Fault Analysis In Microgrid

Aslyna Binti Asrin
Faculty of Electrical Engineering
Universiti Teknologi MARA Malaysia
40450 Shah Alam, Selangor
e-mail: acidburn_junkers@yahoo.com

Abstracts – **This paper presents an analyzing type of fault current and voltage in microgrid. In this paper, the aim would be the discussing type fault that are most severe between single line to ground fault (SLG), line to line fault (LL) and also three phase fault. It is very important to analyze so that it can help in implementatzion of future protection. In general, microgrid can operate in both Islanded and grid-connected mode. A demo version of The Wind Asynchronous Generator In an Isolated Network in Matlab is used and available for both modes after a few Simulink application modification. The Matlab Simulink software version 7.11.0(R2010b) is used to conduct a simulation on this project. The results of all fault current and voltage will be discussed and all simulation results will be included.**

Keyword – fault, Wind Turbine Asynchronous Generator in an Isolated Network, microgrid, islanded mode, grid connected mode

I. INTRODUCTION

Nowadays, with enhanced development power system became much more complicated. There are demands that need to be fulfilled and other issues that should be emphasized which are reliability and cost reduction.

The most important issues when developing a new power system is the reliability of the system itself. In other words, electricity supply should continuously delivered to the consumers 24 hours a day. If power outages happen then consumers will face loss especially industries because of the high possibility that they had to stop their operation. The dependency of fossil fuels that keep on rising force the developer to find other alternative solution by using renewable energy resources in strategically location for cost reduction. Therefore to maintain the power system reliability, fault analysis has to be perform so when fault occurred these power system component can be protected.

Another solution will be by propose a system called microgrid. Microgrid is a localized grouping of electricity sources and loads that normally operate connected to and synchronous with the main grid, but can disconnect and function separately as physical or economic conditions varies [2].

This paper presents a determination of fault current in microgrid. Besides that, it is also important that current analyzed during fault when microgrid is in islanded mode or connected in main grid. Then, fault analysis at all busbars is conducted and discussed to achieve all the purposes.

II. LITERATURE REVIEW

In this section, the theoretical review related to the proposed approach will be presented. In section A the description about fault and B for the microgrid system.

A. Fault

Fault is unwanted condition that may occur when equipment insulation fails due to system overvoltage cause by lightening or switching surge, to insulation contamination or other mechanical causes [3]. Equipment damaged by fault usually had high operating current than normal and consequently exceed beyond their rating. To prevent more loss, faulty section must be separated cause worries it that might affect stability of the microgrid. Single line to ground has the highest frequency of occurrence in power system, it is about 75% of it occur due to flashover during electrical storm and only one in twenty fault due to balanced category [6].

Generally, there are various types of fault that occur in the power system. It has its own characteristic. Fault available in two condition such as:

i. Symmetrical fault - affects each of the three-phases equally and involves all three phases for instance three phase fault and three phase to ground fault.

ii. Asymmetrical fault – it involves only one or two phases for example single line to ground, line to line and double line to ground

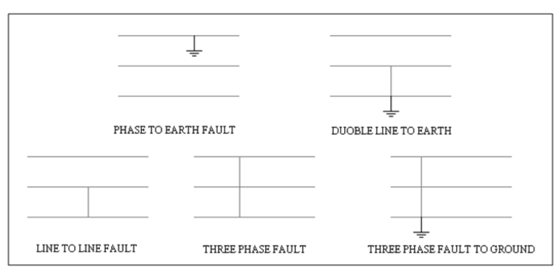


Figure 2.1 shows the condition of each type of fault.

B. Microgrid

Microgrid is similar to the main grid but differ in size that can be connected to or islanded from the main grid. Instead of relying solely on large power plants, a portion of the nation's electricity needs could be met by small generators such as ordinary reciprocating engines, micro turbines, fuel cells, and photovoltaic systems. Inverters are needed to convert DC to AC for installing renewable energy such as photovoltaic systems or other DC generation. A small network of these generators, each of which typically produces no more than 500 kilowatts, would provide reliable power to anything from a postal sorting facility to a neighbourhood [8]. It is most suitable used to guard against power outages at facilities such as data centres, hospitals, and other mission-critical institutions where loss of power would be disastrous.

A Microgrid can operate either in islanded form or connected to the main grid. For example, when the grid offers cheap electricity, the Microgrid can purchase it, but if prices rise or there is a power failure, the Microgrid can isolate itself. This system help increase the constancy of the main grid. Excess power supply also could be sold back to the main grid.

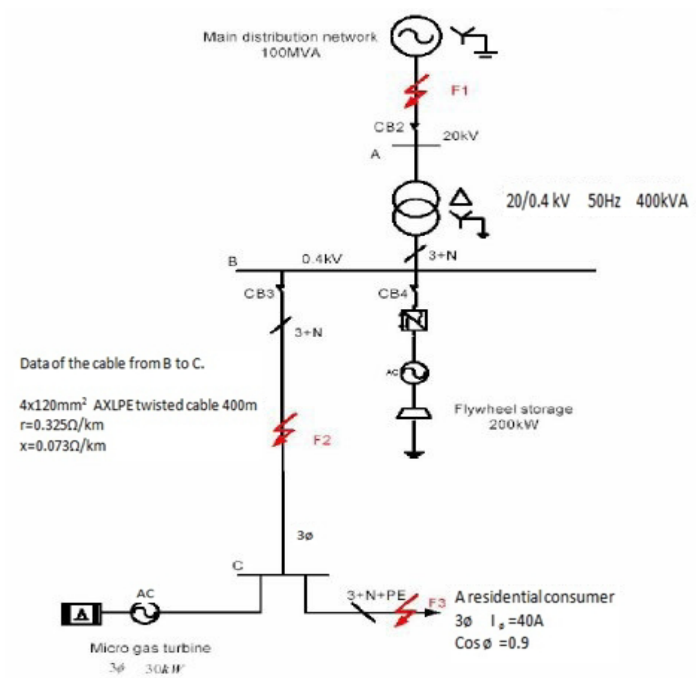


Figure 2.2: Microgrid generated by micro gas turbine and flywheel storage.

III. THEORETICAL BACKGROUND

A. Single-Line-to-Ground Fault

Let a SLG fault has occurred at node k of a network. The faulted segment is then as shown in Fig. 3.1 where it is assumed that phase-a has touched the ground through an impedance Z_f . Since the system is unloaded before the

$$I_{fb} = I_{fc} = 0 \tag{1}$$

occurrence of the fault we have

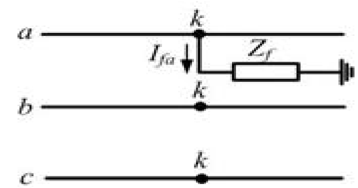


Figure 3.1: Representation of SLG fault

$$V_{ka} = Z_f I_{fa} \tag{2}$$

Also the phase-a voltage at the fault point is given by

$$I_{fa012} = \frac{1}{3}\begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix}\begin{bmatrix} I_{fa} \\ 0 \\ 0 \end{bmatrix} \tag{3}$$

From (1) we can write

$$I_{fa0} = I_{fa1} = I_{fa2} = \frac{I_{fa}}{3} \tag{4}$$

Solving (3) we get

This implies that the three sequence currents are in series for the SLG fault. Let us denote the zero, positive and negative sequence Thevenin impedance at the faulted point as Z_{kk0} , Z_{kk1} and Z_{kk2} respectively. Also since the Thevenin voltage at the faulted phase is V_f we get three sequence circuits that are similar to the ones shown in

$$\begin{aligned} V_{ka0} &= -Z_{kk0} I_{fa0} \\ V_{ka1} &= V_f - Z_{kk1} I_{fa1} \\ V_{ka2} &= -Z_{kk2} I_{fa2} \end{aligned} \tag{5}$$

Fig. 7.7. We can then write

$$\begin{aligned} V_{ka} &= V_{ka0} + V_{ka1} + V_{ka2} \\ &= V_f - (Z_{kk0} + Z_{kk1} + Z_{kk2}) I_{fa0} \end{aligned} \tag{6}$$

Then from (4) and (5) we can write

$$V_{ka} = Z_f I_{fa} = Z_f (I_{fa0} + I_{fa1} + I_{fa2}) = 3 Z_f I_{fa0}$$

Again since

$$I_{fa0} = \frac{V_f}{Z_{kk0} + Z_{kk1} + Z_{kk2} + 3Z_f} \tag{7}$$

The Thevenin equivalent of the sequence network is shown in Figure 3.1.

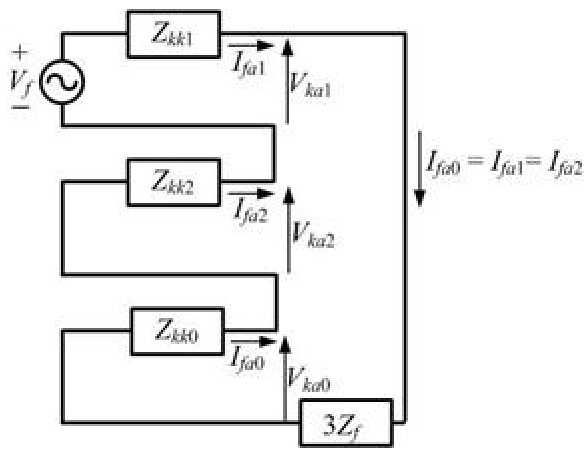


Figure 3.2: Thevenin equivalent of a SLG fault.

B. Line -to- Line Fault

The faulted segment for an L-L fault is shown in Fig. 8.5 where it is assumed that the fault has occurred at node *k* of the network. In this the phases b and c got shorted through the impedance Z_f . Since the system is unloaded

$$I_{fa} = 0 \tag{8}$$

before the occurrence of the fault we have

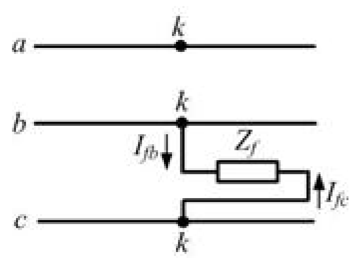


Figure 3.3: Representation of L-L fault.

Also since phases b and c are shorted we have

$$I_{fb} = -I_{fc} \tag{9}$$

Therefore from (8) and (9) we have

$$I_{fa012} = C\begin{bmatrix} 0 \\ I_{fb} \\ -I_{fb} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 0 \\ \left(a - a^2\right) I_{fb} \\ \left(a^2 - a\right) I_{fb} \end{bmatrix} \tag{10}$$

We can then summarize from (8.10)

$$\begin{aligned} I_{fa0} &= 0 \\ I_{fa1} &= -I_{fa2} \end{aligned} \tag{11}$$

Therefore no zero sequence current is injected into the network at bus k and hence the zero sequence remains a dead network for an L-L fault. The positive and negative sequence currents are negative of each other.

Now from Figure 3.3 we get the following expression for the voltage at the faulted point

$$V_{kb} - V_{kc} = Z_f I_{fb} \tag{12}$$

Again

$$\begin{aligned} V_{kb} - V_{kc} &= V_{kb0} + V_{kb1} + V_{kb2} - V_{kc0} - V_{kc1} - V_{kc2} \\ &= \left(V_{kb1} - V_{kc1}\right) + \left(V_{kb2} - V_{kc2}\right) \\ &= \left(a^2 - a\right) V_{ka1} + \left(a - a^2\right) V_{ka2} \\ &= \left(a^2 - a\right)\left(V_{ka1} - V_{ka2}\right) \end{aligned} \tag{13}$$

Moreover since $I_{fa0} = I_{fb0} = 0$ and $I_{fa1} = - I_{fb2}$, we can write

$$I_{fb} = I_{fb1} + I_{fb2} = a^2 I_{fa1} + a I_{fa2} = \left(a^2 - a\right) I_{fa1} \tag{14}$$

Therefore combining (12) - (14) we get

$$V_{ka1} - V_{ka2} = Z_f I_{fa1} \tag{15}$$

Equations (12) and (15) indicate that the positive and negative sequence networks are in parallel. The sequence network is then as shown in Fig. 8.6. From this network we get

$$I_{fa1} = -I_{fa2} = \frac{V_f}{Z_{kk1} + Z_{kk2} + Z_f} \tag{16}$$

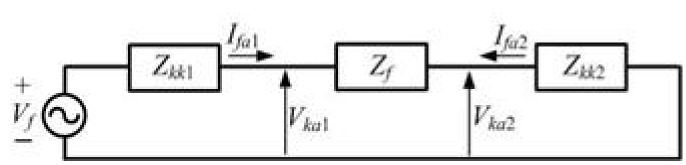


Figure 3.4: Thevenin equivalent of an LL fault.

C. Three Phase Fault

Three phase is a balanced network. Therefore, it can be solved on a per phase basis. It is also known as symmetrical fault. Compared than the others, this type of fault is the most severe although it occurs occasionally. Since the network is balanced, the other two phases have identical magnitude but different in phase shift.

Since in the three phase fault there is no negative and zero sequence condition, the fault circuit can be reduced to a single line diagram. The fault network can be analyzed using Thevenin's method for small network and using bus impedance matrix for large network [7].

For Thevenin's method, few assumptions must take as consideration which are the generator are modelled as an emf behind the subtransient or transient reactance, the network resistance are neglected, shunt capacitance are neglected and the system is considered as having no load and all generators are running at their rated voltage and rated frequency with their emf in phase [7].The fault current can be determine by:

$$I_f = \frac{E}{Z_{TH}} \tag{17}$$

IV. METHODOLOGY

Information on Microgrid and its properties as well as the studies on fault has been made before simulating the fault analysis. These information gathered from sources such as from the journals, internet, reference books, and other previous online thesis. The Matlab Simulink software version 7.11.0(R2010b) was used to conduct a simulation on this project. This software is a friendly-user which is very convenient to use where user can easily make a modification of existing models and edit the components settings.

Figure 4.1 show processes by step to obtain the fault analysis in microgrid.

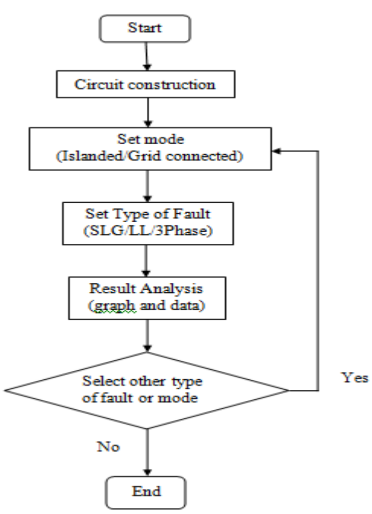


Figure 4.1: Flowchart of process achieved

A. Circuit Construction

In this project, microgrid model which a High-Penetration, No Storage, Wind-Diesel (HPNSWD) system is adapted from demo version entitle Wind Turbine Asynchronous Generator in an Isolated Network is used. The first commercial application of HPNSWD technology was commissioned in 1999 by Northern Power Systems (Vermont, USA) on St. Paul Island, Alaska [11]. It consist of a wind turbine driving 275 kVA induction generator, 300 kVA synchronous machine, a customer load of 50kW and also a variable secondary load (0 to 446.25 kW). All these components's voltage had been rated at 480V with frequency of 60Hz.

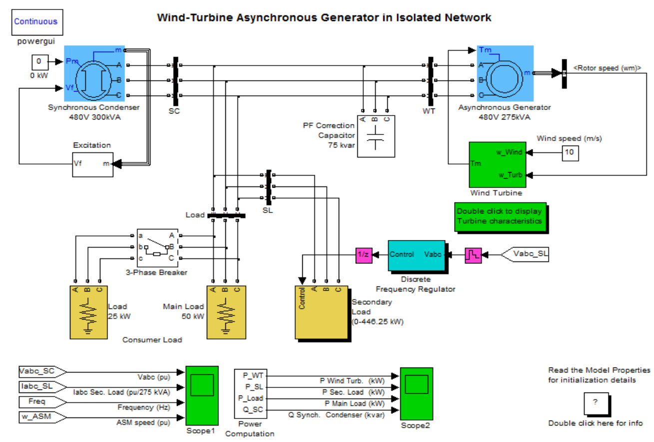


Figure 4.2: The Wind Asynchronous Generator In an Isolated Network

In this all-wind mode, there is no storage systems included. The synchronous machine serves as a synchronous condenser while its excitation system controls the grid voltage at its nominal value. secondary load bank is used to adjust the system frequency by absorbing the wind power exceeding consumer demand. On the other hand, the wind speed is maintained at an average speed of 10 ms^{-1}. This demo model is then modified to fulfill this project objectives.

The model is then modified by connecting the Infinite bus that consist three components such as a three phase source of 2000 MVA 25 kV with wye-ground connection, three phase step down transformer of 1000 MVA 25/0.48 kV with wye-ground to delta connection and also three phase breaker.

B. Configuration Parameters

The configuration parameters need to be set to avoid error. Before running the simulation, the initial condition for modified model need to be obtained. Besides that, the solver is set to ode 23tb (Mod. Stiff/TR-BDF2). Noted that each type of solver gives different result according to the approach adapted to it. Simulation time is set from 0-5 seconds. Simulation time is not the same as clock time. For example, running a simulation for 10 seconds usually does not take 10 seconds. Total simulation time depends on factors such as model complexity, solver step sizes, and computer speed

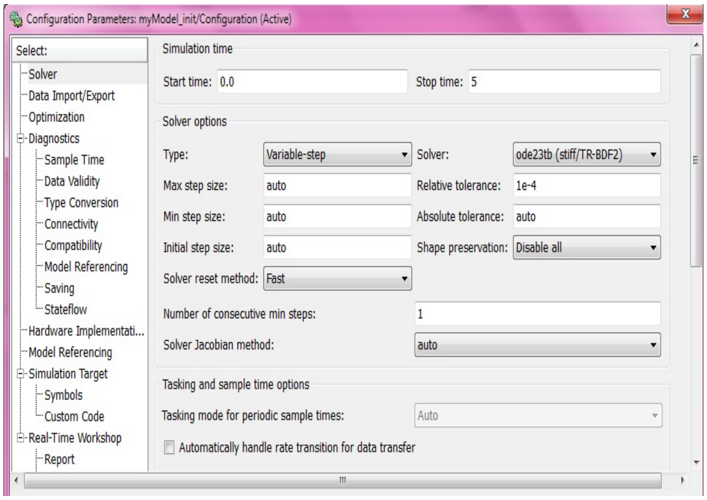


Figure 4.7: Configuration parameters

C. *Fault Location*

Fault location are located in between the three important elements; wind turbine bus, Infinite bus and load bus for future protection especially for circuit breaker and relays. Other than that, Fault resistance is set to a very small value approximate to zero. By selecting the faulty phase at parameter types of fault can be determined. For example, in Figure 4.3 show setting for three phase fault by select all Phase Fault and uncheck the Ground Fault.

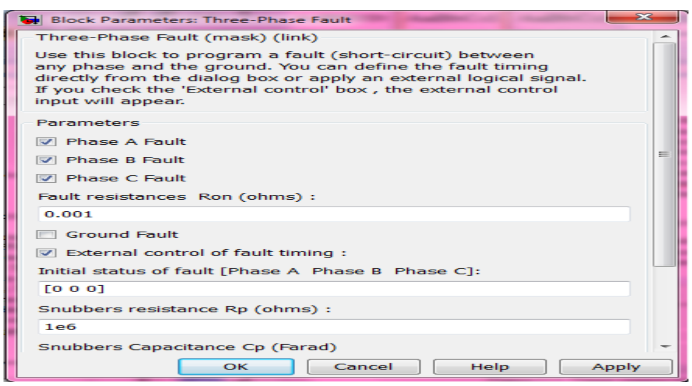


Figure 4.3: Three phase fault block parameters

The timer source block parameters is shown in Figure 4.4. Fault is triggered at 1.5 to 2 seconds of simulation time.

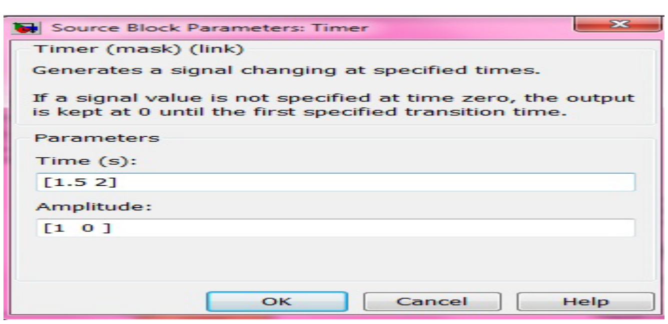


Figure 4.4: Timer source block parameters

D. *Setting Output Device*

During fault, current and voltage is observed and measured. Output devices are placed at fault location as stated. Three-Phase VI Measurement block is used to measure current and voltage at all busbars. Voltage is measured from phase to ground. Figure 3-8 shows the block settings. All measurements are directed to two scopes of current and voltage labeled as Scope1 and Scope2 respectively as shown in figure 4.5.

.

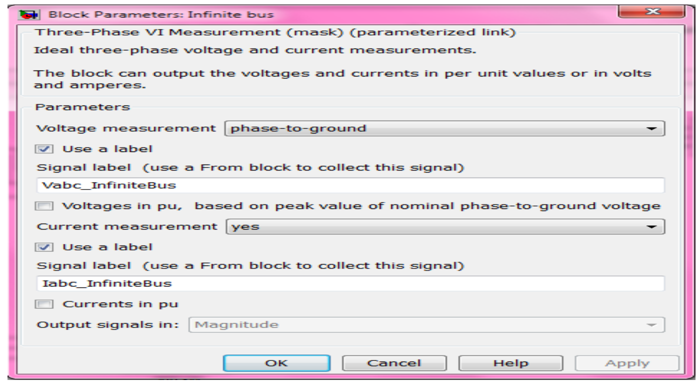


Figure 4.5: Three-Phase VI Measurement block parameter

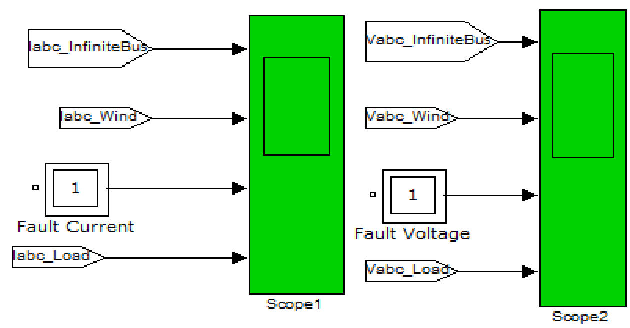


Figure 4.6: Scope

E. *Run Simulation*

After all setting is done, the simulation can be run to check and correcting if any errors occurred. During simulation, islanded mode and grid connected mode are differentiated by opening and closing the three phase breaker correspondingly. The transition times is set to zero. Three-Phase Breaker block parameters is shown in Figure 3-10.

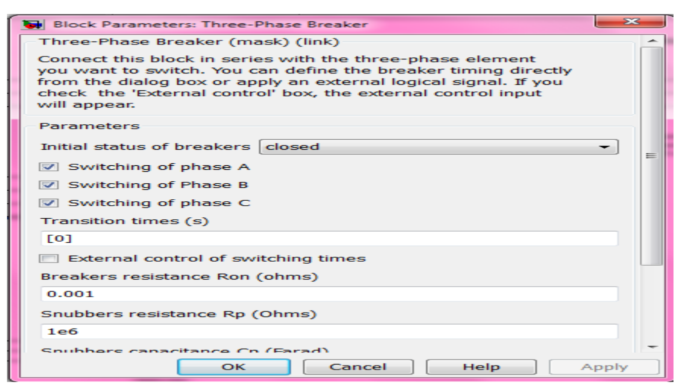


Figure 4.8: Three-Phase Breaker block parameters

F. Result Analysis

Fault data and graph results obtained are then analyzed to compare with the other related references.

V. RESULTS AND DISCUSSION

Results and the discussion part are presented in two parts, which are A. for Islanded mode and B. for Grid-connected mode. The discussions will be based on types of fault analyzed, shape of waveform and magnitude of current at all bus during fault.

A. Islanded mode Results

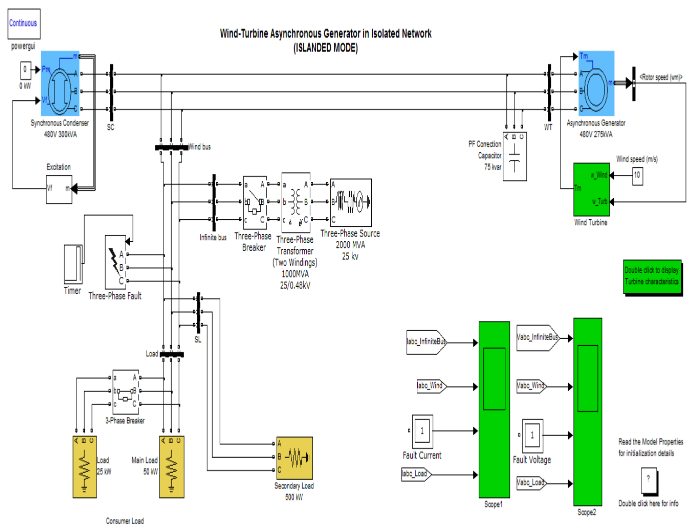
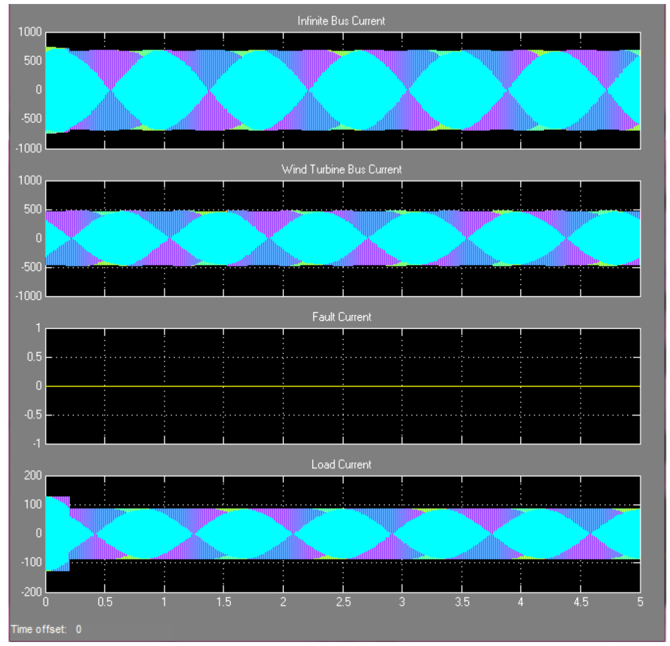


Figure 5.1: Islanded mode of Microgrid

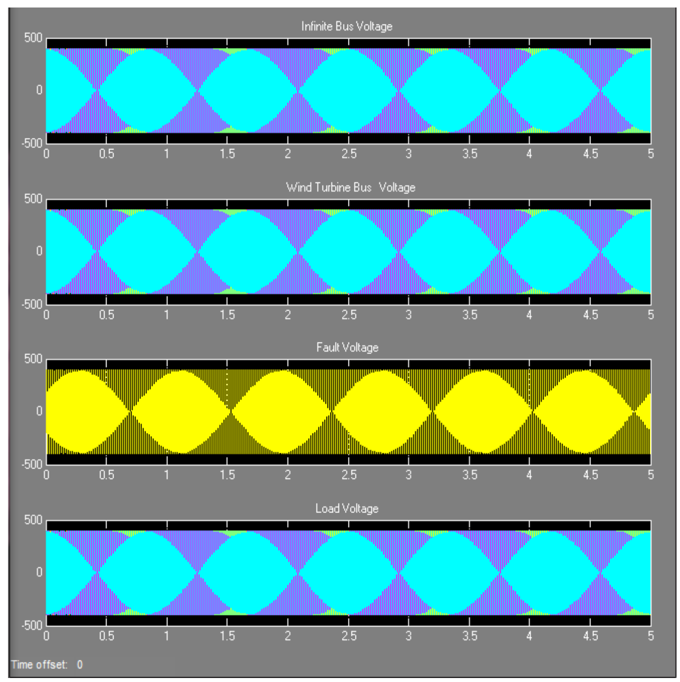
For Islanded mode, the three phase breaker is manually opened so that the infinite bus is disconnected from the Microgrid. Fault assumed to be occurred between Wind Turbine bus and Load bus. Results of each bus are summarize in Table 5.1, Table 5.2 and Table 5.3, Table 5.4 and Table 5.5.

TABLE 5.1: NOMINAL CURRENT AND VOLTAGE OF ISLANDED MODE

Bus	Phase A		Phase B		Phase C	
	Current (A)	Voltage (V)	Current (A)	Voltage (V)	Current (A)	Voltage (V)
Infinite	668	392	668	392	668	392
Wind Turbine	470	392	470	392	470	392
Load	85	392	85	392	85	392



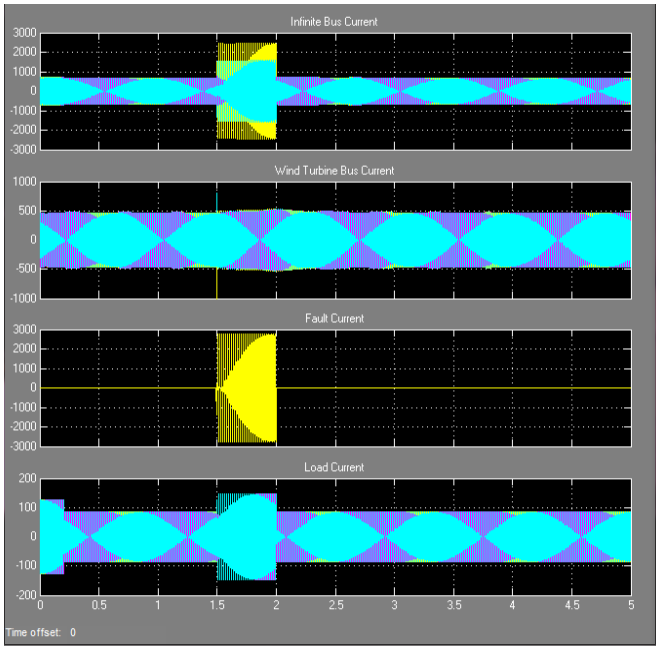
Graph 5.1: Nominal Current of Islanded Mode



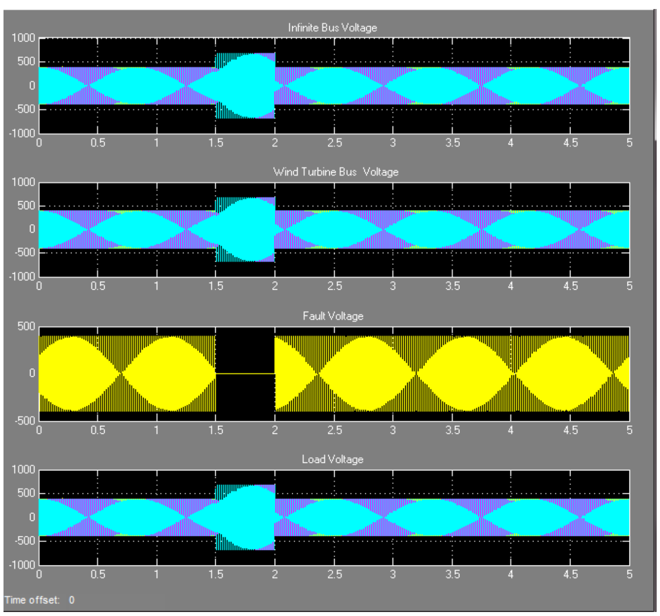
Graph 5.2: Nominal Voltage of Islanded Mode

TABLE 5.2: CURRENT AND VOLTAGE FOR SLG FAULT IN ISLANDED MODE

Bus	Phase A		Phase B		Phase C	
	Current (A)	Voltage (V)	Current (A)	Voltage (V)	Current (A)	Voltage (V)
Infinite	2432	5	1150	670	1500	670
Wind Turbine	500	5	457	670	484	670
Load	1.2	5	145	670	145	670



Graph 5.3: Current for SLG fault in Islanded Mode



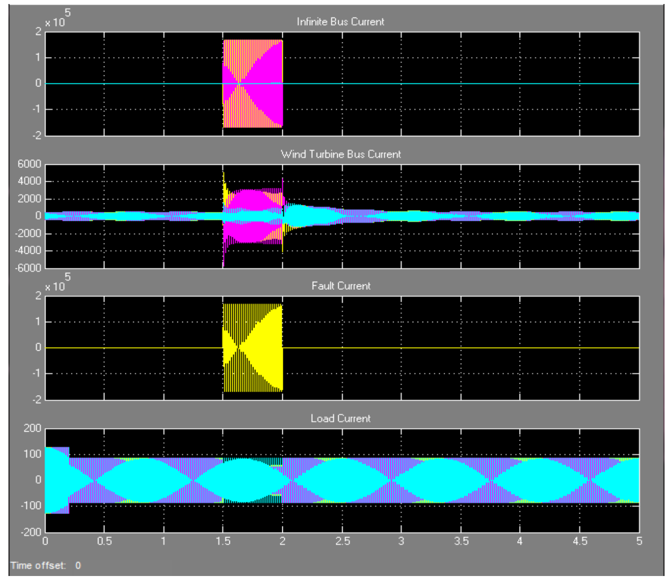
Graph 5.4: Voltage for SLG fault in Islanded Mode

For Table 5.1 nominal currents and voltages at each busbar is recorded. By comparing the nominal values and during fault values, it can be observed that:

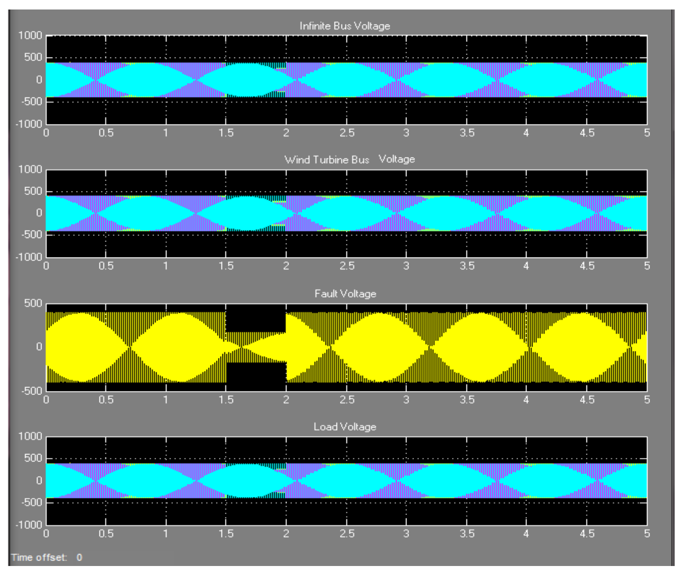
i. The Wind Turbine bus, Infinite bus, and Load bus currents increased except Load bus current of phase A decreased.
ii. Current of phase A at Infinite bus increased to 2.432 kA.
iii. Infinite bus current of phase A waveform is identically to theoretical where the current which is the faulty phase increased higher than the other healthy phase.
iv. Both voltage at phase B and C increased to 670 V.
v. Since phase A at faulty, its voltage decrease to 5 V.

TABLE 5.3: CURRENT AND VOLTAGE FOR L-L FAULT IN ISLANDED MODE

Bus	Phase A		Phase B		Phase C	
	Current (A)	Voltage (V)	Current (A)	Voltage (V)	Current (A)	Voltage (V)
Infinite	166 460	270	166 460	270	1244	392
Wind Turbine	2220	270	2220	270	813	392
Load	60	270	60	270	85	392



Graph 5.5: Current for LL fault in Islanded Mode



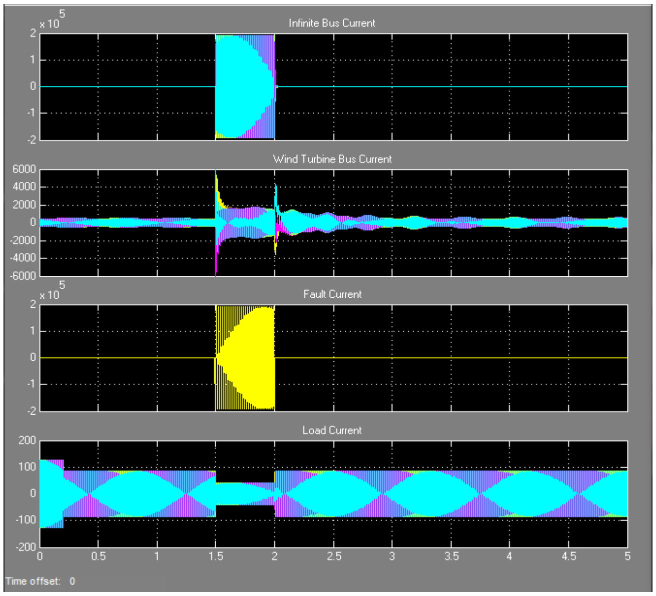
Graph 5.6: Voltage for LL fault in Islanded Mode

For Table 5.3, it can be observed that:

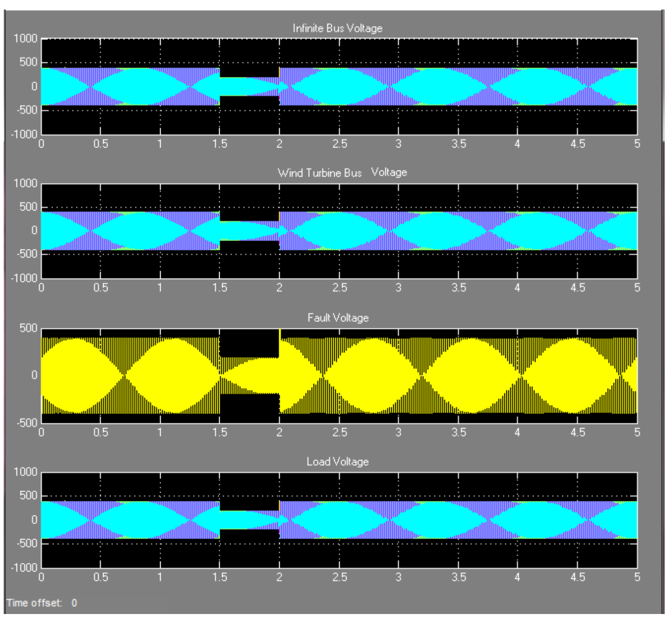
i. Infinite bus and Wind turbine bus current in both Phase A and B increased extremely to 166.46 kA and 2.22 kA respectively.
ii. Current and voltage in Phase A and Phase B have similar current value.
iii. Both voltage for all busbars in phase A and B also similar with value of 270 V
iv. It proves that when line-to-line fault occur in any phase, the current and voltage magnitude must be equal since they are tied together.

TABLE 5.4: CURRENT AND VOLATGE FOR THREE PHASE FAULT IN ISLANDED MODE

Bus	Phase A		Phase B		Phase C	
	Current (A)	Voltage (V)	Current (A)	Voltage (V)	Current (A)	Voltage (V)
Infinite	192650	192	192650	192	192650	192
Wind Turbine	1860	192	1860	192	1860	192
Load	41	192	41	192	41	192



Graph 5.7: Current for three phase fault in Islanded Mode



Graph 5.8: Voltage for three phase fault in Islanded Mode

Table 5.4 is the results of currents and voltage recorded for all buses in three phase fault. By comparing with the nominal values, it can be observed that:

i. All three phases' currents in Infinite bus and Wind Turbine bus increased.
ii. The magnitude for all phases and busbars are equal.
iii. Current at Load bus decreases to 41 A

TABLE 5.5: FAULT CURRENT AND VOLTAGE IN ISLANDED MODE

Fault type	SLG	LL	Three phase
Current (A)	2570	166 740	192 000
Voltage (V)	2.75	166	192

Referring to Table 5.5, it can be concluded that three phase fault in Islanded mode is the most severe carrying current magnitude of 192 kA.

B. Grid-connected mode Results

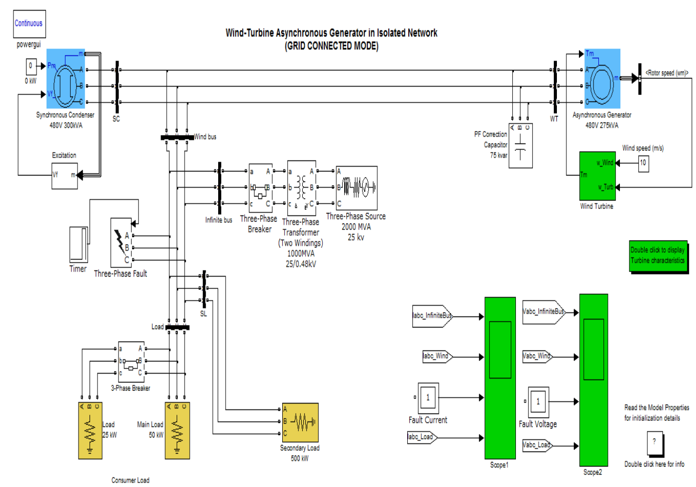
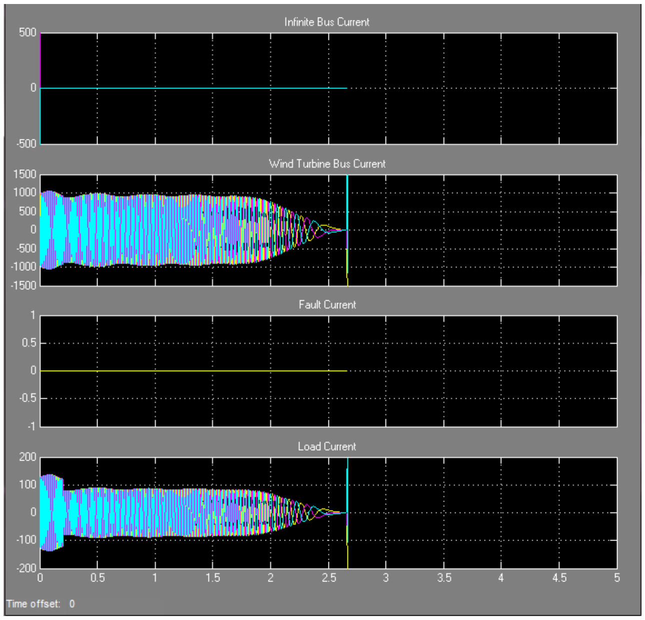


Figure 5.2: Grid connected mode of Microgrid

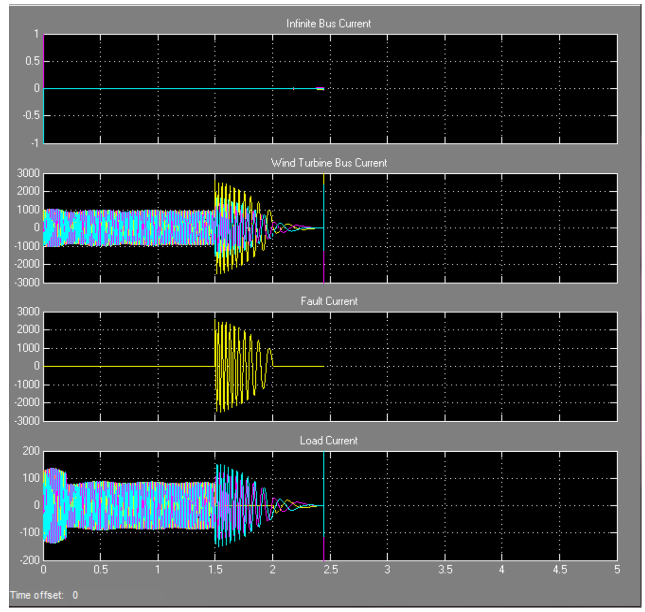
In this mode, the three phase breaker is manually closed so that the infinite bus is connected to the Microgrid. Fault assumed to be occurred between Wind Turbine bus, Infinite bus and Load bus. Results of each phase current and voltage of each bus are summarize in Table 5.6, Table 5.7, Table 5.8, Table 5.9 and Table 5.10.

TABLE 5.6: NOMINAL CURRENT AND VOLTAGE OF GRID CONNECTED MODE

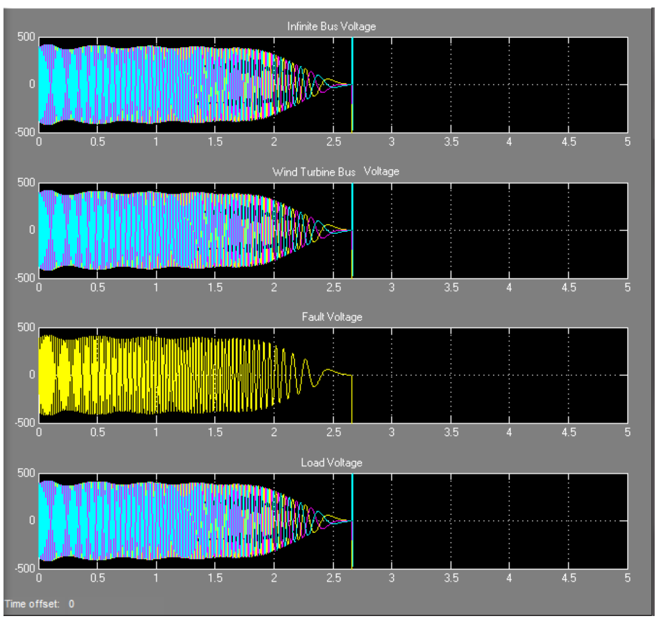
Bus	Phase A		Phase B		Phase C	
	Current (A)	Voltage (V)	Current (A)	Voltage (V)	Current (A)	Voltage (V)
Infinite	0.0004	392	0.0004	392	0.0004	392
Wind Turbine	910	392	910	392	910	392
Load	85	392	85	392	85	392



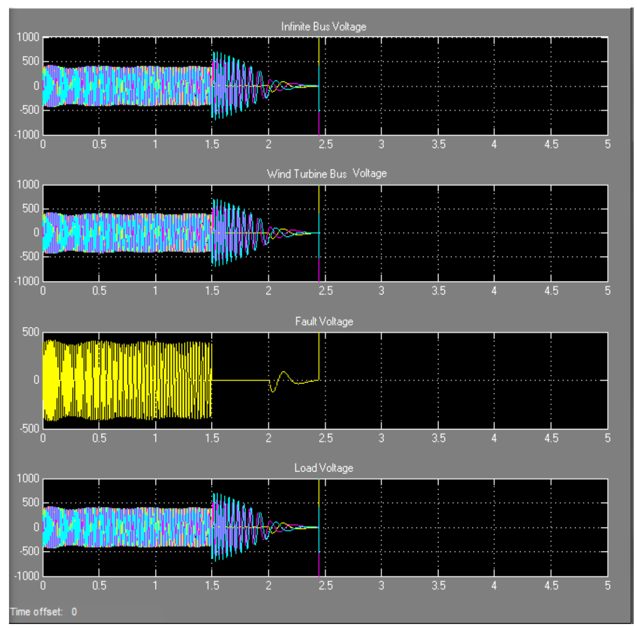
Graph 5.9: Nominal Current of Grid connected Mode



Graph 5.11: Current for SLG fault in Grid connected Mode



Graph 5.10: Nominal Voltage Grid connected Mode



Graph 5.12: Voltage for SLG fault in Grid connected Mode

TABLE 5.7: CURRENTAND VOLTAGE FOR SLG FAULT IN GRID CONNECTED MODE

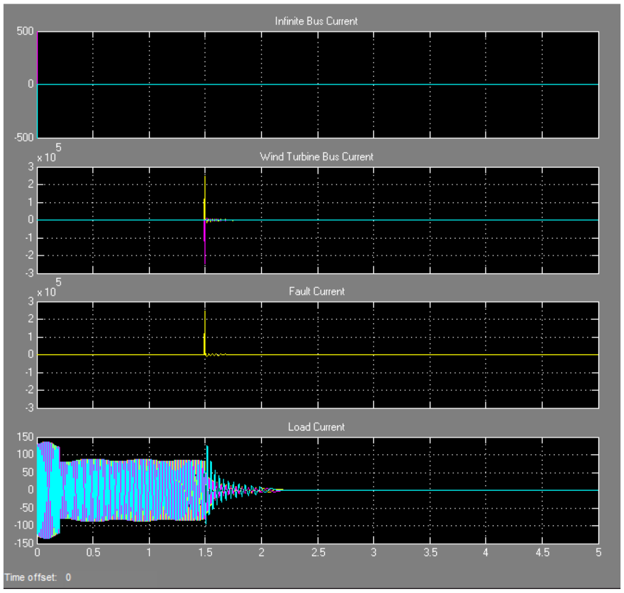
Bus	Phase A		Phase B		Phase C	
	Current (A)	Voltage (V)	Current (A)	Voltage (V)	Current (A)	Voltage (V)
Infinite	0.0005	4	0.0008	550	0.0011	690
Wind Turbine	2300	4	1200	545	1450	675
Load	0.85	4	110	526	132	642

Table 5.7 is results nominal currents and voltages recorded at each bus. By comparing the nominal values and during fault values, it can be observed that:

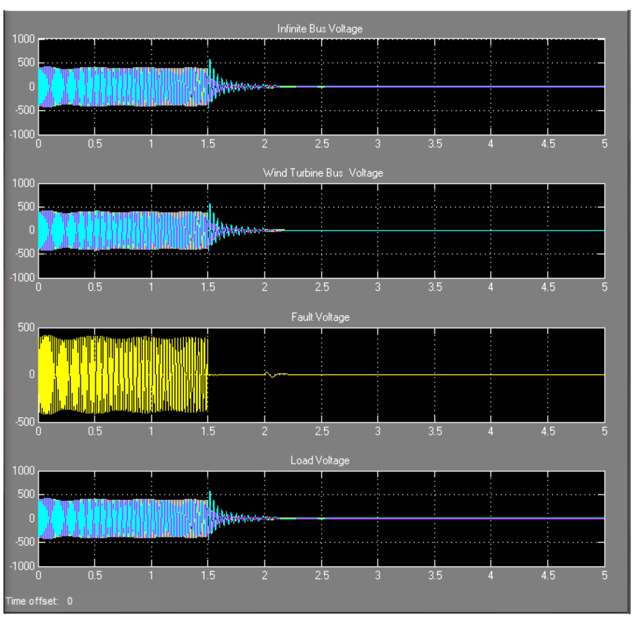
i. Slight change in Infinite bus current where the values is very small.
ii. Current at Load bus decreases gradually from the nominal values.
iii. Current at Wind Turbine bus increased from the nominal values.
iv. Since phase A is at fault, all voltages at all bus is similar in all buses with value of 4V and much smaller compared to other healthy phases.

TABLE 5.8: CURRENT AND VOLTAGE FOR L-L FAULT IN GRID CONNECTED MODE

Bus	Phase A		Phase B		Phase C	
	Current (A)	Voltage (V)	Current (A)	Voltage (V)	Current (A)	Voltage (V)
Infinite	0.003	165	0.003	165	0.0001	320
Wind Turbine	11 800	165	11 800	165	650	320
Load	14	165	14	165	27	320



Graph 5.13: Current for LL fault in Grid connected Mode



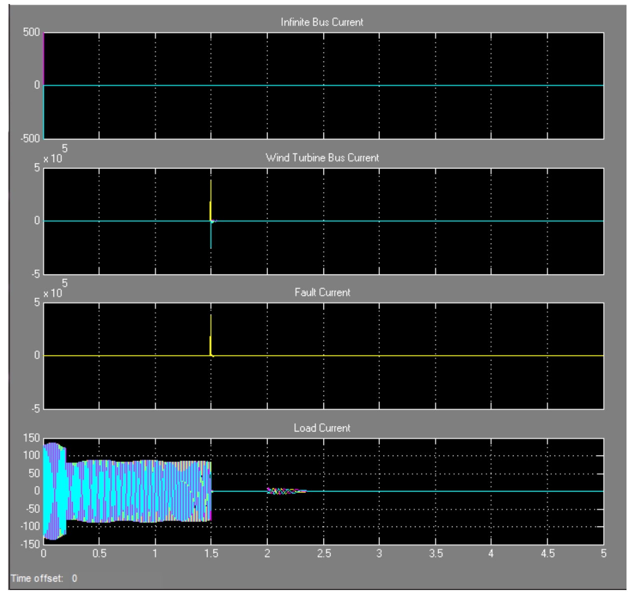
Graph 5.14: Voltage for LL fault in Grid connected Mode

For Table 5.8, it can be observed that:

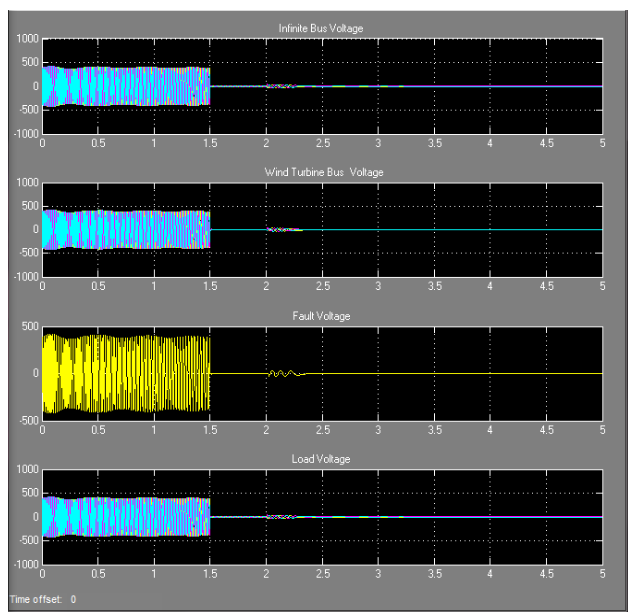
i. Infinite bus and Wind turbine bus current in both Phase A and Phase B increased respectively.
ii. Voltages in all busbars are the same in phase A and B with value of 165 V.
iii. Current and voltage is similar as theoretical where in Phase A and Phase B have identical values since they are set to be faulty.

TABLE 5.9: CURRENT AND VOLTAGE FOR THREE PHASE FAULT IN GRID CONNECTED MODE

Bus	Phase A		Phase B		Phase C	
	Current (A)	Voltage (V)	Current (A)	Voltage (V)	Current (A)	Voltage (V)
Infinite	0.0004	2	0.0004	2	0.0004	2
Wind Turbine	2150	2	2150	2	2150	2
Load	0.5	2	0.5	2	0.5	2



Graph 5.15: Current for three phase fault in Grid connected Mode



Graph 5.15: Voltage for three phase fault in Grid connected Mode

Table 5.9 is the results of currents and voltages recorded for all bus in three phase fault. By comparing with the nominal values, it can be observed that:

i. Wind Turbine bus current increased to 2.15 kA.
ii. Load bus current decreased to 0.5 A.
iii. All bus voltages decreased to 2V.
iv. Data recorded show similar with theoretical whereby all busbars in each phases are identical.

TABLE 5.10: FAULT CURRENT AND VOLTAGE IN GRID CONNECTED MODE

Fault type	SLG	LL	Three phase
Current (A)	2627	247 000	352 500
Voltage (V)	0.56	246	542

Referring to Table 5.10, in can be concluded that three phase fault in Grid connected mode is the most severe carrying current magnitude of 352.5 kA.

VI. CONCLUSION

This paper has presented an approach to prove and analyze types of fault such as single phase to ground (SLG) fault, line to line (LL) fault and three phase fault in both islanded and grid connected mode in Microgrid.

From results, it show that three phase fault have highest current fault in both modes but after compared with both modes results, it can be conclude that three phase fault in grid connected mode is the most severe case. Therefore, all data of currents and voltages for each bus provided are adequate for future relay protection and breaker implementation in Microgrid.

ACKNOWLEDGMENT

This project was implemented under final year project for the final year student, Faculty of Electrical Engineering UiTM. The author would also like to thank Universiti Teknologi Mara for their equipment such as software support to complete this project.

REFERENCES

[1] WIKIPEDIA, Microgrid, Available: http://en.wikipedia.org/wiki/Distributed_generation#Microgrid

[2] M.H Idris. *Fault Analysis In Power System,* pg 5, Skudai, Johor:University Teknologi Malaysia ,2009

[3] A. A Mohd Zin and M.S Majid, *Power System Engineering, Lecture Note Edition,* pg 1.2, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 2010

[4] A.A. Mohd Zin and S.P. Abdul Karim, IEEE Transactions on Power Delivery, Vol 2, No 44, 2007

[5] N. D. Tleis, *Power Systems Modelling and Fault Analysis. Theory and Practice.* Oxford, U.K.: Elsevier Ltd, 2008

[6] Unsymmetrical Faults, Available: http://nptel.iitm.ac.in/courses/Webcourse-contents/IIT-KANPUR/power-system/chapter_8/8_intro.html

[7] M.W. Mustafa, *Power System Analysis*, *Teachimg Module Third Edition*, *Faculty of Electrical Engineering*, University Teknologi Malaysia, 2011

[8] D. Krotz, Microgrids: reliable power in a small package, Available: http://www.lbl.gov/Science-Articles/Archive/EETD-microgrids.html

[9] A. A. Salam, A. Mohamed and M. A. Hannan *Technical Challenges On Microgrids, Vol 3, No6,* ARPN Journal of Engineering and Applied Sciences,Dec 2008