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## Load shedding analysis on microgrid during island mode

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**Abstract.** This paper evaluates implementation load shedding strategy in island mode of microgrid(MG). Microgrid normally operates in interconnected mode either with the medium voltage(MV) and low voltage(LV) network. Microgrid can function both in grid and island mode connected. As electricity demand increases, microgrid deployment becomes an attractive option to meet energy demands. Microgrid during utility grid failure, however, suffers from crucial stability problems come from many aspects. Load Shedding Strategy (LSS) is one of the method used to sustain operation of power system in stable state. The main objective in this paper is to analyze the implementation of Load Shedding Strategy (LSS) on two different cases. The simulation model developed from a mix of generator, photovoltaic cell of source and the lumped load. ETAP software was used in analysing the result.

**Keywords** – Microgrid, Island Mode, Load Shedding, Stability, ETAP

### 1. Introduction

Nowadays, modern technology is the most important aspect in human daily life. However, power system cannot be avoided from having power failure caused by many factor. When it's happened, many activity is affected and cause some big losses especially in industrial sector. This situation highlight the electricity stability is a main necessity for human in order to perform their routine.

Previous history implies that there is consistent development in burden request in generation [1]. In fact, the small of the generation unit Low Voltage (LV) have changed to Medium Voltage (MV) and High Voltage (HV). Microgrid (MG) system is an energy medium based on smart technologies that have been used for many countries. MG can be defined as a Low Voltage (LV) network and also several generation systems connected by providing power to loads. The development of MG also can help to reduce greenhouse gas emission and increase energy efficiency. There are two different operating conditions for MG to operate which are normal interconnected mode and island mode. MG is designed to function independently in island mode which can perform well.

Distributed generation (DG) is defined as a small unit installed in distributed system. In distribution system, DG is located near to the load side so that energy losses in transmission lines can be reduced [2]. However, allocation of DG should be at located the suitable place because it will effect the increasing of cost and having a big effect of power generation.



During emergency of distributed generation system, it will shed most of the load except for priority loads because to maintain system integrity. The nearest generator will keep supplying the electricity to the main loads. However, this method cannot reach maximum capacity of distributed generators. In this paper, microgrid has been designed and analysed in two different situation: (i) during island mode; (ii) Loss of generator. The analysis is carried out fault and islanded condition which in transient stability analysis.

## 2. Microgrid's operation

Power grids consists of a complex generation plants which are substation, transformer, and transmission lines that supply electricity to cities and industry. A small-scale power that operate together with other small power grids is called microgrid. Microgrid can supply to rural areas and industries have always been a big challenge due to their distance from the generation power plant. It is good to build and maintain long distance transmission line. Additionally, microgrid used diesel generators and also diesel backup system for electricity generation. In advancement grid technology, microgrid started integration of renewable energy such as solar and wind array in used combination with diesel generators

Microgrid operates in two different operating conditions which are normal interconnected mode and emergency mode [3]. Normal interconnected mode is when microgrid connected to a main medium voltage (MV) network either supplied or injecting some power to main system. While, emergency mode is when microgrid operates automatically in a similar way to islands during no connection from the upstream MV network occurs.

## 3. Emergency Mode of Microgrid

Emergency mode of microgrid usually cause by power quality event such as maintenance and force isolation due to the fault. It will make microgrid disconnect from the main grid and fully operated by itself to supply the demand within its scale [4]. This kind of mirgrogrid's connection is known as island mode connected.

Island mode operation have two condition of generator. The first one is stand-alone generators not connected to the electricity grid and second is generators connected to the electricity grid in parallel mode which can generate independently in the event of a grid supply failure.

Islanding can be dangerous for utility worker because they may not realize that the circuit still have powered. Additionally, frequency limit must be set strictly for controlling the balanced between load and generation. It also to prevent from leading to abnormal frequencies and voltage which can cause fault or system breakdown.

The load shedding is designed for island mode under two conditions. First, set the frequency of the voltage bus bar. If the frequency drops below the set limit, the generator turbine will be overloaded and the steam turbine fault will result in frequency dip. The other condition is that the system will lose electricity at some power during a generator tripping [5]. The other generator cannot cover the load in a short time, but can still take 5 to 10 MW out of the grid. All setting is performed as per generator power losses by calculation and trip load. This concept is used in emergency situations.

## 4. Load Shedding

In power system, power outage happens when the frequency decline and voltage fluctuation as an after effect of unbalance load generation. A stability of frequency is needed even though the power demand and supply are equal. The response frequency was delivered through synchronous generator system and the load follow the event of the generation load imbalance [6]. To stable the demand power and supply, the proficient methodology in an emergency is by load shedding [7-8]. A selective load shedding concept is introduced to enhance the flexible power system and to restore activities for residential users in power system.

Through this method, a combination of under voltage (UVLS) and under frequency (UFLS) load shedding is used to achieve a good system performance and stability.



condition between reactive power produced and reactive power consumed. The relay (59) is for an overvoltage relay that operates during overvoltage condition.

### 5.2.2. Frequency relay protection.

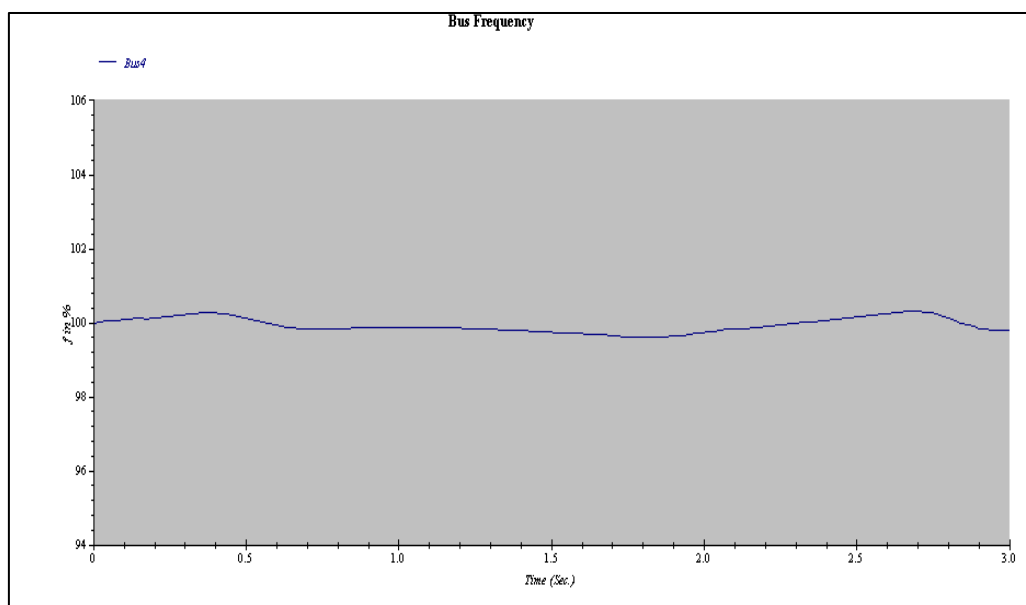
While, a relay used for frequency replay protection (81 H/L). The function of this relay is to takes the decision based on the frequency of the system.

## 6. Result and discussion

The proposed load shedding strategy tested on the power network had been describe in the previous part. The system considered two different types of study cases. The first disturbance case is to make the system in islanding mode. Meanwhile as for the second cases, loss of generator is considered.

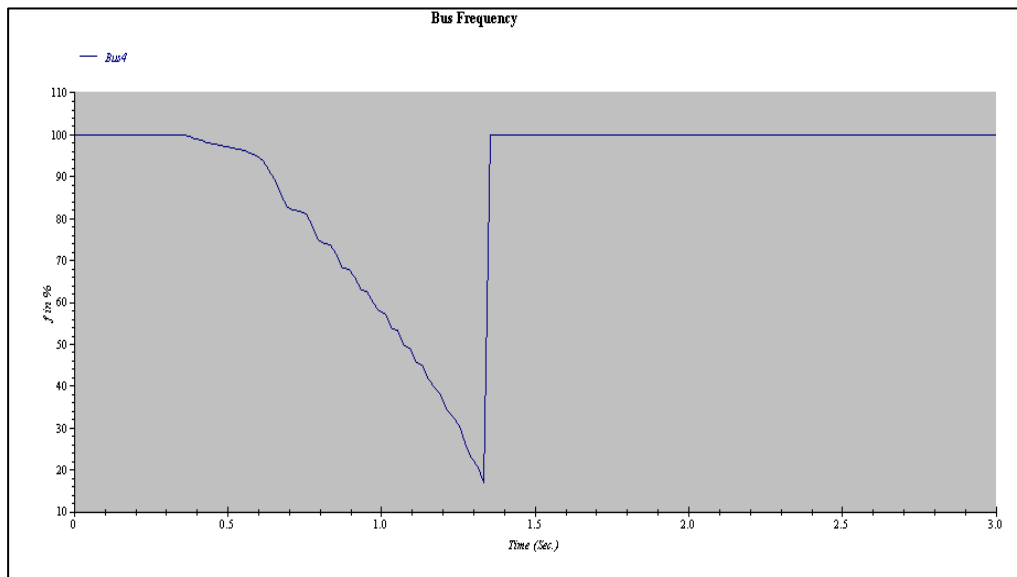
### 6.1. Case study I: Island mode

For case study 1, it was considering the network system being in island mode The event is set 0 second for fault at bus 3 at normal condition while 0.3 second is set for islanding. The total simulation test for this case is 3 seconds only. **Figure 2** shows the result of frequency for stability of microgrid before islanding. The early frequency is 100 % which is 50 Hz. The graph is not constant straight line is because there is small disturbance at the transmission line but still in stable power system. The stable frequency analysis has been seen is a constants value after nearly 0.5 seconds.



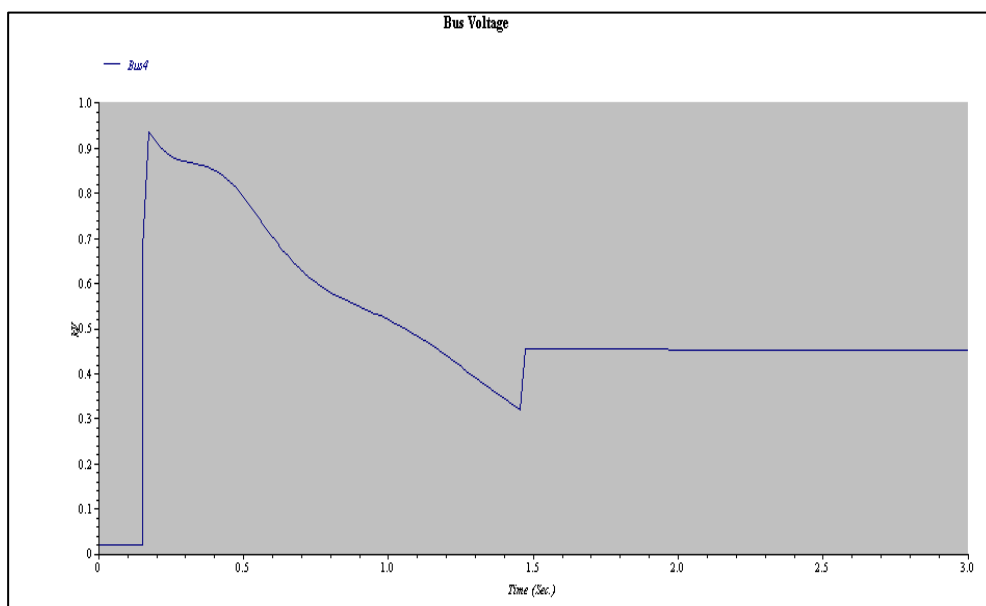
**Figure 2:** Frequency of microgrid before islanding

**Figure 3** shows the result of frequency for transient stability of the microgrid after islanding process occurs. The result is obtained by setting bus 4 as a feeder for producing output. After islanding happens, the frequency drops constantly from 100% to 8% at the time of 0.5 s until 1.35 s. The system starts to increase back to the 100% frequency for the system back to normal happened at 1.4 s. The setting time required for frequency after islanding already reduced half of the condition.



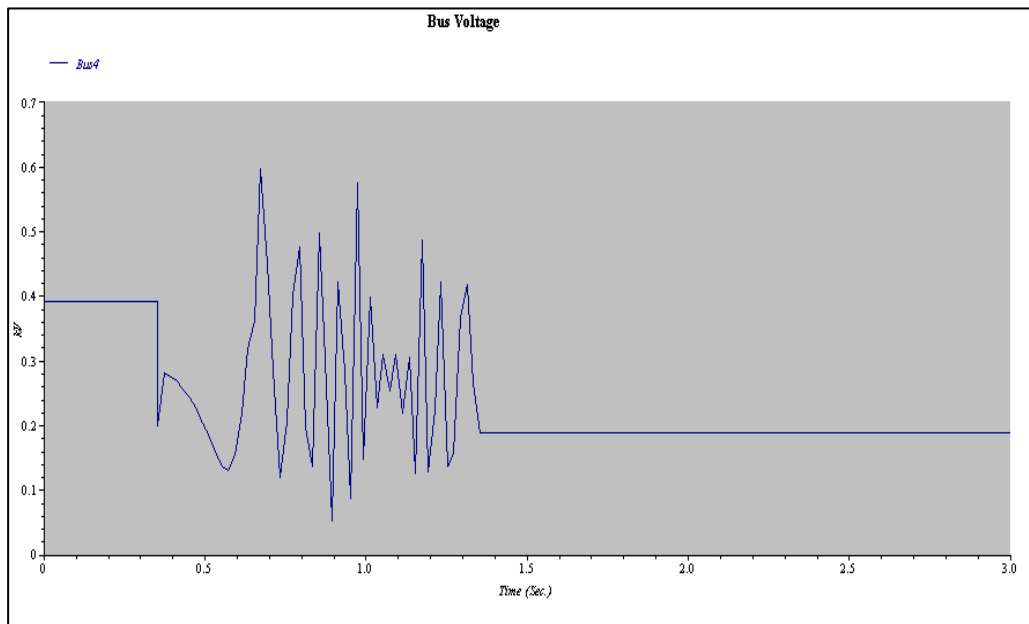
**Figure 3:** Frequency of microgrid after islanding

**Figure 4** shows the response of the voltage parameter toward the microgrid system. Fault occur at the bus 3. Fault happen at 0.3 s cause the voltage drop suddenly until 1.4 s then it back to stable voltage.



**Figure 4:** Voltage response of microgrid before islanding

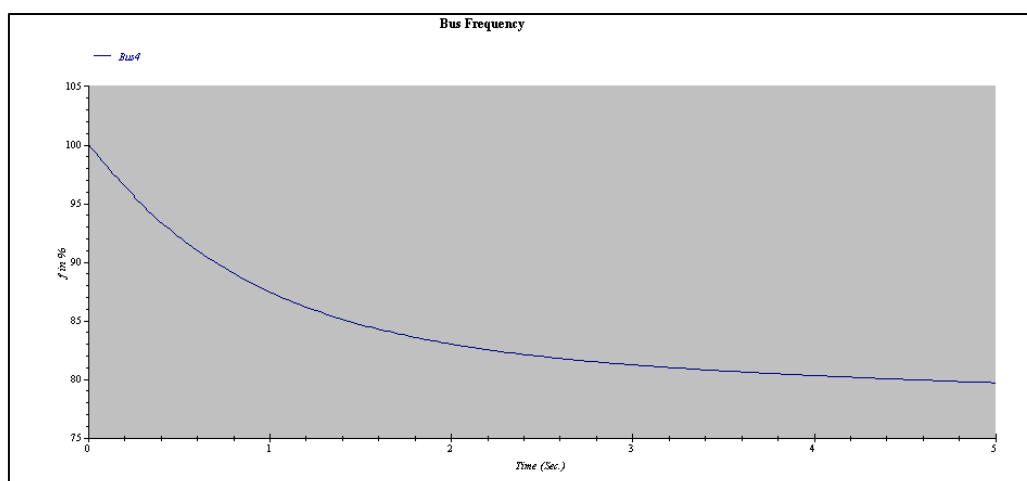
After islanding which shown in **Figure 5**, the rated voltage recovery at 1.4 seconds with the stable voltage is 0.2 kV. This is why islanding scheme is designed and it is necessary to isolate the microgrid from main grid. But with microgrid connected to the system, it is able to maintain the continuity of supply and also make system more reliable.



**Figure 5:** Voltage response of microgrid after islanding

### 6.2. Case study II: Loss of generator

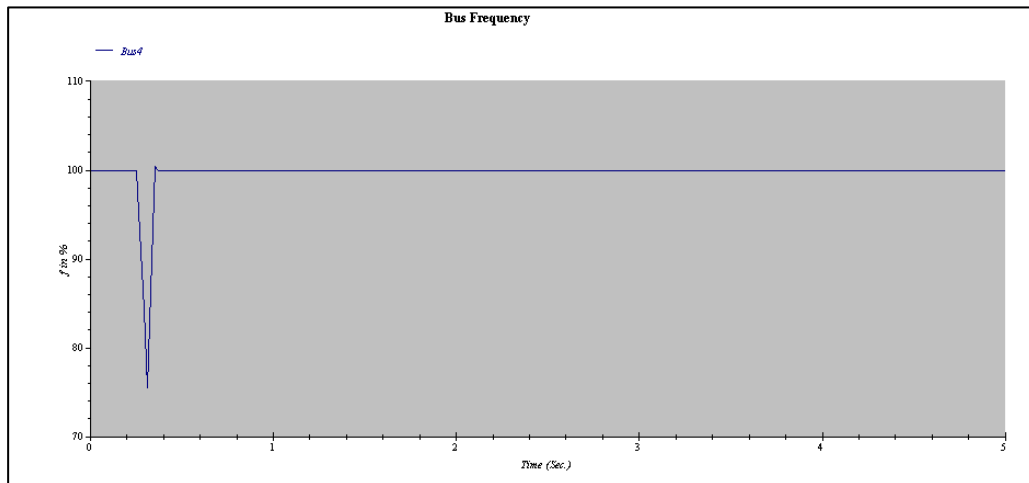
The second case study is by considering the loss of generator situation. In order to create this generator loss case, bus 8 is involved since this bus bar consist of generator. The total simulation for this second case is 5 seconds. When fault occurs at bus 8 where this fault is cause by the generator loss, the frequency decrease constantly as shown in **Figure 6** up to 80% approximately. This might be because of the unbalance between load and supply where load demand is high but since there is loss of generator, the remaining supply is not enough to cover all the local demand. Thus it causes to the unstable system that lead to the frequency drop. Without load shedding, the frequency setting will continue be lower than 100% (50 Hz).



**Figure 6:** Frequency response at bus 4 before load shedding

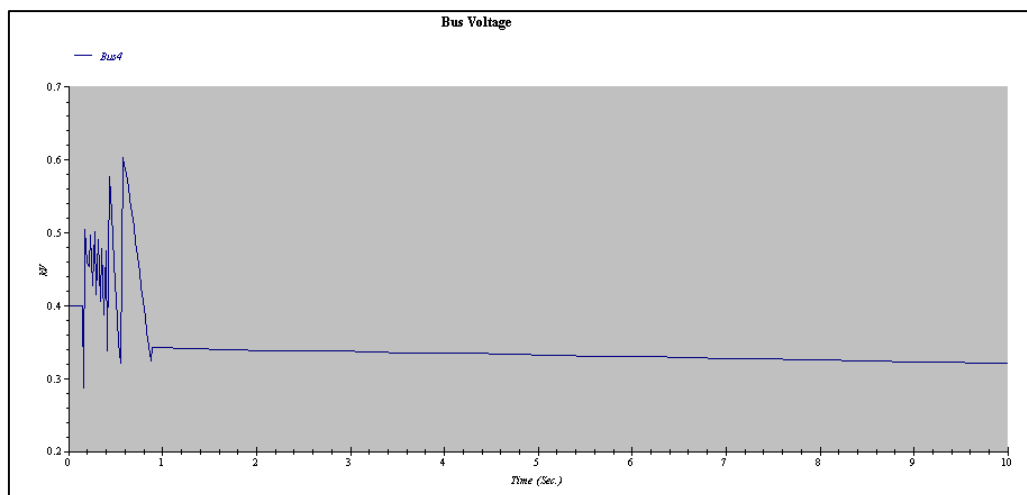
By implementing load shedding, where one of the not priority load is cut, the frequency drops only occur at time 0.2 s then get to the normal frequency back (100% operation) which is 50Hz as

shows in **Figure 7**. Generally, since the frequency drop occur, the voltage also will be affected. This can be shown in the next figure.



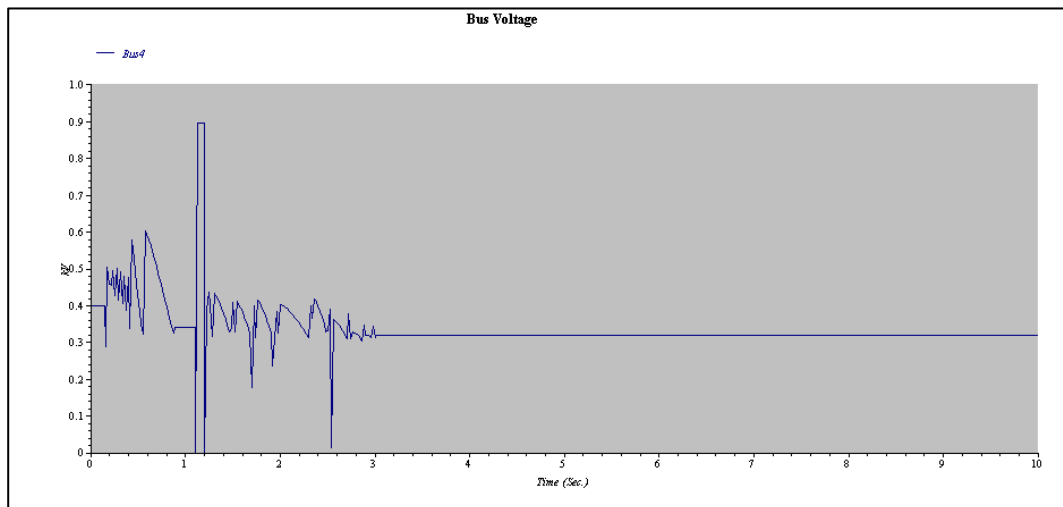
**Figure 7:** Frequency response at bus 4 after load shedding

**Figure 8** shows the voltage response before load shedding apply for cases of generator losses. The voltage is 0.4 kV at normal condition but when generator loss happens, the fault occurs at 0.1 s and constant having disturbance until 0.9 s. At 1 s, the voltage stables again but the supply voltage decreasing to 0.32 kV.



**Figure 8:** Voltage response before load shedding

**Figure 9** shows the simulation results for voltage response after having load shedding. The voltage relay active at 0.2 s when detecting fault happen at bus 8. The unstable voltage is clearly seen start 0.3 until 2.4 s. At 2.5 s, one load had been shed which is breaks the lumped load 1 to stabilize the system. At 3 s, the voltage back to normal after back-up supply active. The voltage response back normal at the value of 0.38 kV.



**Figure 9:** Voltage response after load shedding

## 7. Conclusion

In this project, an analysis of implementation load shedding during island mode of microgrid is carried out by using Electrical Transient and Program (ETAP) software. Load Shedding schemes are used as the initiative to solve the problem of overload situation and unstable frequency as well as voltage parameter when the microgrid is disconnected from the main grid.

This paper is highlighting Load Shedding Strategy (LSS) on two different cases when the islanding mode happened and when there is generation loss during islanding mode. A limit of frequency is pre-define to prove the restore frequency. Based on the two situation, when the microgrid is in islanding mode, a few significant parameters such as frequency and voltage will be affected. It will lead to the frequency drop and also voltage drop. This state will cause to unstable system in microgrid to function well.

For both cases, when utility grid failure (case I) and generator loss (case II) occur, the result shows the disturbance in frequency and voltage. However, after performing load shedding, both parameter tend to back to the normal signal. It proves that load shedding strategy does help to improve the transient stability of microgrid.

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