that they are basically sealed. The major advantages of VRLAs are less cost in maintenance and the battery cells can be packaged more tightly because of the sealed construction and immobilized electrolyte, reducing the footprint and weight of the battery[10].

C. Lithium Ion Battery

Lithium-ion batteries have a high energy density (energy in relation to volume) as well as power density (rate at which energy changes) compared to other batteries. This allows them to take up minimum physical space while providing high energy and power[11].

CHAPTER 3

METHODOLOGY

3.1 Overview

This chapter will discuss about the type, method and parameter of constructing the circuit for the system network. The construction and simulation of fuel cell, grid and battery storage are using MATLAB, Simulink. The construction of the system is including designing fuel cell system connected with grid, battery storage connected with grid, fuel cell system connected together with grid and battery storage system in grid-connected mode and fuel cell system connected together with grid and battery storage system in grid-disconnected mode.

3.2 Project Flowchart

The flowchart below is showing the arrangement of the work while doing this project. The arrangement is including literature review, designing, simulation, analysis, result presentation and report writing. From the flowchart showed in figure 3.1 below, the decision at designing part refer to the result for achieving voltage at 415V. If the 415V of voltage is not achieved, the circuit is checked through and run the simulation again.

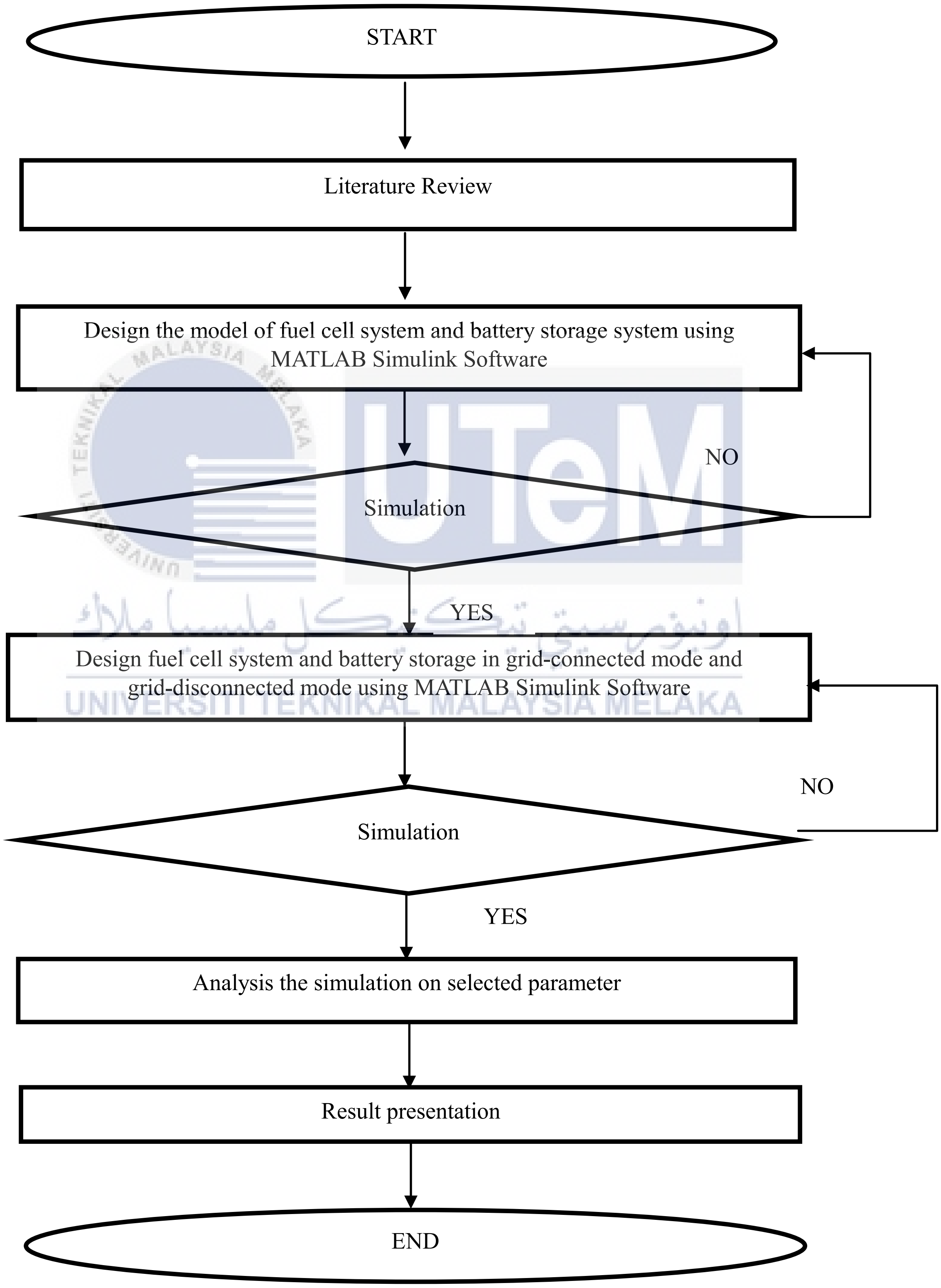

Figure 3.1: Project Flowchart

3.3 Designing The System Network

Simulink is a block diagram environment for multidomain simulation and Model-Based Design. It supports simulation, automatic code generation, and continuous test and verification of installed systems. Simulink provides a graphical editor, customizable block libraries, and solvers for modeling and simulating dynamic systems. The construction of fuel cell, grid and battery storage are referred from the Simulink Library Model and from the research as in literature review.

3.4 Fuel Cell Circuit Design

Designation of fuel cell is done by referring to the Simulink library. From the library, the design can be drag to the drawing column. Figure below shows the fuel cell stack.

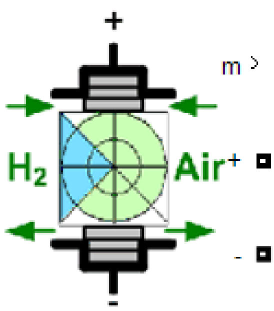

Figure 3.2: Fuel Cell Stack

The Fuel Cell Stack block appliance a generic model parameterized correspond to most popular types of fuel cell stacks fed with hydrogen and air. The block represents two versions of the stack model: a simplified model and a detailed model. In this research, the option choose for the stack is simplified model by switching the detail level in the block dialog box.

3.4.1 Simplified Model

In this project, the drawing for the circuit is using simplified model. The simplified model corresponds to a particular fuel cell stack operating at nominal conditions of temperature and pressure.

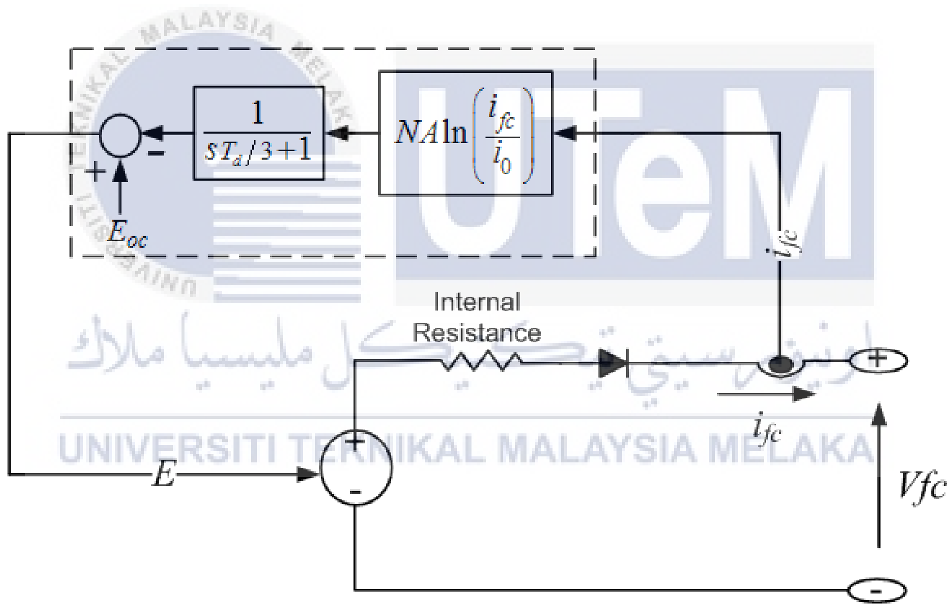

Figure 3.3: Simplified Model

From the simplified circuit, the graph obtain can be divided into three parts which are activation region, ohmic region and mass transport region.

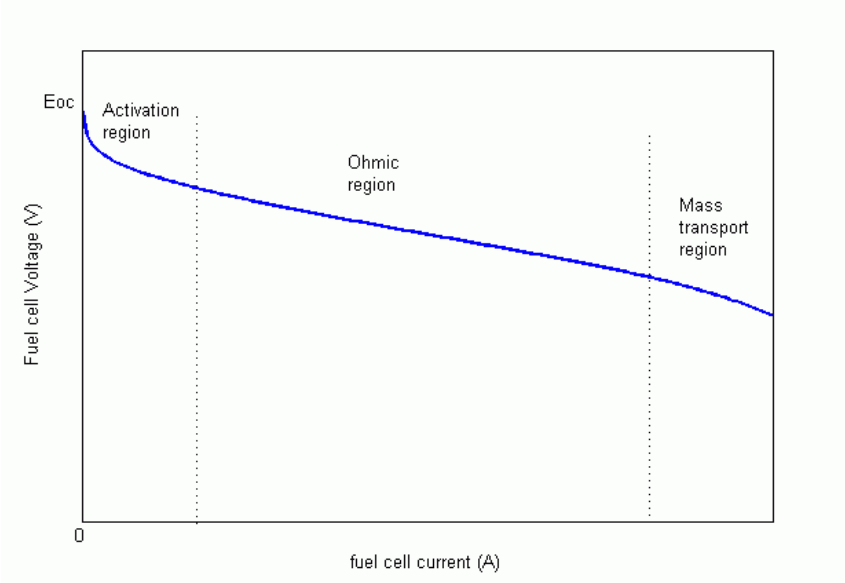

Figure 3.4: Fuel Cell I-V polarization curve

The first region represents the activation voltage drop due to the slowness of the chemical reactions taking place at electrode surfaces. The second region represents the resistive losses due the internal resistance of the fuel cell stack. Finally, the third region represents the mass transport losses resulting from the change in concentration of reactants as the fuel is used.

3.4.2 Fuel Cell Simulink Model

There are few types of fuel cell in the Simulink library model, in this project PEMFC is choose based on the characteristic value of power and dc voltage that higher than the other type. Figure 3.5 shows a basic circuit from the Simulink library.

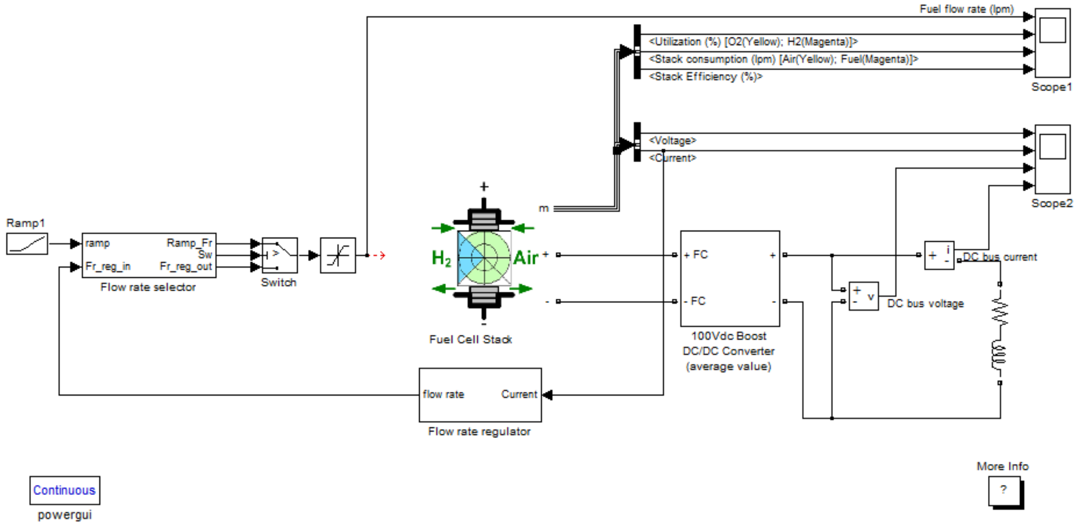

Figure 3.5: PEMFC 50KW 625Vdc circuit

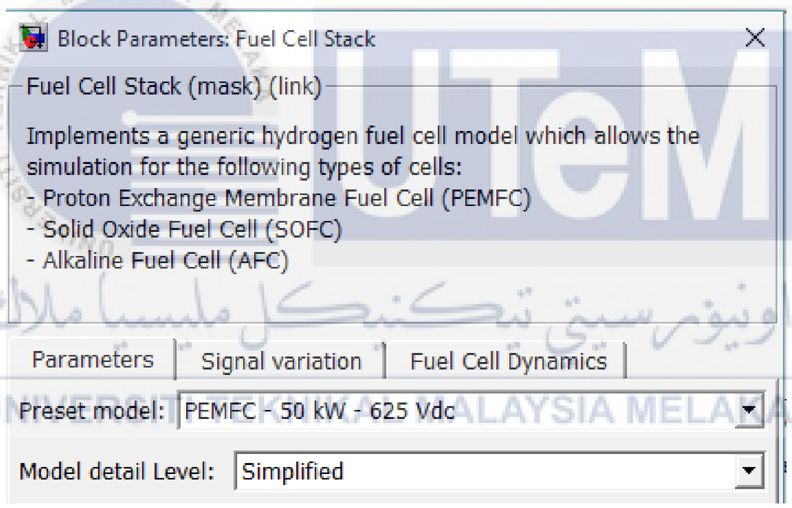

Figure 3.6: Block Parameter for Fuel Cell Stack

From the figure 3.6, the parameters are set as shown. PEMFC type is chose based on the value of Vdc. It is better to have 625Vdc since it will experience voltage drop until 415Vdc, which is a suitable value of voltage to supply to the load. The model detail level is fixed to simplified circuit. The simplified model represents a particular fuel cell stack operating at nominal conditions of temperature and pressure. The output of fuel cell is in dc so the converter and inverter is used to convert dc to ac. To connect the circuit with grid, transformer is used to step down the voltage from the grid to the fuel cell system. The circuit in figure 3.7 shows the connection of the fuel cell with main grid.

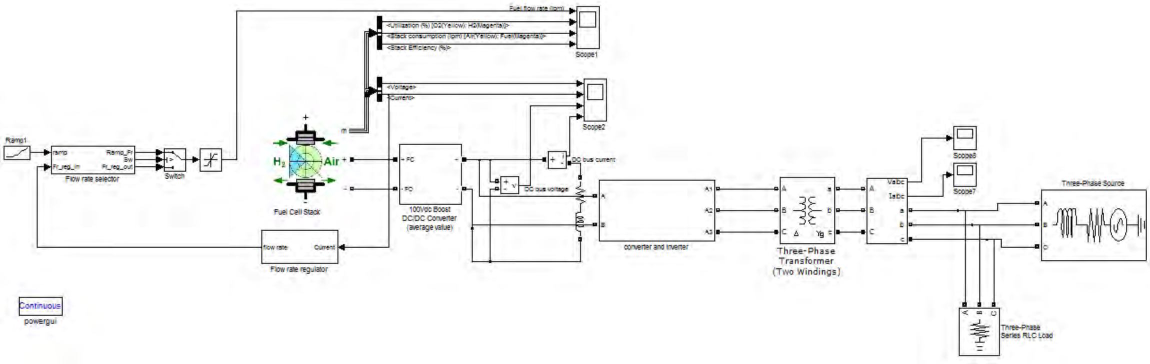

Figure 3.7: PEMFC circuit connected with grid

3.5 Battery Storage Circuit Design

Designation of battery storage is done by referring to the Simulink library. From the library, the design can be drag to the drawing column. Figure below shows the battery storage stack.

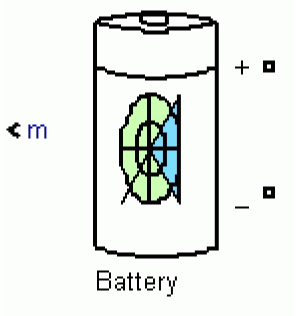

Figure 3.8: Battery Storage Stack

In this research, thetype of battery storage chose is Lead-Acid based on the explanation in literature review section. Lead-Acid is the most used for uninterruptable power supply since it has bigger storage than others. Figure 3.9 shows the parameters of the battery storage. In this project the value of battery capacity is 50Ah. Ah is the value for Ampere times hour which means one-amp hour is equal to one ampere of current drawn for one hour of time. The output of voltage that operate the system is 400V.

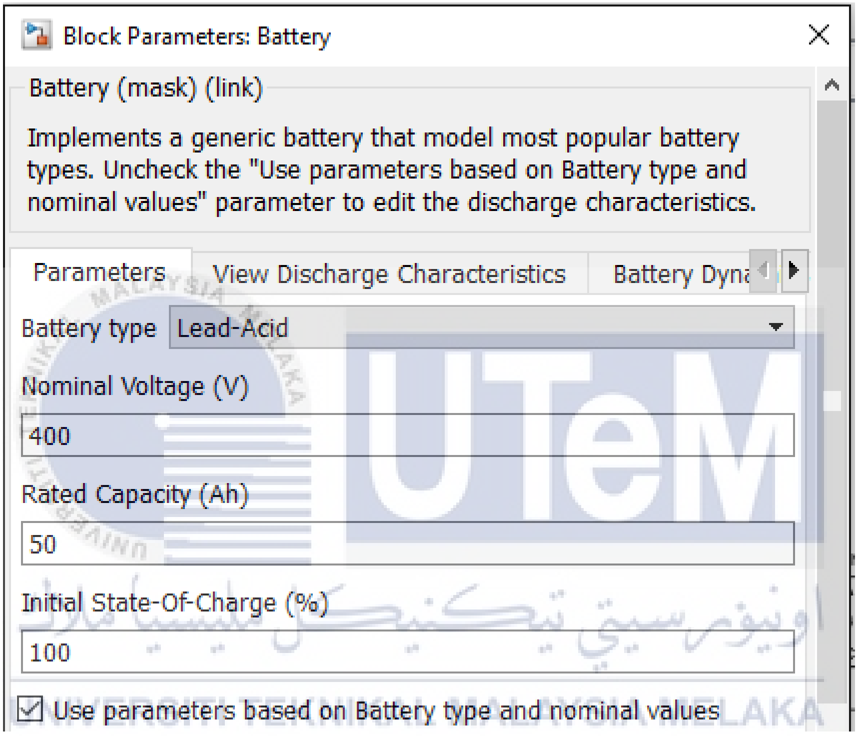

Figure 3.9: Block Parameter for Battery Storage

From figure 3.10, the battery is connected to the converter and inverter to change from dc to ac. After getting the value of ac voltage and current, the value is step up using transformer to connect it with grid.

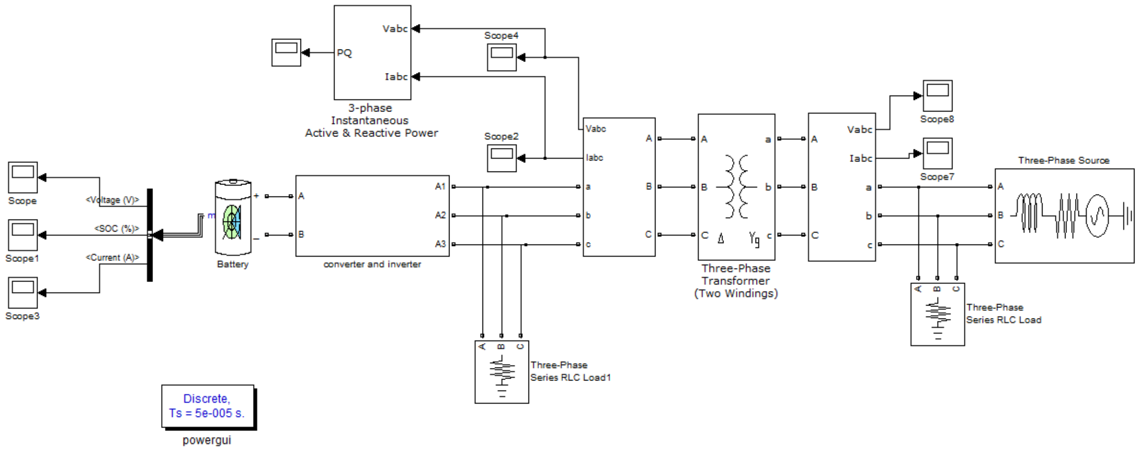

Figure 3.10: Battery storage circuit connected with grid

3.6 Microgrid System Circuit Design

After designing fuel cell and battery storage, both plant is connected together with grid. Figure below are shown the connection for the microgrid. A breaker is put at the grid to compare the value of voltage, current, active power and reactive power before and after opening the breaker. Opening the breaker will lead the system to be in islanded mode which is the system is operating without the power supply from the grid. In this paper, grid-connected mode is referring to the normal condition that is the supply of power is comes from grid and grid-disconnected mode is referring to the islanded mode.

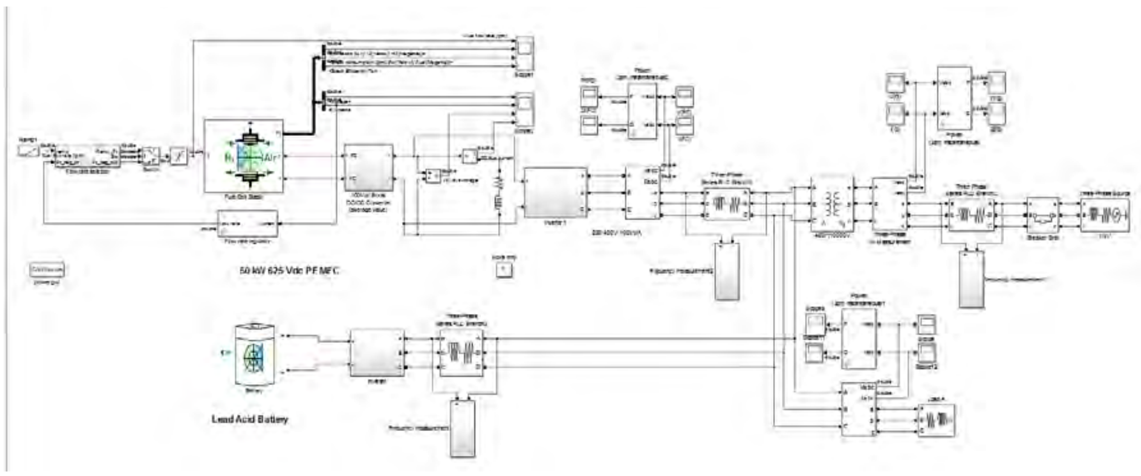

Figure 3.11: Microgrid System Circuit Design

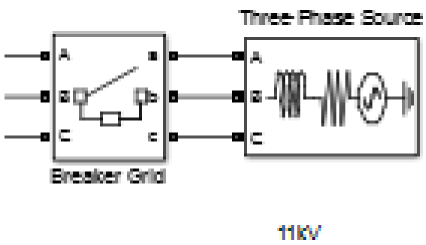

Figure 3.12(a): Breaker connected at grid in opened mode

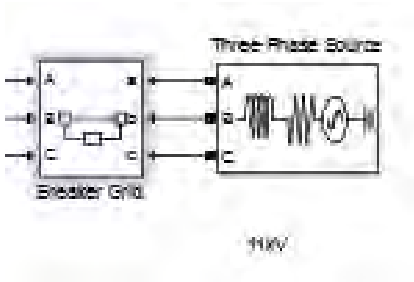

Figure 3.12(b): Breaker connected at grid in closed mode

CHAPTER 4

RESULT AND DISCUSSION

4.1 Result of Fuel Cell

The results below show the fuel cell voltage and current. The voltage basically starts with 625V and decreased to 415V. This is due to the chemical reaction that take part during start up. The value of the current and voltage below are in dc since fuel cell is operating the system with the output of dc. The analysis for fuel cell is done for voltage and current at the fuel cell side only since the design is in separate circuit with battery storage.

Figure 4.1: Voltage and Current of Fuel Cell

The value of dc is then changed to ac using inverter. Below is the result for ac voltage of fuel cell.

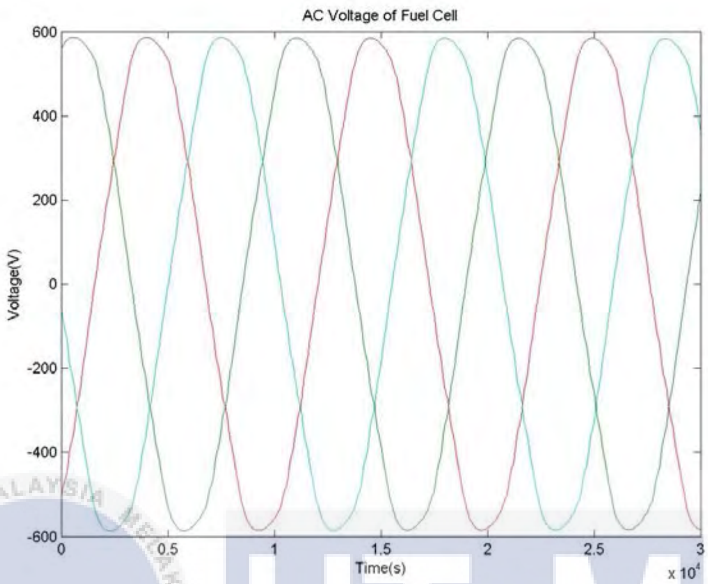

Figure 4.2: AC Voltage of Fuel Cell

The value from the graph is achieving 600V this is due to the value from the dc voltage of fuel cell that is 625V. As a DG for three phase supply the value of the voltage is 415V so the voltage is step down to 415V using transformer.

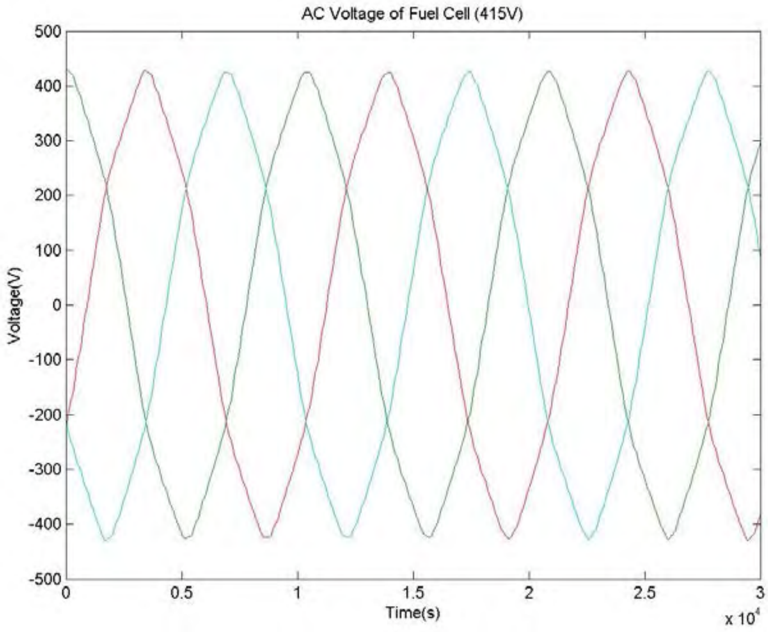

Figure 4.3: AC Voltage of Fuel Cell after step down.

The value of current obtained is 25A. Both voltage and current obtained are in Vpp value.

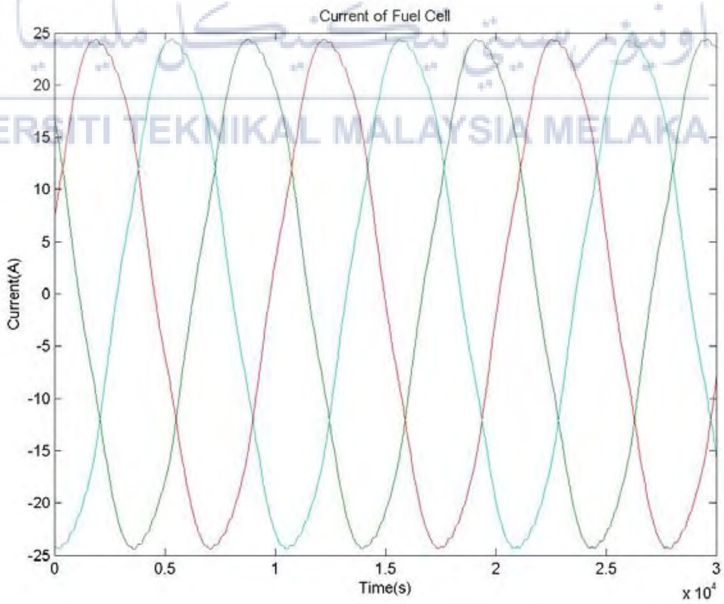

Figure 4.4: Current of Fuel Cell

4.2 Result of Battery Storage

From the circuit shown in figure 3.10, the analyzing of the voltage and current is observe after the inverter is connected to the battery storage. The value of voltage obtain is in phase to phase voltage, Vp-p, that is 415V. The analysis for battery storage is done for voltage and current at the battery storage side only since the design is in separate circuit with fuel cell.

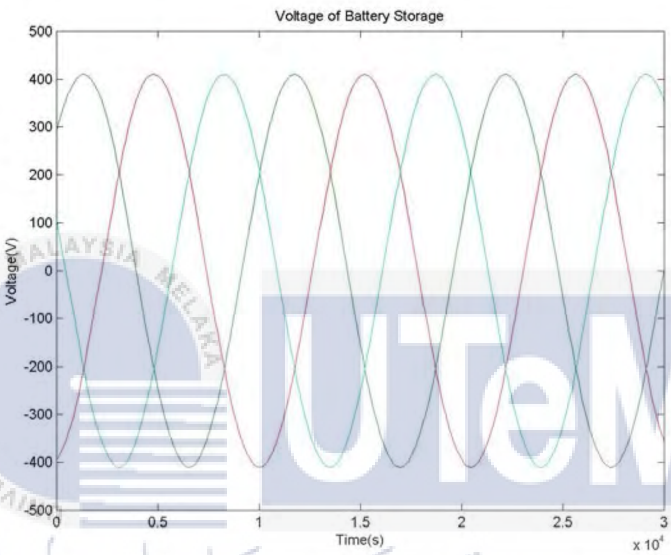

Figure 4.5: Voltage of Battery Storage

For current, the value obtained is 15A. The value of current is also after connecting the inverter with battery as in circuit shown in figure 3.10.

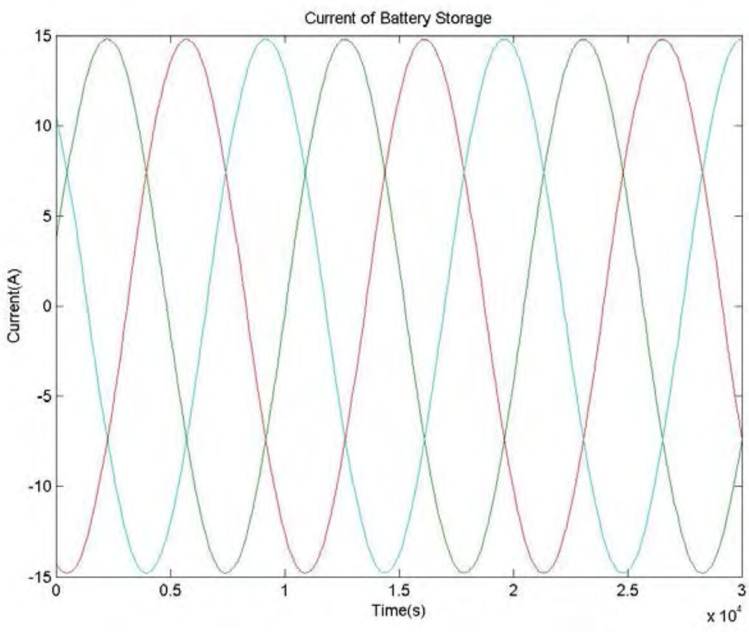

Figure 4.6: Current of Battery Storage

4.3 Results of Microgrid

To form a microgrid system, fuel cell system and battery storage are connected to a grid through a step up transformer. This microgrid system is using a breaker at the grid and the simulation is done with the breaker in closed mode and open mode. The simulation with breaker in closed mode is referring to grid – connected mode while simulation with breaker in opened mode is referring to grid – disconnected mode. The analysis will be included voltage, current, real power and reactive power.

4.3.1 DG results in grid – connected mode.

The value of voltage obtain at the DG side is 415V. The value obtain is showing the voltage from combination of fuel cell system and battery storage system.

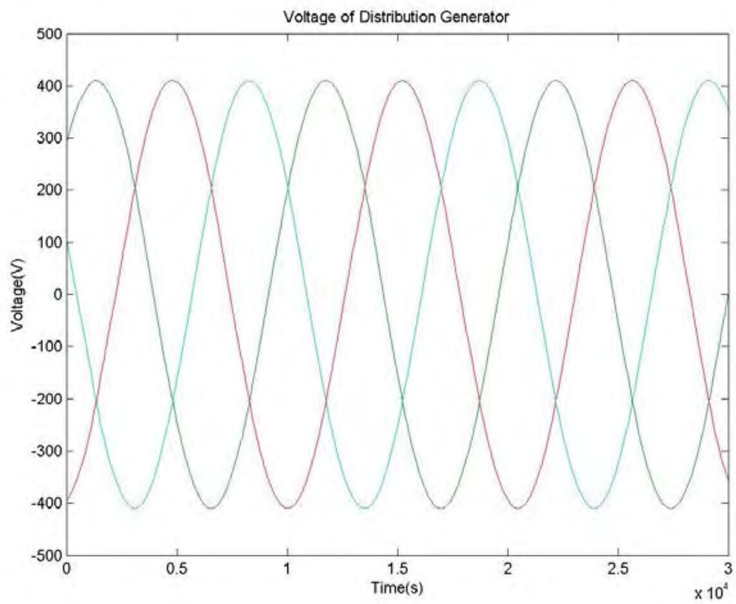

Figure 4.7: Voltage of DG in grid – connected mode

The value of current obtained is 35A.

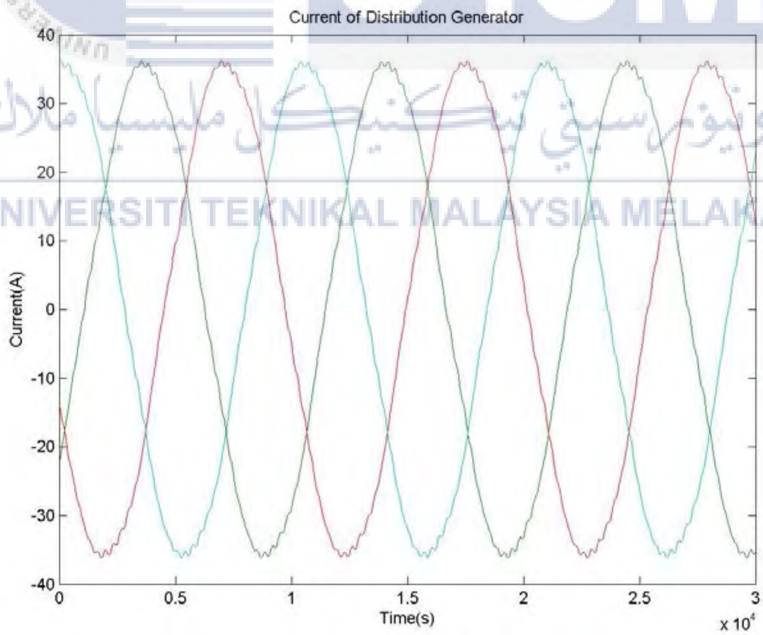

Figure 4.8: Current of DG in grid – connected mode

The value of active power obtained is 7000W

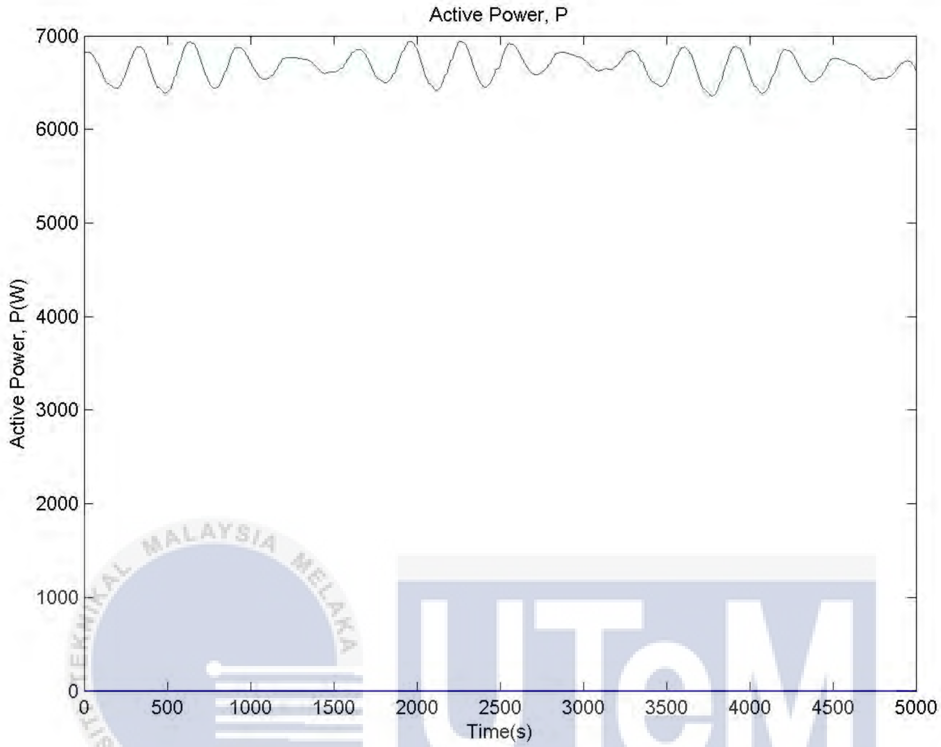

Figure 4.9: Active Power, P of DG grid – connected mode

The value of reactive power as shown in figure 4.10 is -9000Var. The value for reactive power is negative. The negative shows the flowing power is from grid to DG since DG the power generate by DG is not enough.

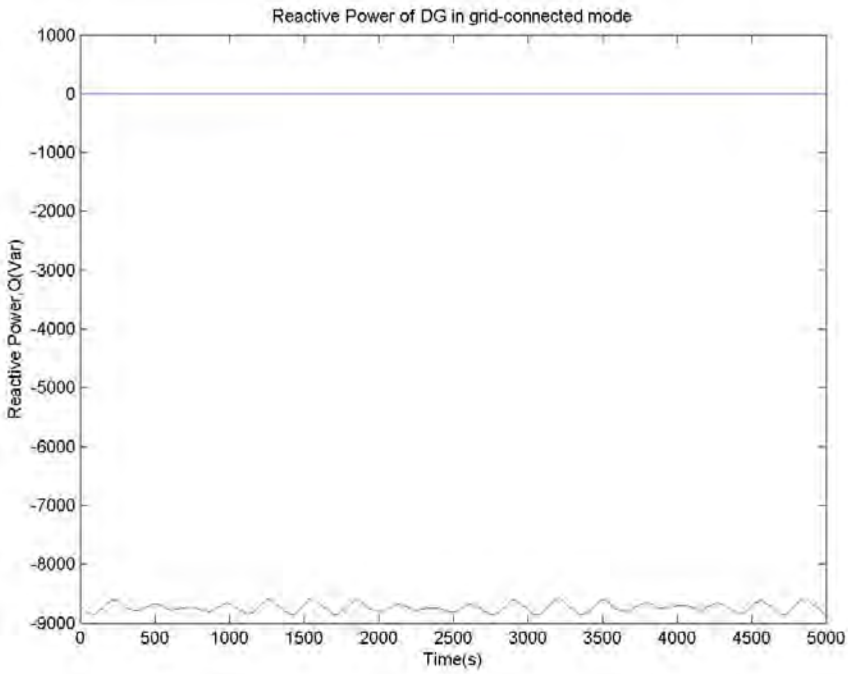

Figure 4.10: Reactive Power, Q of DG in grid – connected mode

4.3.2 Grid results in grid – connected mode

This section showing the value of voltage, current, active power and reactive power at the grid in grid – connected mode. Figure 4.11 shows the voltage achieved is 11kV.

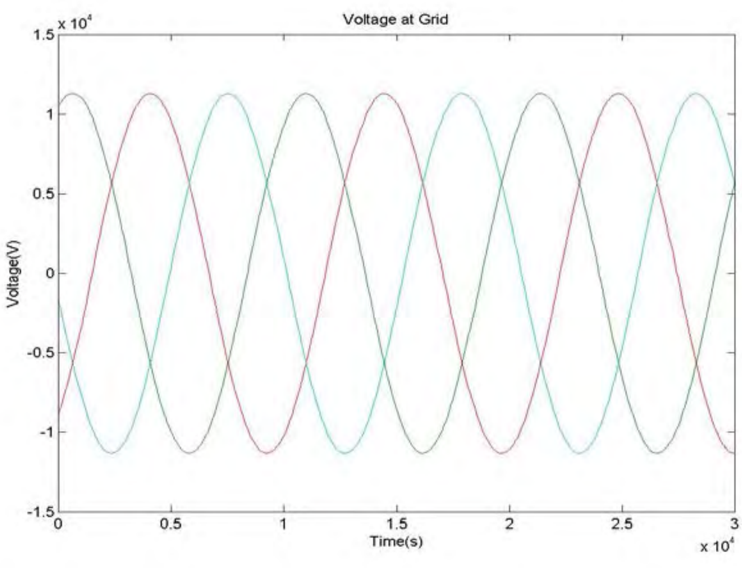

Figure 4.11: Voltage at Grid in grid – connected mode

The value of current obtained is 1.4A.

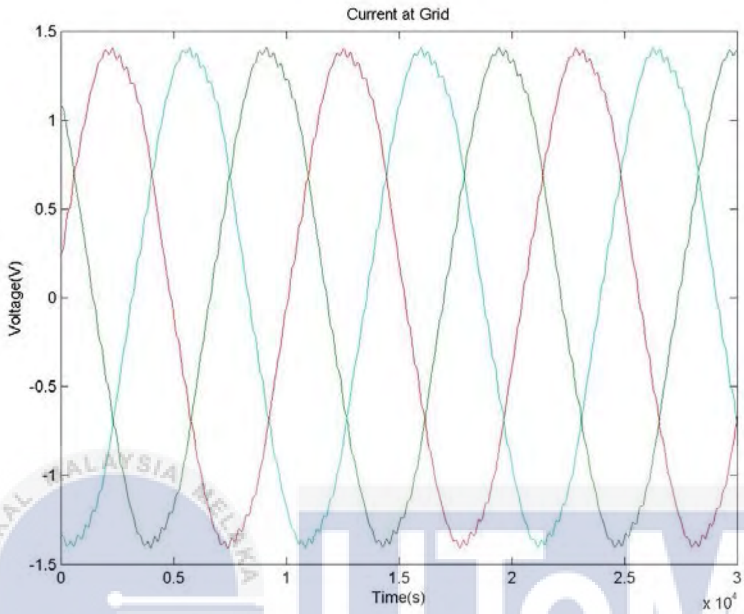

Figure 4.12: Current at Grid in grid – connected mode

The value of active power is 600W. The negative from active power showing the flow of the power is flowing from DG to the grid.

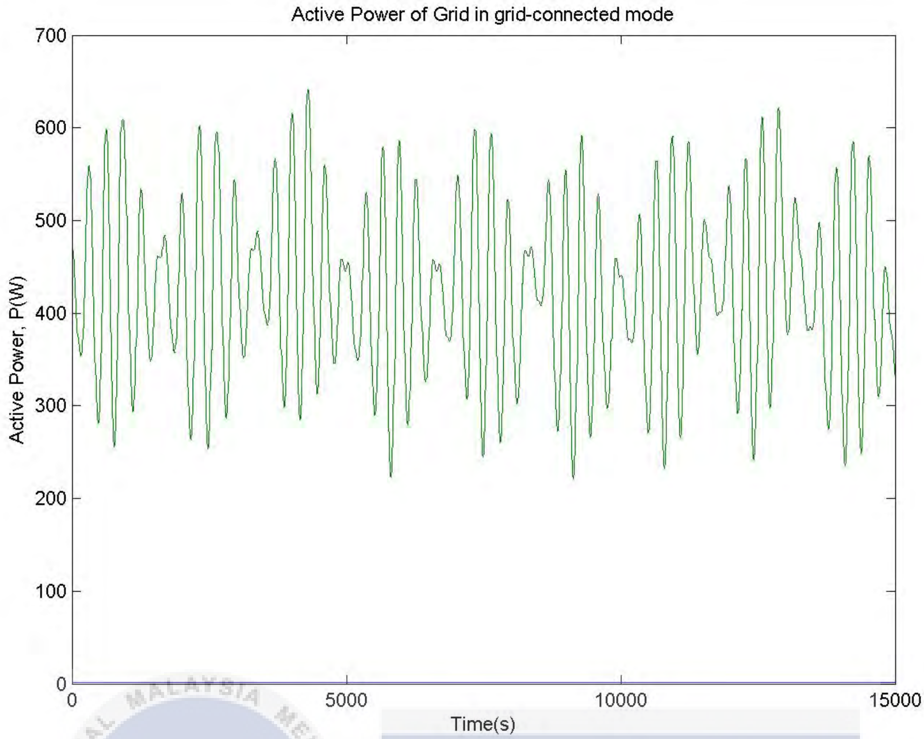

Figure 4.13: Active Power at Grid in grid – connected mode

The value for figure 4.14 is -18kVar. The value of reactive power is high and in negative value since the value of active power is low and the generating power is not enough hence the negative value shows the draw of power from DG to the grid.

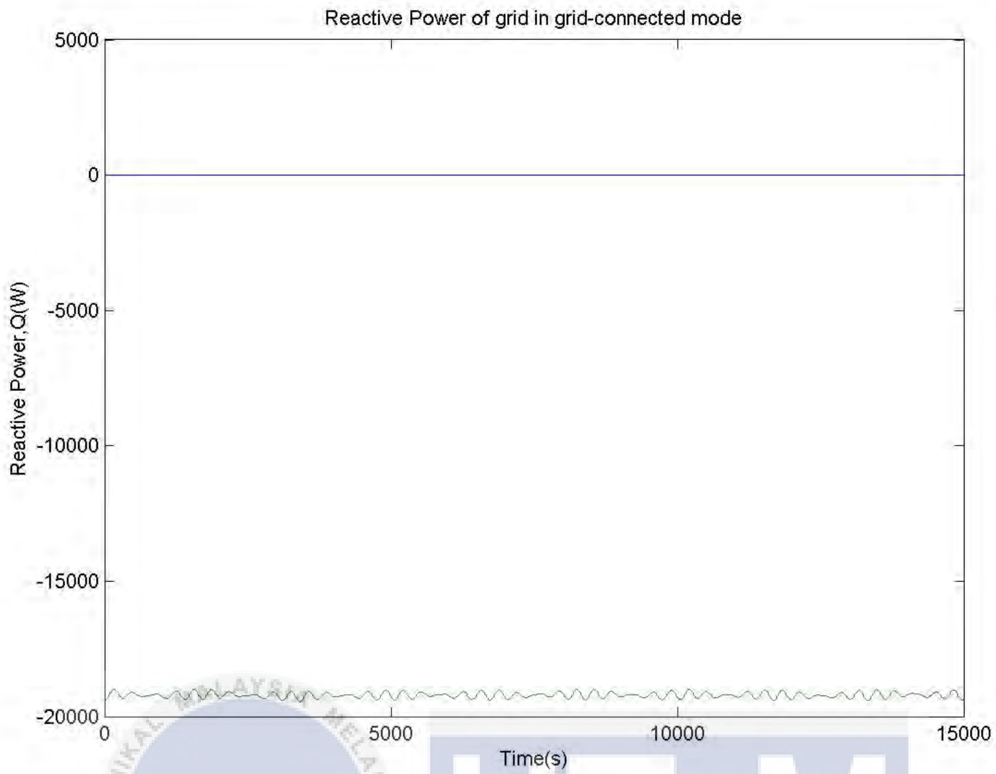

Figure 4.14: Reactive Power at Grid in grid – connected mode

4.3.3 DG results in grid – disconnected mode

This section shows the results obtained when the simulation is run in grid – connected mode that is when opening the breaker at the grid. From figure 4.15, the voltage obtained at DG side is 415V.

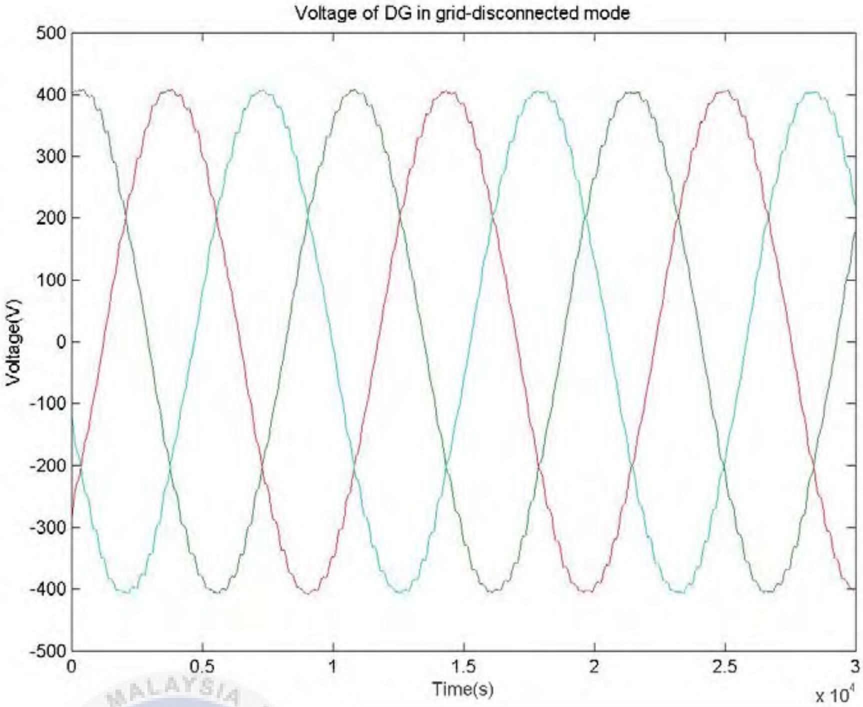

Figure 4.15: Voltage of DG in grid – disconnected mode

The voltage obtained in current is 5A.

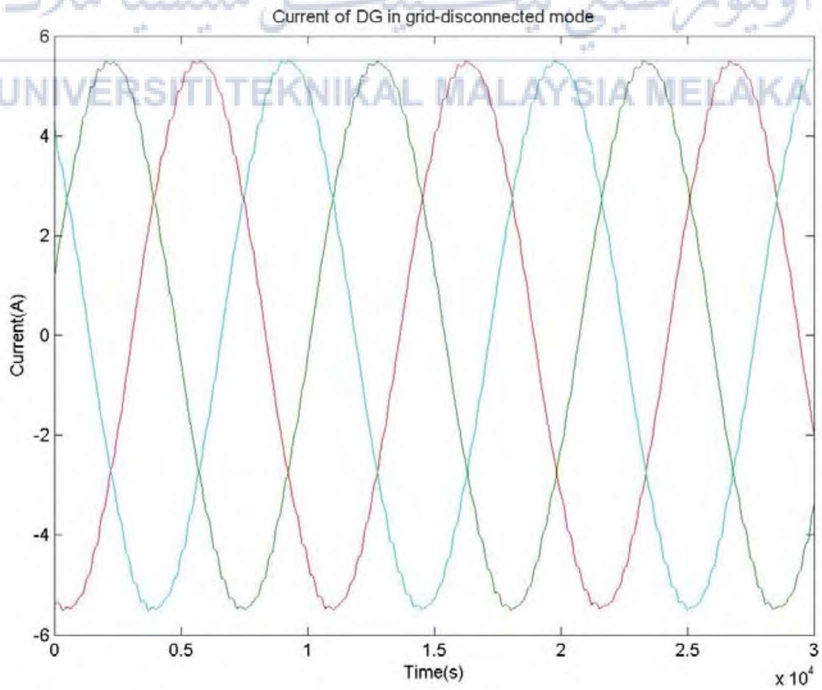

Figure 4.16: Current of DG in grid – disconnected mode

The value obtained for active power in DG connected in grid - disconnected mode is 1400W. The negative value showing the flow of the power from the grid to the DG.

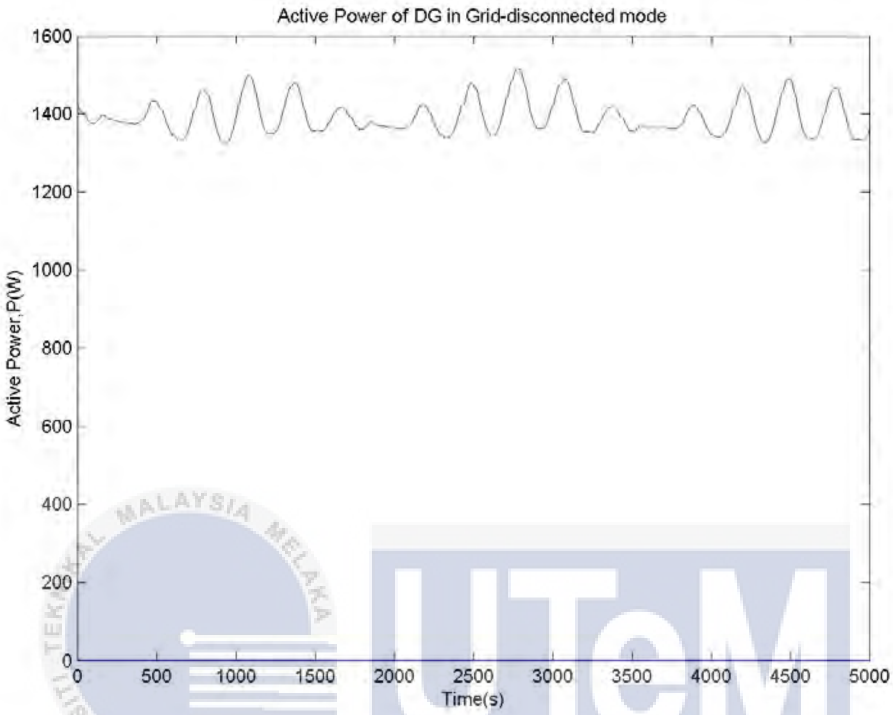

Figure 4.17: Active Power of DG in grid – disconnected mode

The value of reactive power of DG in grid – disconnected mode is 3000Var.

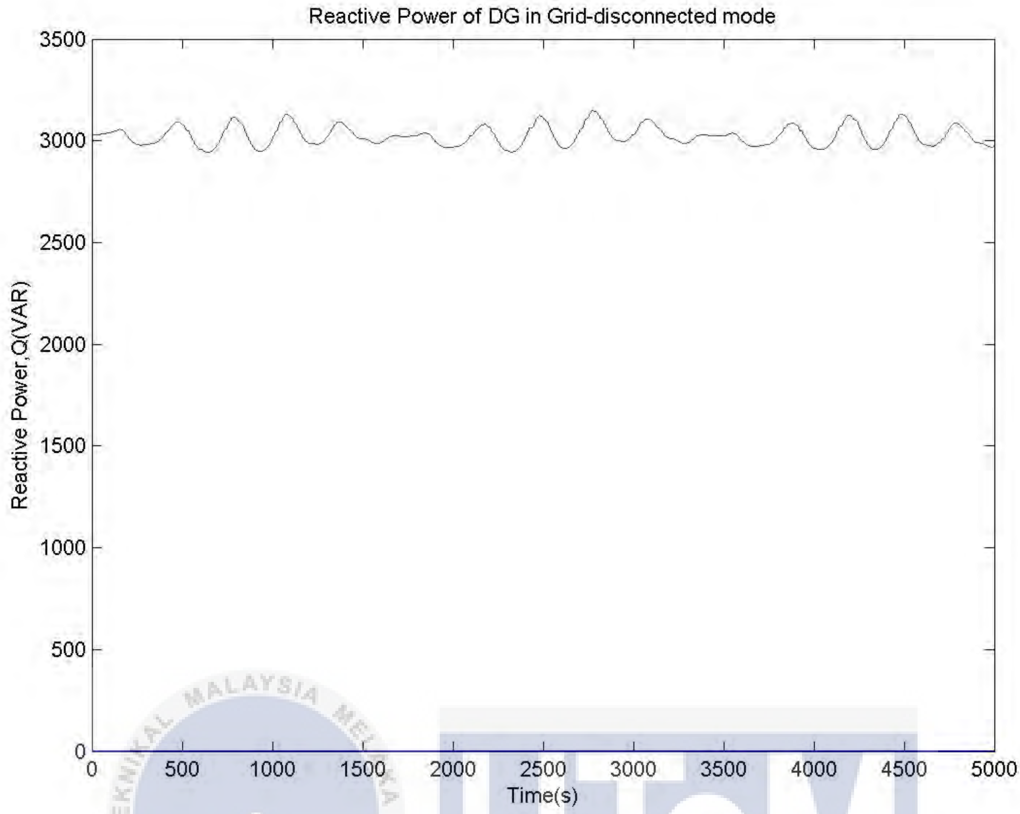

Figure 4.18: Reactive Power of DG in grid – disconnected mode

4.3.4 Grid results in grid – disconnected mode

This section showing the results obtained at the grid side when running the simulation in grid – disconnected mode which is opening the breaker. The voltage obtained is 6000V lower than 11kV as obtained in grid – connected mode.

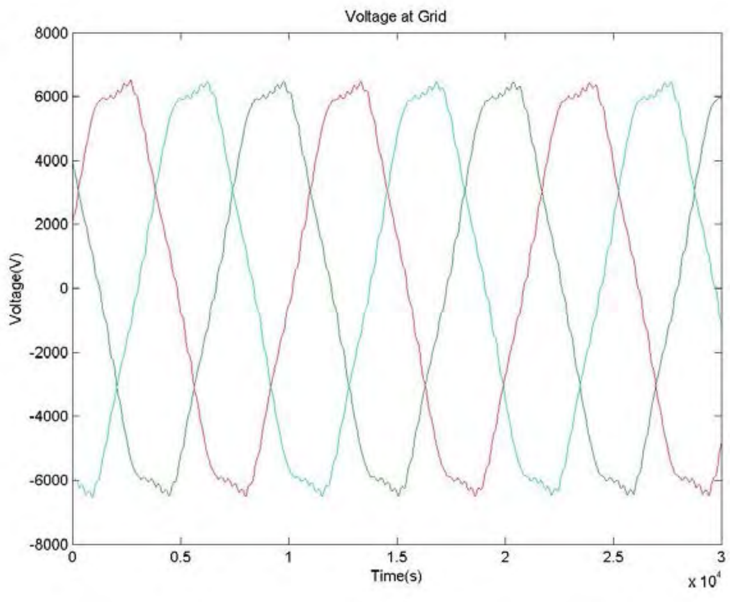

Figure 4.19: Voltage of Grid in grid – disconnected mode

The value of current is 4.5mA.

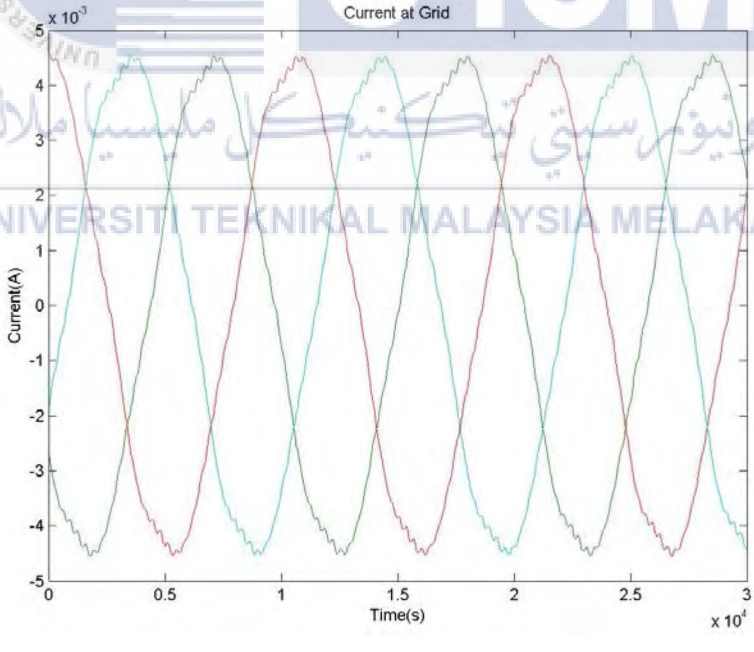

Figure 4.20: Current at Grid in grid – disconnected mode

The value of active power obtained is 14W.

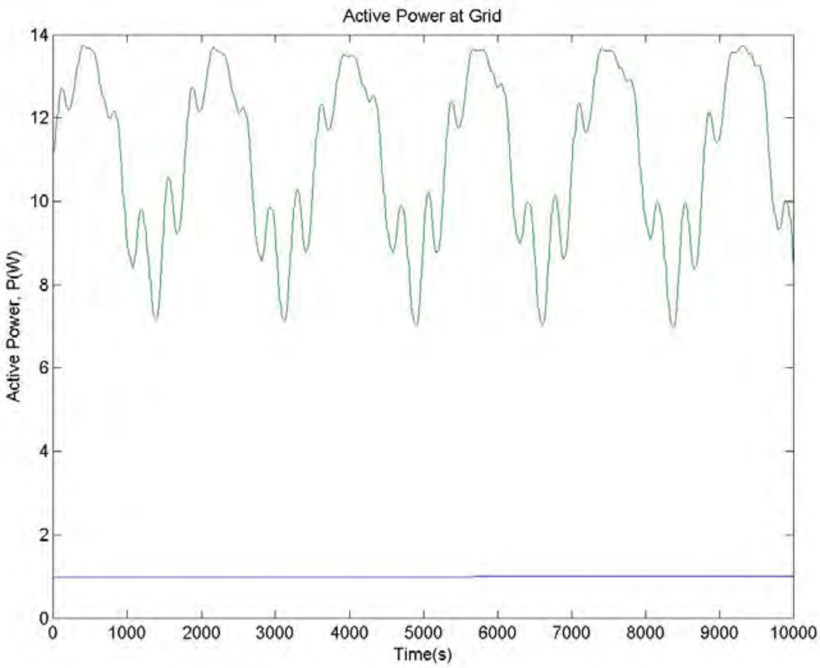

Figure 4.21: Active Power at Grid in grid – disconnected mode

The value obtained for the reactive power is -40Var. The value is in negative since it has no supply to generate the power itself, so the power is draw from the DG.

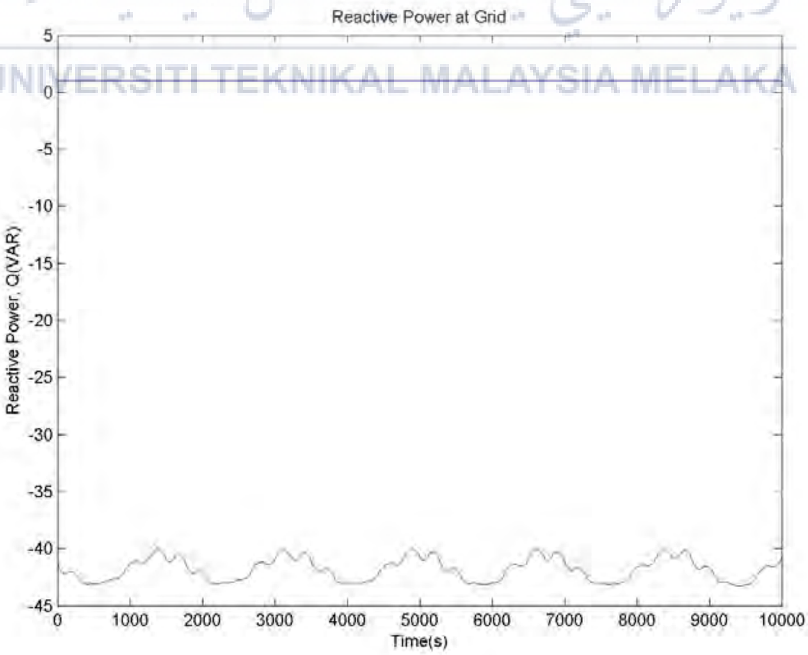

Figure 4.22: Reactive Power at Grid

4.4 Analysis between the grid – connected mode and grid – disconnected mode

Table 4.1: Comparison between opened breaker and closed breaker

System	Parameters	Condition of Breaker	
		Closed	Opened
Distribution Generator(DG)	Voltage(V)	415	415
	Current(A)	35	5
	Active Power, P(W)	4300	3000
	Reactive Power, Q(VAR)	25000	1500
Grid Source	Voltage(V)	11000	6000
	Current(A)	5	4.5x10^$^{-3}$
	Active Power, P(W)	600	14
	Reactive Power, Q(VAR)	-18000	-40

From the table 4.1, the voltage value when closed the breaker is normal at 415V in DG and 11kV in grid. However, the value of voltage at grid is low, reduced to 6000V. The value of DG in grid-connected mode is maintained as in grid-connected mode since it has to stay generating in stand – alone system. The value of current also reduced from 35A to 5A in DG and 5A to 4.5mA in grid source since the source is no longer supplying the power. The value of both power, active and reactive for the DG in grid – connected mode are in positive value shows that the direction of the flowing power is from grid to the generator.Even when in grid-disconnected mode, the value is still positive since it operates in stand – alone. The situation is different from grid source, the value of reactive power are both in negative shows the flowing of power is from DG to the grid.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

From studying the operation of DG, MG and battery storage in the system network, it would be best to have microgrid system implemented in small area like hospital to have continuous power supply without interruption.

All the circuit of fuel cell, battery storage and MG system are successfully design by using MATLAB Simulink software.

By analyzing the performance of fuel cell and battery storage system of microgrid by using MATLAB Simulink Software, it shows that the performance of the system is reduced in grid-disconnected mode than in grid-connected mode.

In addition, I would recommend the MG system to be improved by implement control system. Other than that is the DG system is not only limited to two types of DG in one MG system, it can be more than two so the MG system can be improved by adding different type of DG or substitute fuel cell with another type of DG.

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APPENDIX

Project Planning

Month / Activities	SEPT		OCT				NOV				DEC				JAN
FYP 1 (SEPT 2015- JAN 2016)															
Choosing a title															
Gather the information															
Research															
Analysis															
Preliminary result															
Report															
Presentation															
FYP 2 (FEB 2016- JUN 2016)	FEB		MAC				APR				MAY				JUN
Simulation															
Troubleshooting															
Result															
Report															
Presentation															