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Research Article

Photovoltaic Voltage Ramp down Optimization on Hybrid Generation System

Haryo Pratomo[1]
[1]PT PLN (Persero)
Corresponding author:** ***Haryo Pratomo, haryo.pratomo@pln.co.id

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Abstract: Hybrid generation system which consist of photovoltaic and diesel engine generator can be hard to control because of the nature of photovoltaic which very depends on the weather condition and the intensity of sun radiation. The power which the photovoltaic source generates can be goes up and down rapidly and drastically depends on the weather. As a hybrid generation, the diesel engine generator should be able to compensate it before the entire system failed and blacked out. In this paper we tried to find the best combination for certain photovoltaic source, diesel engine generator control system and certain type of load. For simulation purpose we will use ETAP software and Homer software. This software was chosen because they are already widely used and proven in electrical industries.

Keywords: hybrid generation, photovoltaic, diesel engine, ETAP software, Homer software

1. Introduction

Hybrid power systems are those that generate electricity from two or more sources, usually renewable, sharing a single connexion point. Although the addition of powers of hybrid generation modules are higher than evacuation capacity, inverted energy never can exceed this limit. In that way, a hybrid generation plant can, therefore, use, for example, photovoltaic energy when the sun shines and another source, such as wind, in cloudy weather, thus ensuring a more stable and efficient supply. Hybrid installation may or may not always include storage Hybrid power systems are those that generate electricity from two or more sources, usually renewable, sharing a single connexion point. Although the addition of powers of hybrid generation modules are higher than evacuation capacity, inverted energy never can exceed this limit. In that way, a hybrid generation plant can, therefore, use, for example, photovoltaic energy when the sun shines and another source, such as wind, in cloudy weather, thus ensuring a more stable and efficient supply. Hybrid installation may or may not always include storage.

2. Materials and methods

2.1. System Modelling

In this study we will simplify the system modelling down to the components which consist of single diesel engine generator, one photovoltaic source, one medium voltage feeder, and a compound of static load.

This simplification is taken because we want to focused on studying the effect of power ramp down from the photovoltaic source without much interference from the other components. The figure of system modelling is shown below. We use the ETAP Software for system modelling and simulation.

1. Diesel engine generator
2. This is the main source of power. As the main source, the capacity of generator itself should be enough to supply all of load, without the photovoltaic source.
3. Photovoltaic source
4. If the photovoltaic source is in operating condition, because the capacity of diesel engine itself is enough to supply the load, the diesel engine should lower its supply power.
5. A thing we should consider, a diesel engine cannot lower its supply below 40% from the full capacity, so the photovoltaic source capacity should not higher than 60% from the diesel engine capacity.
6. Medium voltage feeder
7. This is a conductor connecting power sources to the load.
8. Static load
9. A type of load which don't have much induction (or capacitance) characteristic, for simplified verification purpose in transient stability simulation.

2.2. Important Parameters

There are some important parameters which we need to set for ourself, and not to leave it as default. This is because those parameters are not in their typical settings or the default parameters from ETAP Software are simply doesn't match the settings on real field condition.

Those parameters and its value are shown in Figure 1 – Figure 3.

2.3. Simulation

Next step, we will do a simple standard Load Flow Simulation for our model. Load Flow Simulation is a basic procedure to make sure our model is right, in term of steady state condition.

The Transient Stability Simulation is the real simulation test of this study. It is made to simulate when the photovoltaic source is covered by cloud in the sky, is the system still stable, and when the cloud suddenly disappear, is the system still in stable condition.

If it turns out that the system cannot hold, we will try to reduce the capacity of the photovoltaic source, this means also increase the diesel generation output, and find a balance between two compositions stable enough to endure the stress of the case.

2.4. Tools for Modelling

As a data source for modelling, we will use a simple 3 Volt small PV that we record its voltage output for seven days.

The PV Source we use to gather data are shown in Figure 4.

As a voltage recorder we will use a three channel 3000 mV Voltage recorder, as shown in Figure 5.

2.5. PV Data Gathering

Data of irradiation curve as a function of voltage is gathered by a voltage recorder, and a small PV Source. These simple tools are just a mini modelling of a power PV Source generator.

Data collected from seven days period of sample irradiation from PV source are in voltage level. Recorded voltage for every 15 minutes from 6:00 a.m. to 6:00 p.m. for seven days. From that data we can make an average 15 minutes data for irradiation level, and also and average daily irradiation curve.

The sample data that we get from the voltage recorder are shown in Figure 6.

For simplification, we will serve the data as a voltage – time curve. The sample graph for a day period is shown in Figure 7.

3. Results and discussion

In this section, we will make conclusion from the PV Data that have been gathered for seven days, and to analyze the results from simulation process.

The result from simulation process using ETAP software are shown below. The results are divided into two categories of study, first is for Load Flow Simulation, and the second is for Transient Stability Result.

3.1. PV Data

Data collected from seven days period of sample irradiation from PV source are in voltage level. Recorded voltage for every 15 minutes from 6:00 a.m. to 6:00 p.m. for seven days. From that data we can make an average 15 minutes data for irradiation level, and also and average daily irradiation curve.

The results are shown in Figure 9 - 14.

3.2. Load Flow Simulation Result

The main purpose of Load Flow Simulation is to understanding how the system will behave in steady state condition. In this study it means the variable condition is the load of Photovoltaic Source in 0% shading until 100% shading (fully covered by cloud). And to maintain system utilization, diesel engine generator will be used as slack (swing generator). The complete results are shown in Figure 15.

The system is stable in the steady state condition. So, we can continue to the next simulation process.

3.3. Transient Stability Result

In this study, we will walkthrough second by second as shading simulates the walking cloud affects the photovoltaic source, and how well the diesel generator will respond to it. The studies divided into nine categories of photovoltaic versus diesel generation loading. From 90% Photovoltaic – 10% diesel, to 10% Photovoltaic – 90% diesel. The results are shown in Figure 16 - 24.

From the simulations process, we can see the result that the system can only survived if the PV suddenly cannot supply (maybe because of cloudy condition), if the PV load is more than 30% (Diesel load less than 70%).

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3.4. Figures and tables

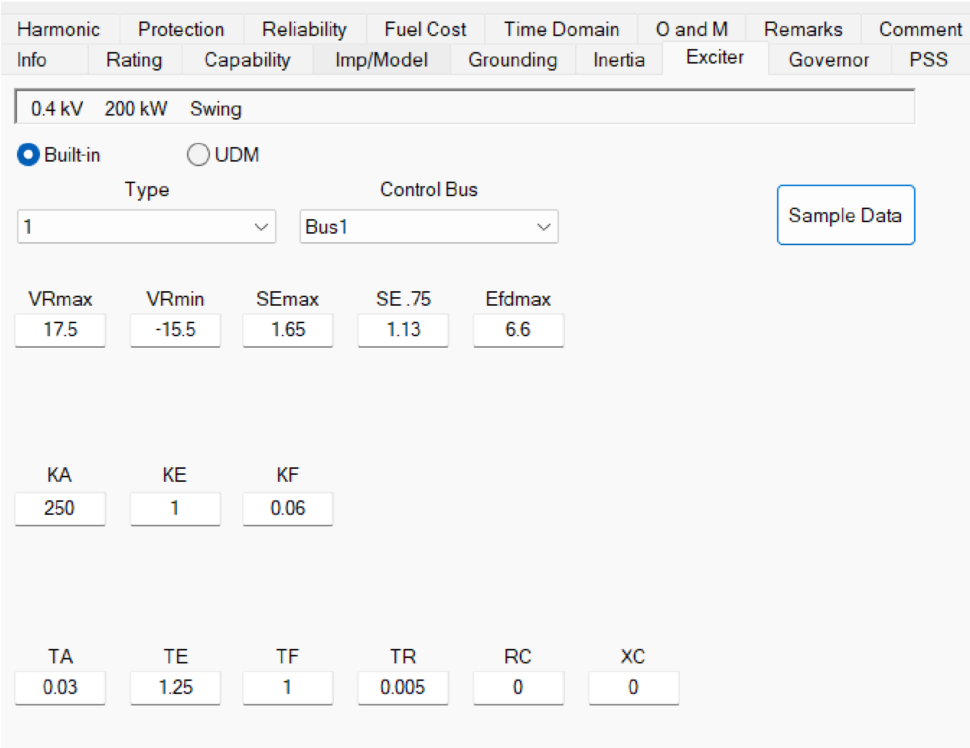

Figure 1. Generator Exciter Parameter

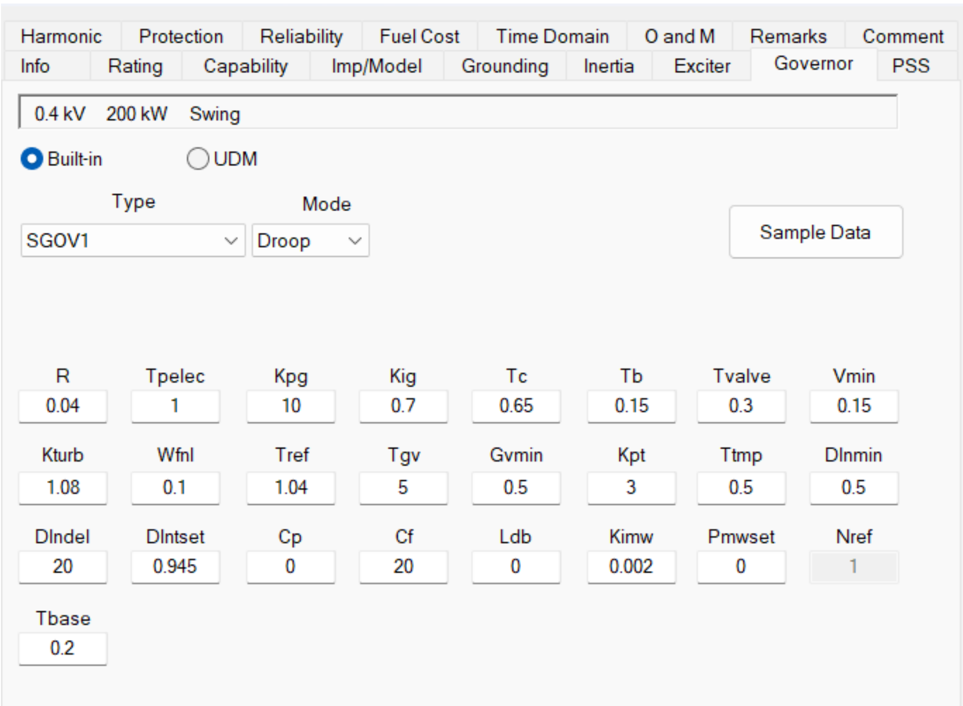

Figure 2. Generator Governor Parameter

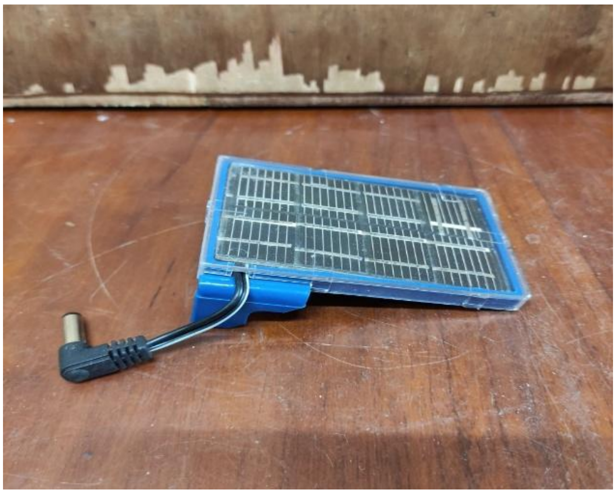

Figure 3. Modelled PV Source

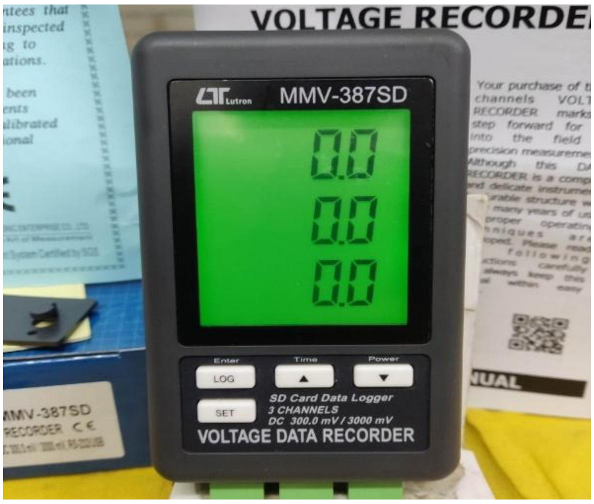

Figure 4. Voltage Recorder

Time	Voltage
06:00	0.3
06:15	0.3
06:30	0.5
06:45	0.5
07:00	0.7
07:15	0.7
07:30	0.7
07:45	0.5
08:00	0.9
08:15	0.9
08:30	1
08:45	1
09:00	1
09:15	1.2
09:30	1.4
09:45	0.8
10:00	1.4
10:15	1.2
10:30	1.4
10:45	1.6
11:00	1.8

Figure 5. Sample Voltage Data

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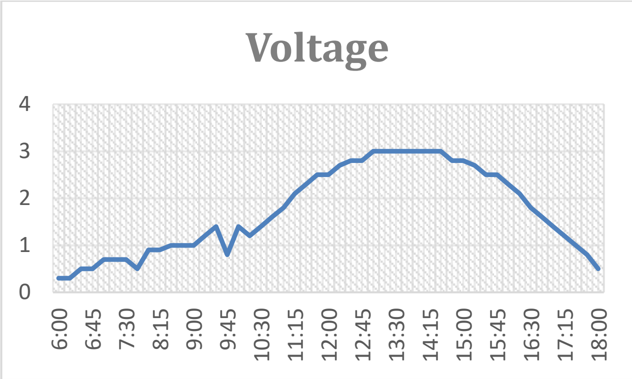

Figure 6. Sample Voltage Graph

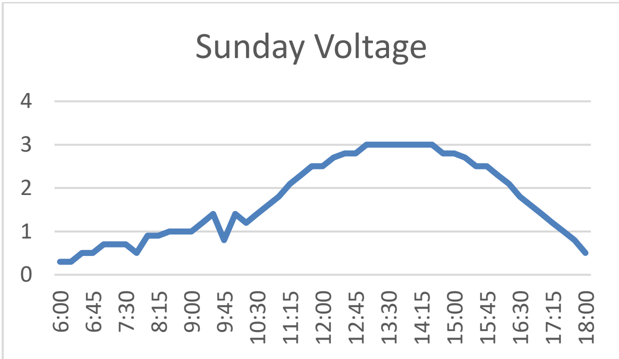

Figure 7. Sunday Graph

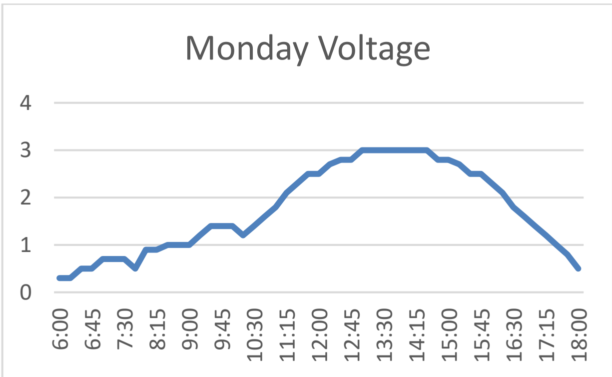

Figure 8. Monday Graph

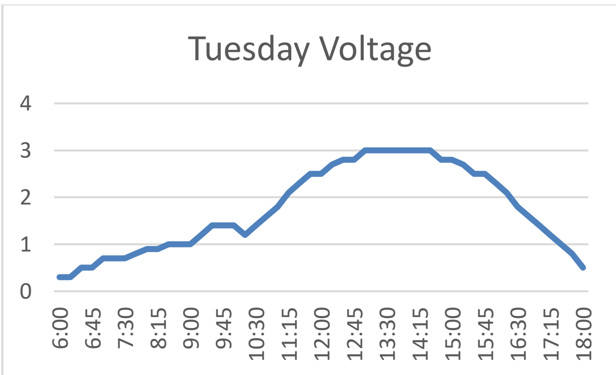

Figure 9. Tuesday Graph

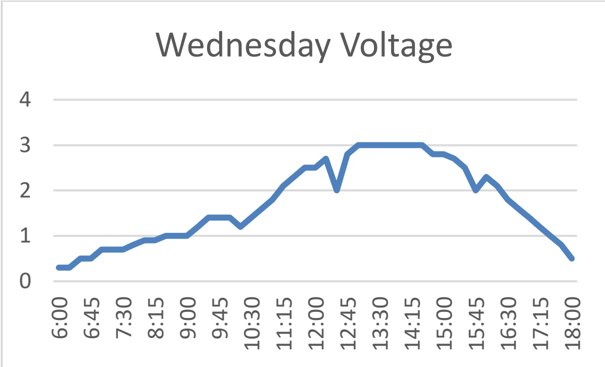

Figure 10. Wednesday Graph

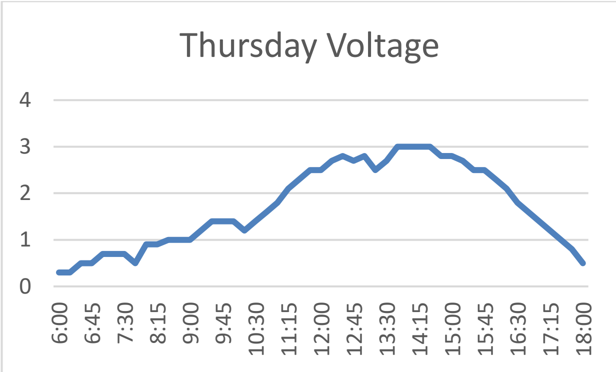

Figure 11. Thursday Graph

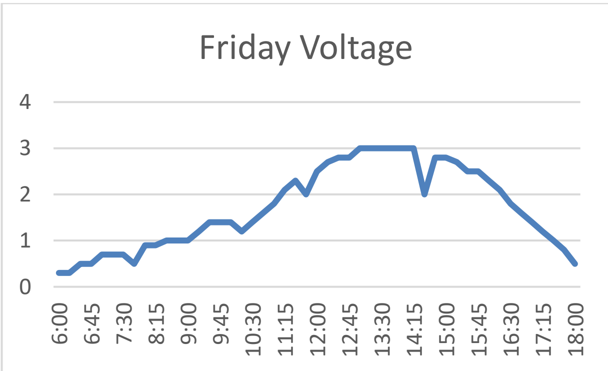

Figure 12. Friday Graph

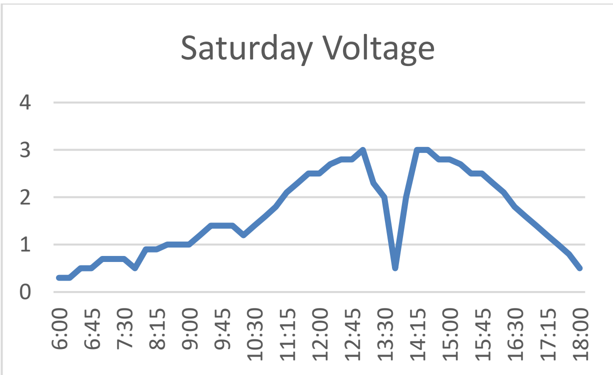

Figure 13. Saturday Graph

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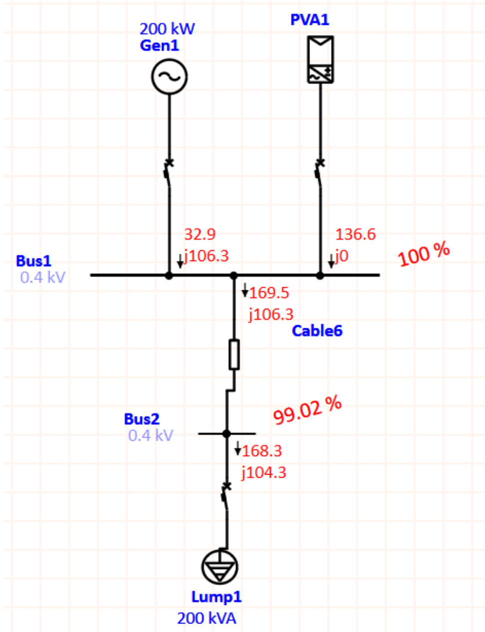

Figure 14. Load Flow Simulation Result

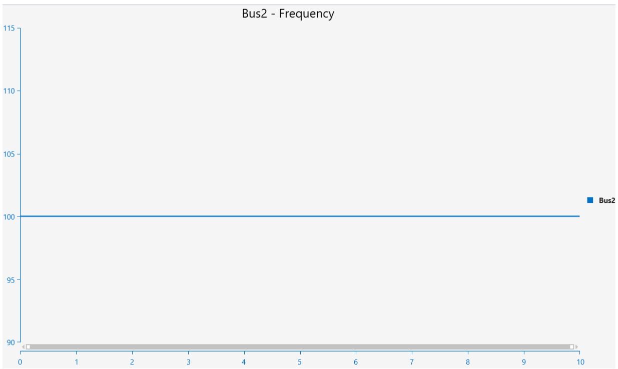

Figure 15. 20% PV- 80% Diesel

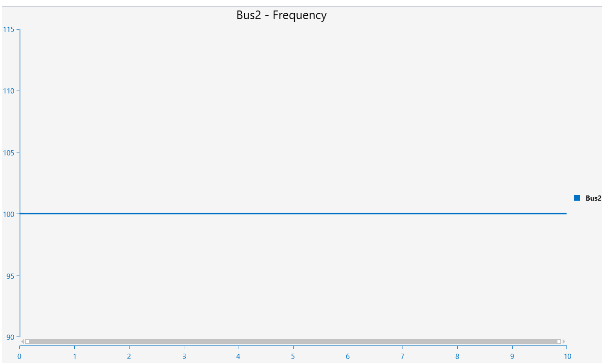

Figure 16. 30% PV- 70% Diesel

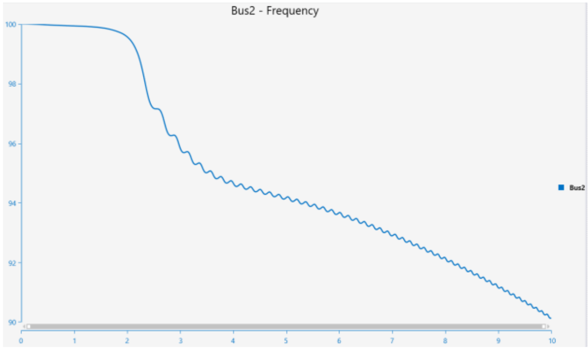

Figure 17. 40% PV- 60% Diesel

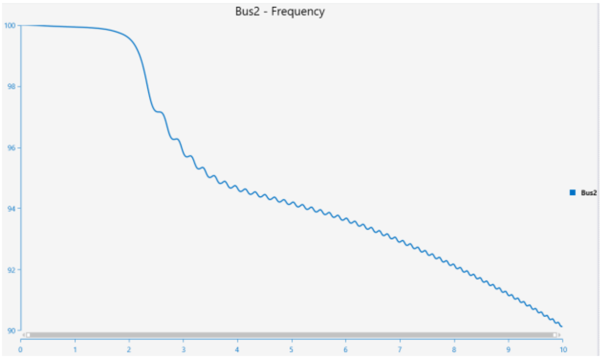

Figure 18. 50% PV- 50% Diesel

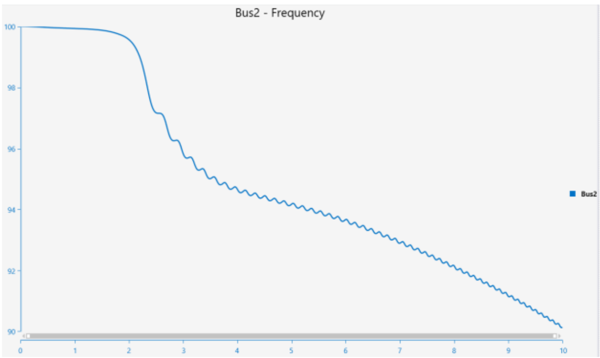

Figure 19. 60% PV- 40% Diesel

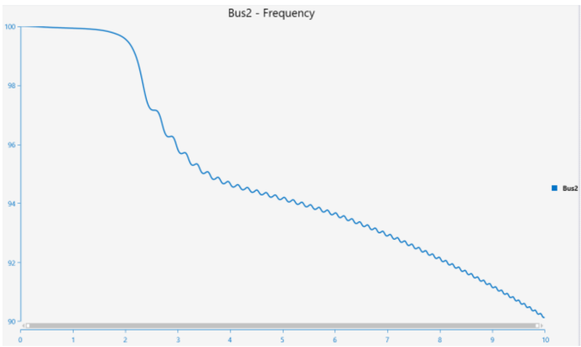

Figure 20. 70% PV- 30% Diesel

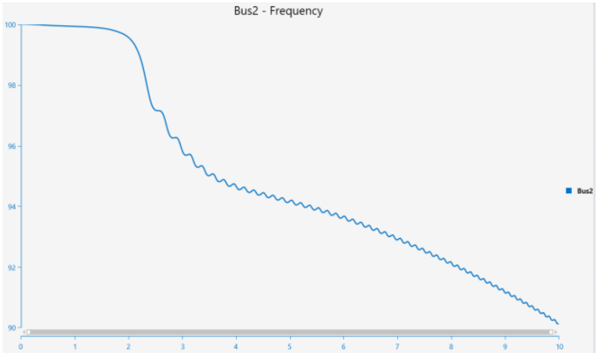

Figure 21. 80% PV- 20% Diesel

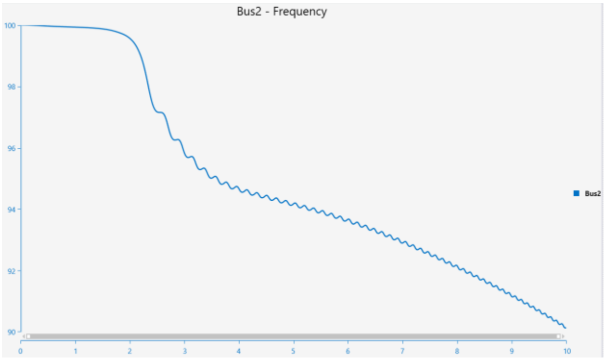

Figure 22. 90% PV- 10% Diesel

From the simulations process, we can see the result that the system can only survived if the PV suddenly cannot supply (maybe because of cloudy condition), if the PV load is more than 30% (Diesel load less than 70%).

4. Discussion

In this simulation, the system became unstable if the PV Source load was more than 30%, before it's supply loss if the system in the hybrid condition with Diesel Generator with specific governor and exciter modelling. Much more have to be studied if we use another type of governor and exciter, or completely different type of generator.

5. Conclusion

From this simple modelling of PV Source – Diesel Generator Hybrid modelling, and System Stability Simulation, we can conclude that:

1. Photovoltaic output can be going down rapidly in a cloudy condition.
2. Diesel generator cannot fast enough to compensate the rapid output of the Photovoltaic source.
3. System can still be survived if photovoltaic load not more than 30%.

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