VOLTAGE STABILITY ANALYSIS OF A MICRO GRID

V. Harika
Student of EEE,
RVR&JC CE,
Guntur, A.P India,
vishnumolakalharika@gmail.co

R. Anupama
Student of EEE,
RVR&JC CE,
Guntur, A.P India,
anupamaraparla.22@gmail.com

R. Nithin
Student of EEE,
RVR&JC CE,
Guntur, A.P India,
nithinrayapaneni18@gmail.com

U.Mounika
Student of EEE,
RVR&JC CE,
Guntur, A.P India,
uppiretlamounila07@gmail.com

Abstract — This Paper presents Voltage Stability Analysis of a microgrid connected to PV, Wind and Battery Storage system. Voltage stability analysis of a power system is a very important, particularly in the planning phase of the development or expansion of a power network. In the trans- Mission level, each transmission line has a certain power transfer capability limit. Exceeding such a limit leads to incidences such as outage of a transmission line, losing Generation units, and the possibility of customers losing their power supply. When such scenarios occur, and when these instability events lead to more cascaded outages as well as losing generation and loads, a voltage collapse may be in place. The main reason for the instability of the voltage or voltage collapse is the load. Either sudden Loosing of major loads or restoring such amount can cause voltage instability problems either over-voltages or under- voltages. Since stability phenomena always link with time Frame, it is expected to have time classification of voltage stability. A micro-grid is normally composed of relatively small-distributed generators supplying an islanded distribution network. Although a micro-grid may not be a complex interconnected power system similar to a transmission network, but it has some characteristics that makes it undergo instability problems when it is exposed to disturbances. The standard 9 Bus microgrid available in IEEE papers will be developed and simulated in the project considering Different cases by using the Stability Indices such as VCPI, VSI and PTSI. Voltage stability assessment will be carried out in PSAT software. The different solution for voltage stability may be suggested and simulated in the project.

Keywords – Microgrid, Power Quality, Harmonics, PowerFlow Control, Stability.

I. INTRODUCTION

Microgrid is a cluster of local resources, energy storage systems and loads operating a single controllable source. The disturbance in microgrid can be initiated by any type of fault, line tripping or by any event which can cause single or even multiple enclosure actions. microgrid can be operated in three modes as follows (i) Grid connected mode, (ii) Islanded mode (iii) Transmission to grid connected mode. One of the major technical issues to be found in operation of microgrid is the Reliability. Major management and operational issues related to microgrid are as follows:

(1) For maintaining power quality like active and reactive power balance must be maintained within the microgrid on a short-term basis.

(2) Microgrid should operate stand-alone in regions where utility supply is not available or in grid-connected mode within a larger utility distribution network. Microgrid operator should be able to choose the mode of operation within proper regulatory framework.

(3) In microgrid Generation, supply and storage of energy must be suitably planned with respect to load demand.

(4) Supervisory control and data acquisition (SCADA) based metering, control and protection functions should be incorporated in the microgrid CCs and MCs. Provisions must be made for system diagnostics through state estimation functions.

(5) Economic operation should be ensured through generation scheduling, economic Load dispatch and optimal power flow operations.

(6) System security must be maintained through contingency analysis and emergency Operations (like demand side management, load shedding, islanding or shutdown of Any unit). Under contingency conditions, economic rescheduling of generation should Be done to take care of system loading and load-end voltage/frequency.

(7) Temporary mismatch between generation and load should be alleviated through Proper load forecasting and demand side management. The shifting of loads might Help to flatten the demand curve and hence to reduce storage capacity.

(8) Suitable telecommunication infrastructures and communication protocols must be employed for overall energy management, protection and control.

II. PROBLEM STATEMENT

Referring to the literature survey, a microgrid is a hybrid power system consists of Several distributed generation resources and local loads, which provide the solution to Supply premium power to remote or specific areas. A microgrid is electrically isolatable from the utility microgrid and would often have sufficient cumulative capacity to meet The needs of those within in, although most microgrid concepts also specify a utility backup. Some microgrids could operate as full-time islands, while others could operate as part of the microgrid during normal operation and only separate into an island during Service interruptions. However, some undesired effects are accompanied with their Installations and operations, such as imbalance, voltage fluctuation, and harmonics. To the aspect of voltage quality, the switching on and off of the distributed generation Resources may cause power fluctuation, hence the associated power quality disturbances Are produced and affect the connected power system. From above discussion, it is observed that voltage stability is most important issues in microgrid, so we can analysis the voltage stability in microgrid.

III. METHODOLOGY

1. Assessment of Voltage Stability in microgrid causes and its effect.
2. To study the different voltage stability indices.
3. Analyze the behavior of voltage stability for different cases.
4. Comparative study of voltage stability and stability indices.

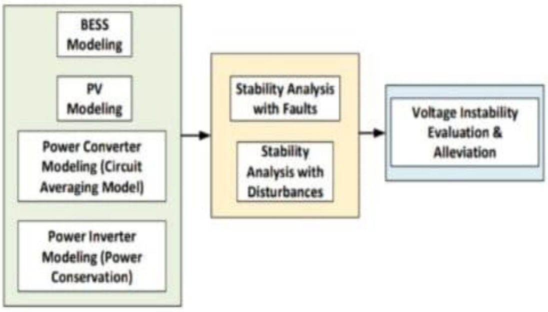

Fig (1) Methodology of the Project

IV. PV Modeling

Generation of electricity by using solar energy depends upon the photovoltaic effect in some specific materials. There are certain materials that produce electric current when these are exposed to direct sun light. This effect is seen in combination of two thin layers of semiconductor materials. One layer of this combination will have a depleted number of electrons. When sunlight strikes on this layer it absorbs the photons of sunlight ray and consequently the electrons are excited and jump to the other layer. This phenomenon creates a charge difference between the layers and resulting to a tiny potential difference between them. The unit of such combination of two layers of semiconductor materials for producing electric potential difference in sunlight is called solar cell. Silicon is normally used as the semiconductor material for producing such solar cell. For building cell silicon material is cut into very thin wafers. Some of these wafers are doped with impurities. Then the un-doped and doped wafers are then sandwiched together to build solar cell. Metallic strip is then attached to two extreme layers to collect current. Conductive metal strips attached to the cells take the electrical current. One solar cell or photovoltaic cell is not capable of producing desired electricity instead it produces very tiny amount of electricity hence for extracting desired level of electricity desired number of such cells are connected together in both parallel and series to form a solar module or photovoltaic module.

Types of Solar Power Stations:

1. Stand Alone or Off Grid type Solar Power Plant
2. Grid Tie type Solar Power Plant
3. Grid Tie with Power Backup or Grid Interactive type Solar Power Plant
4. Grid Fallback type Solar Power Plant.

Grid Tie with Solar Power Backup:

It is also called grid interactive system. This is a combination of a grid-tie solar power generation unit and storage battery bank. As we said, the main drawback of grid tie system is that when there is any power cut in the grid the solar module is disconnected from the system. For avoiding discontinuity of supply during power cut period one battery bank of sufficient capacity can be connected with the system as power backup.

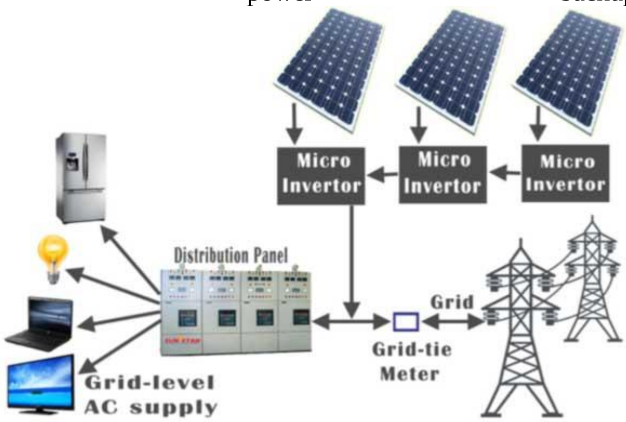

Fig (2) Structure of Grid Tie with Solar Backup Power Station

Components of a Solar Power Station:

Solar Panels

The primary component of a solar electric system is the solar panel, which is also known as a photovoltaic solar panel. There are different types of solar panels available in the market. A solar panel, or solar module, is an array of solar cells connected in series and parallel. Each solar cell generates a potential difference of approximately 0.5 volts. Therefore, to charge a 12-volt battery, the desired number of solar cells must be connected in series to obtain 14 to 18 volts.

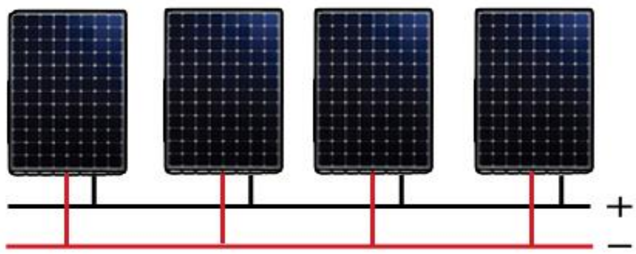

Fig (3) Solar Panel

Batteries

In a grid-tie solar generation system, the solar modules are directly connected to the inverter, not the load. The power collected from solar panels is not constant but varies with the intensity of sunlight. As a result, solar modules cannot directly feed any electrical equipment. Instead, they feed an inverter whose output is synchronized with the external grid supply. In this system, the battery is charged by solar electricity, and then it feeds a load directly or through an inverter. This approach ensures that the variation of power quality due to the variation of sunlight intensity is avoided in the solar power system. As a result, an uninterrupted and uniform power supply is maintained.

Controller

It is not desirable to overcharge or under discharge a lead acid

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 05 | May - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

battery, as both these situations can severely damage the battery system. To avoid such scenarios, a controller is required to be attached to the system. The controller helps to maintain the flow of current to and from the batteries, ensuring that overcharging and under discharging do not occur.

Inverter

In a solar power system, the electricity generated by the solar panels is DC, whereas the electricity from the grid supply is AC. To run common equipment from both sources, an inverter is required to convert the DC of the solar system to AC of the same level as the grid supply. In an offgrid system, the inverter is connected across the battery terminals to convert DC into AC. In a grid-tie system, the solar panel is directly connected to the inverter, which feeds the grid with the same voltage and frequency power.

Solar Cell and its Construction:

The name "solar cell" means that it is a cell or a plate which converts solar energy into the useful electrical energy. The energy which we get from sun is enormous and it is a great source of energy. Its energy will never finish so this is also known as as the main source of renewable energy. With the scarcity of non-renewable energy, it is of utmost importance to find a way out to solve the energy problem by some means within a very short period of time. So there is a way out which is now developing. That's we are now able to convert the sun energy to electrical by some means and that is why the importance of solar cell comes into play. Though it is developing but if it is developed completely, then every household may produce the energy of its own. The solar cell is a device which is made of p-n junction diode which effect photovoltaic effect to convert light energy into electrical energy.

The junction diode is made of SI OR Ga. As a thin layer of p-type is grown on the n-type semiconductor. Top of the p-layer is provided with a few finer electrodes which leaves open space for the light to reach the thin p-layer and it under lays p-n junction. Bottom of the n-layer is provided with a current collecting electrode.

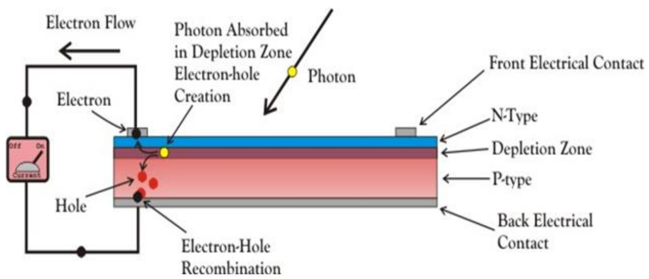

Fig (4) Structure of a Solar Cell

VI characteristics of a Solar Cell:

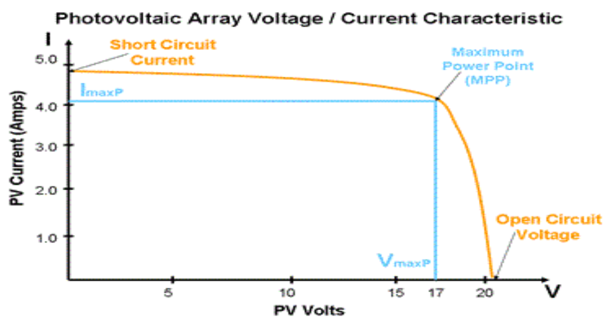

Fig (5) VI characteristics of Solar Cell

MPPT (Maximum Power Point Tracker):

MPPT, which stands for Maximum Power Point Tracking, is an algorithm used in charge controllers to extract the maximum available power from a PV module under certain conditions. The maximum power point, or peak power voltage, is the voltage at which a PV module can produce its maximum power. This value varies depending on solar radiation, ambient temperature, and solar cell temperature. A MPPT, or maximum power point tracker, is an electronic DC to DC converter that optimizes the match between the solar array and the battery bank or utility grid. In simpler terms, it converts the higher voltage DC output from solar panels (and some wind generators) down to the lower voltage required to charge batteries. MPPTs are sometimes referred to as "power point trackers" for short, not to be confused with "panel trackers," which are a solar panel mount that follows or tracks the sun.

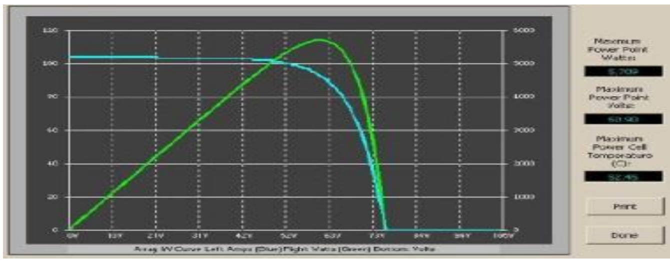

Fig (6) Figure of a Real MPPT

On the left is a screen shot from the Maui Solar Software "PV Design Pro" computer program (click on picture for full size image). If you look at the green line, you will see that it has a sharp peak at the upper right - that represents the maximum power point. What an MPPT controller does is "look" for that exact point, and then does the voltage/current conversion to change it to exactly what the battery needs. In real life, that peak moves around continuously with changes in light conditions and weather.

V. BESS Modeling

One of the distinctive characteristics of the electric power sector is that the amount of electricity that can be generated is relatively fixed over short periods of time, although demand for electricity fluctuates throughout the day. Developing technology to store electrical energy so it can be available to meet demand whenever needed would represent a major breakthrough in electricity distribution. Helping to try and meet this goal, electricity storage devices can manage the amount of power required to supply customers at times when need is greatest, which is during peak load. These devices can also help make renewable energy, whose power output cannot be controlled by grid operators, smoothly and dispatched.

They can also balance microgrids to achieve a good match between generation and load. Storage devices can provide frequency regulation to maintain the balance between the network's load and power generated, and they can achieve a more reliable power supply for high tech industrial facilities. Thus, energy storage and power electronics hold substantial promise for transforming the electric power industry.

High voltage power electronics, such as switches, inverters, and controllers, allow electric power to be precisely and rapidly controlled to support long distance transmission. This capability will allow the system to respond effectively to disturbances and to operate more efficiently, thereby reducing the need for additional infrastructure. A major challenge being addressed by DOE is to reduce the cost of energy storage technology and power electronics and to accelerate market acceptance.

OE's Energy Storage Program:

As energy storage technology may be applied to a number of areas that differ in power and energy requirements, OE's Energy Storage Program performs research and development on a wide variety of storage technologies. This broad technology base includes batteries (both conventional and advanced), electrochemical capacitors, flywheels, power electronics, control systems, and software tools for storage optimization and sizing. The Energy Storage Program works closely with industry partners, and many of its projects are highly cost-shared.

The Program also collaborates with utilities and State energy organizations such as the California Energy Commission, Massachusetts Clean Energy Center (MASS CEC), Oregon DOE, Vermont, Hawaii, Washington, and New York State Energy Research and Development Authority (NYSERDA), to name a few, to design, procure, install, and commission major pioneering storage installations that are up to several megawatts in size. It also supports analytical studies on the technical and economic performance of storage technologies as well as technical evaluations of both ES systems components and operating systems. Enhanced energy storage can provide multiple benefits to both the power industry and its customers. Among these benefits are:

- Improved power quality and the reliable delivery of electricity to customers;
- Improved stability and reliability of transmission and distribution systems;
- Increased use of existing equipment, thereby deferring or eliminating costly upgrades;
- Improved availability and increased market value of distributed generation sources;
- Improved value of renewable energy generation; and
- Cost reductions through capacity and transmission payment deferral.

The Energy Storage Program also seeks to improve energy storage density by conducting research into advanced electrolytes for flow batteries, development of low temperature Na batteries, along with and nano-structured electrodes with improved electrochemical properties. In Power Electronics, research into new high-voltage, high power, high frequency, wide-band-gap materials such as silicon-carbide and gallium-nitride is underway. In addition, advanced power conversion systems using advanced magnetics, high voltage capacitors, packaging and advanced controls to significantly increase power density and performance.

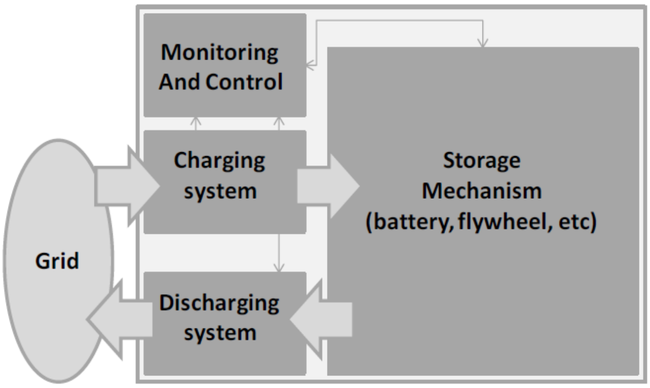

Fig (7) Components of Energy Storage System

VI. WIND ENERGY

Wind is a form of solar energy. Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetative cover. This wind flow, or motion energy, when "harvested" by modern wind turbines, can be used to generate electricity.

Wind Turbines

Wind turbines, like aircraft propeller blades, turn in the moving air and power an **electric generator** that supplies an electric current. Simply stated, a wind turbine is the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.

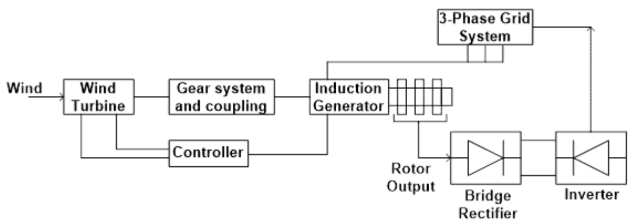

Fig (8) Working of a Wind Power Station

VII. MICROGRID

Microgrid is considered as a small self-contained power system operating at the consumer voltage (440v) where generators and loads are grouped together, where some diesel generators and renewable energy sources are used. microgrids are currently attracting attention due to their various benefits which are:

• Increased reliability i.e. they can provide continuous and backup power supply.

• Higher power security for sensitive applications such as government and military installations.

• Local control and ownership, so that the local operator can decide on levels of power quality.

• Reduced cost for remote locations where the cost of transporting diesel fuel is high.

The grid is classified into three types. Strong grid. weak grid and micro grid. The term 'weak grid' means, the voltage level is not as constant. Put this way the definition of a weak grid is a grid where it is necessary to take voltage level and fluctuations into account because there is a probability that the values might exceed the requirements in the standards when load and production cases are considered. Weak grids are usually found in more remote places where the feeders are long and operated at a medium voltage level. The grids in these places are usually

designed for relatively small loads. When the design load is exceeded the voltage level will be below the allowed minimum and/or the thermal capacity of the grid will be exceeded.

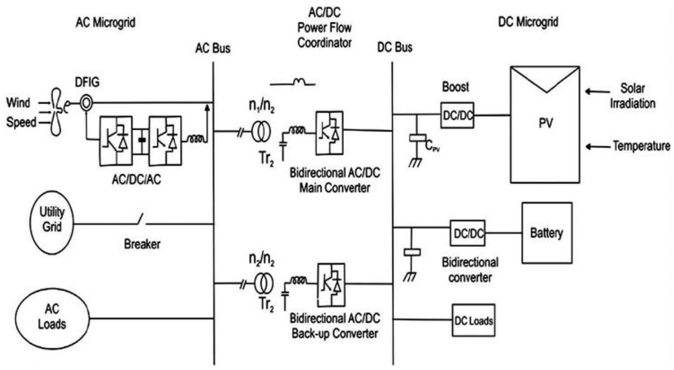

Fig (9) Structure of a Microgrid

VIII. SIMULATION AND RESULTS

The voltage stability of a power system refers to its ability to properly maintain steady acceptable voltage levels at all buses in the network at all times, even after being subjected to a disturbance or contingency. A power system may enter a condition of voltage instability when the system is subjected to a steady increase in load demand or a change in operating conditions, or a disturbance (loss of generation in an area, loss of major transformer or major transmission line). This causes an increased demand in reactive power. Voltage instability is characterized by gradually decreasing voltage levels at one or more nodes in the power system. Both static and dynamic approaches are used to analyze the problem of voltage stability. Dynamic analysis provides the most accurate indication of the time responses of the system. Dynamic analysis is therefore extremely useful for fast voltage collapse situations, following large disturbances such as loss of generation and system faults, when specific information concerning the complex sequence of events leading to instability, is required. Dynamic simulations however, fail to provide information such as the sensitivity or degree of stability. More importantly, dynamic simulations are extremely time consuming in terms of CPU and engineering resources required for the computation and analysis of the several differential and algebraic equations needed for quantification of the phenomenon. The simulation software used is PSAT, in which load flow and transient stability analysis is performed for the different Cases. The microgrid test bed. The system Considered has 9 buses and 8 lines. The total load demand is met by a synchronous generator of 47 MVA, wind turbine of 10MW and PV system of 1.64 MW. Industrial loads as well as the domestic loads are met with this generation. A steady state stability analysis is carried out to determine the most critical bus for the events considered. The most critical bus from the simulation is determined as bus 9.

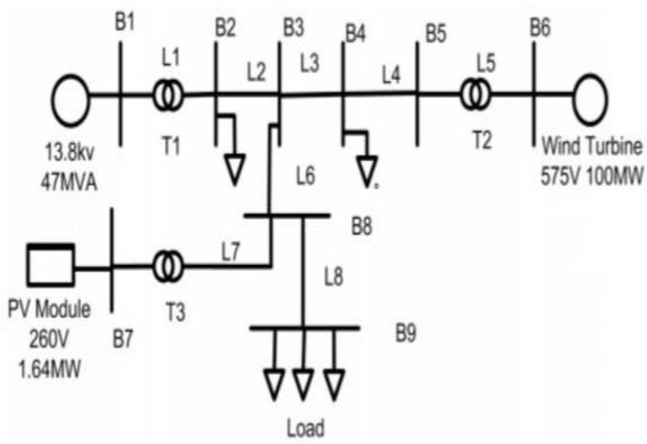

Fig (10) Construction of a Microgird using 9- bus system

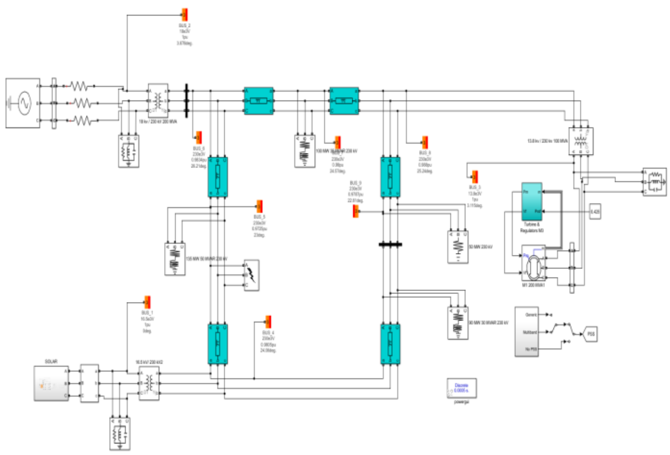

Fig (11) Simulated Figure of a 9-Bus Microgrid

Results at PV module:

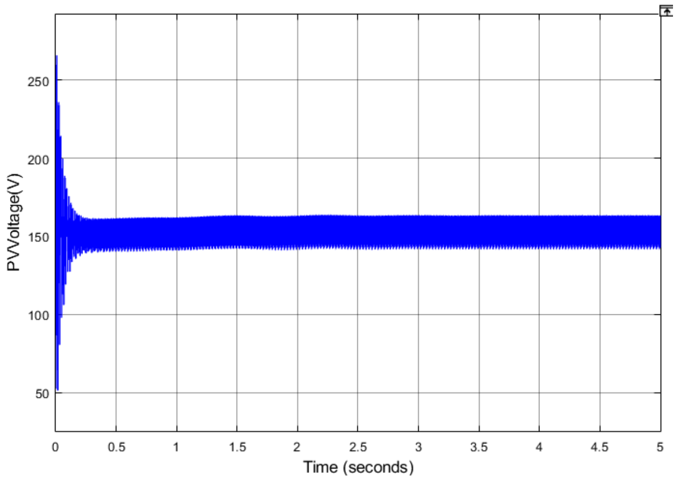

Fig (12) Graph between PV voltage and Time

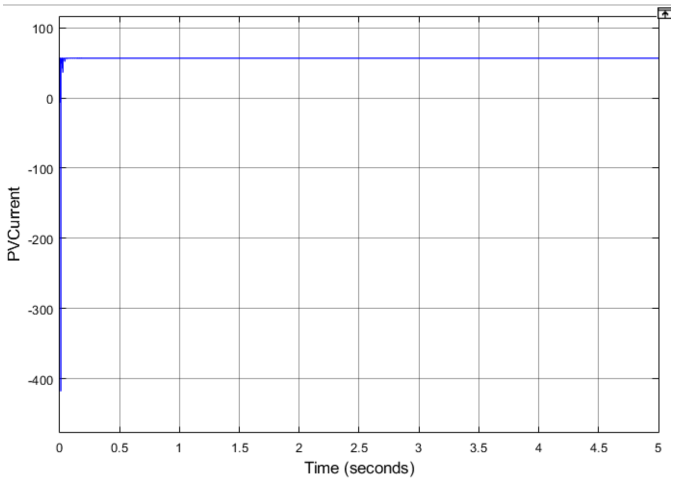

Fig (13) Graph between PV current and Time

Results at Wind Module:

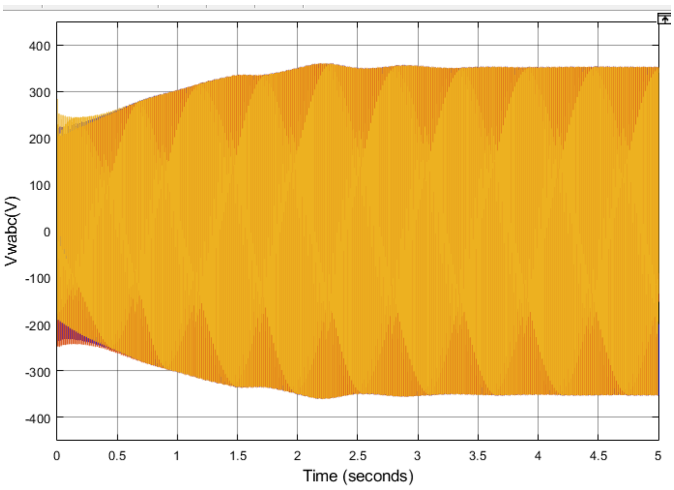

Fig (14) Graph between Wind Voltage and Time

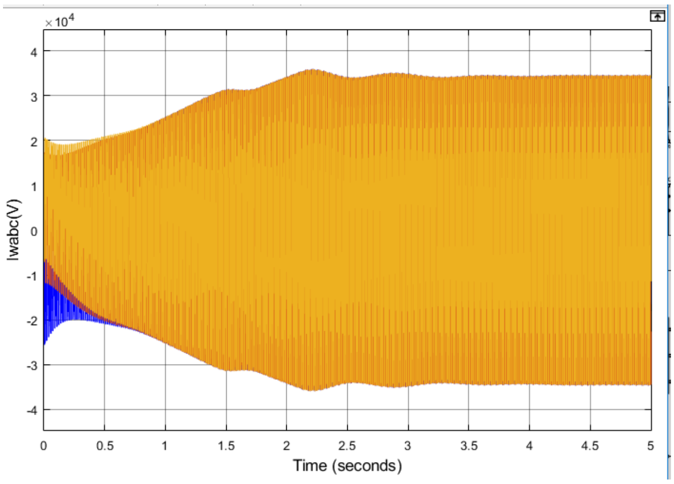

Fig (15) Graph between Wind Current and Time

Results at Grid Unit:

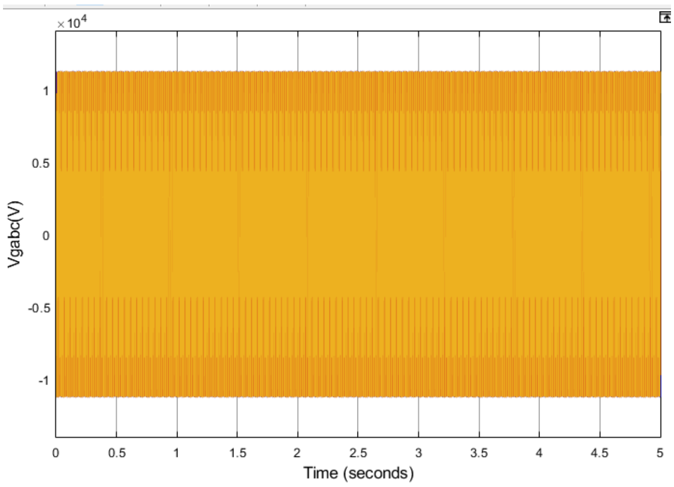

Fig (16) Graph between Grid Voltage and Time

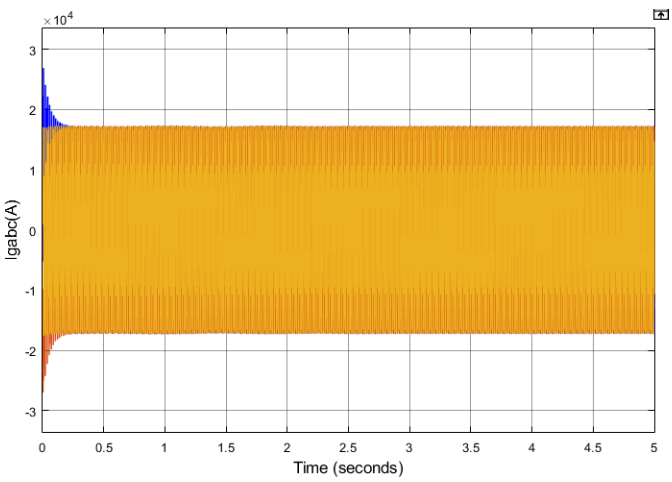

Fig (17) Graph between Grid Current and Time

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 05 | May - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

Results at Energy Storage Systems:

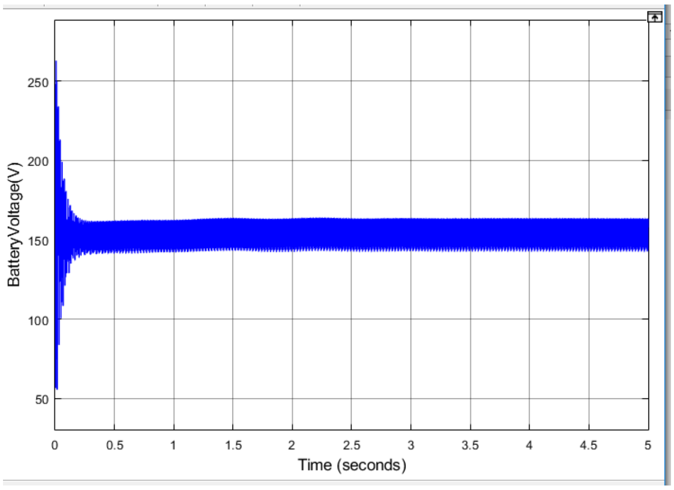

Fig (18) Graph between Battery Voltage and Time

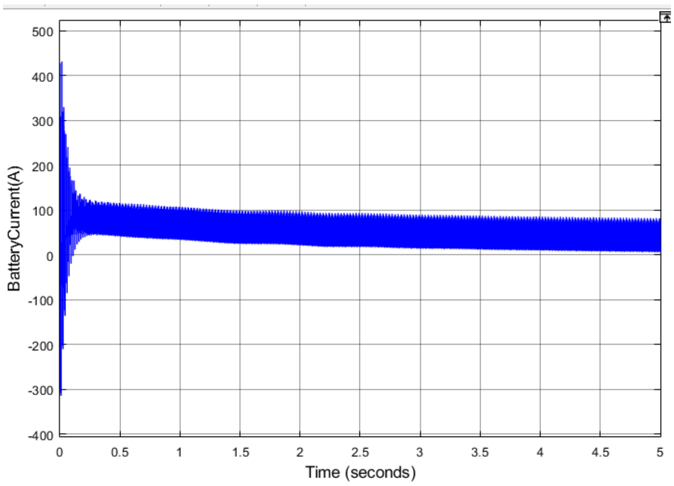

Fig (19) Graph between Batter Current and Time

Bus Voltages:

Bus – 4

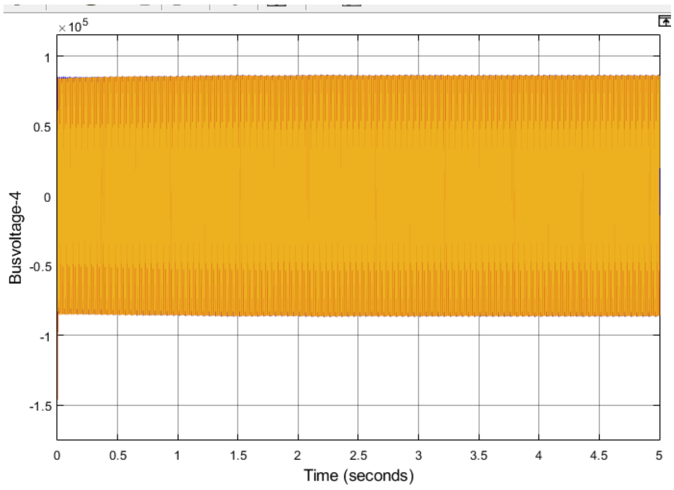

Fig (20) Graph between 4th Bus Voltage and Time

Bus – 5

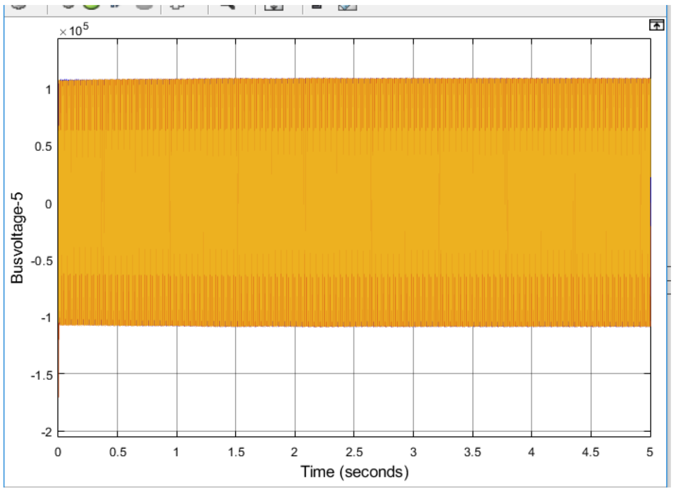

Fig (21) Graph between 5th Bus Voltage and Time

Bus – 6

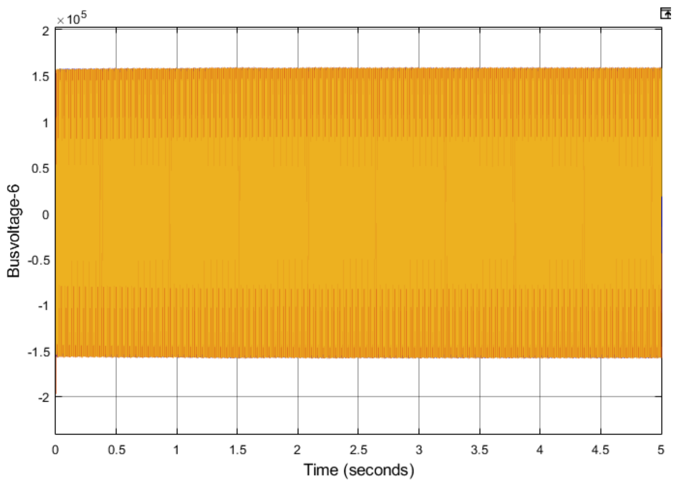

Fig (22) Graph between 6th Bus Voltage and time

Bus – 7

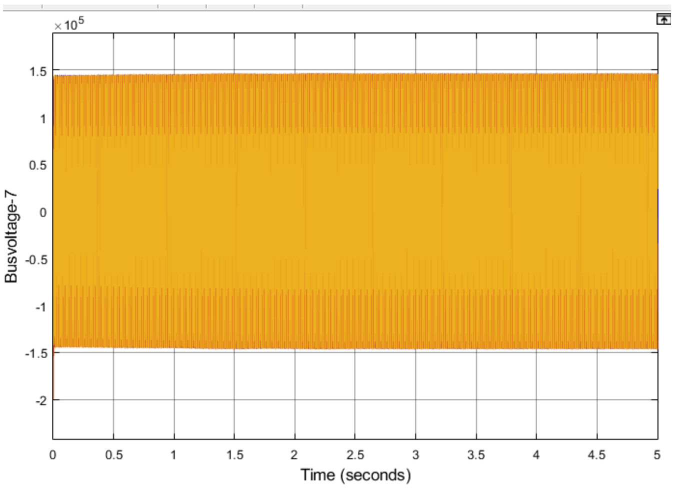

Fig (23) Graph between 7th Bus Voltage and Time

Bus – 8

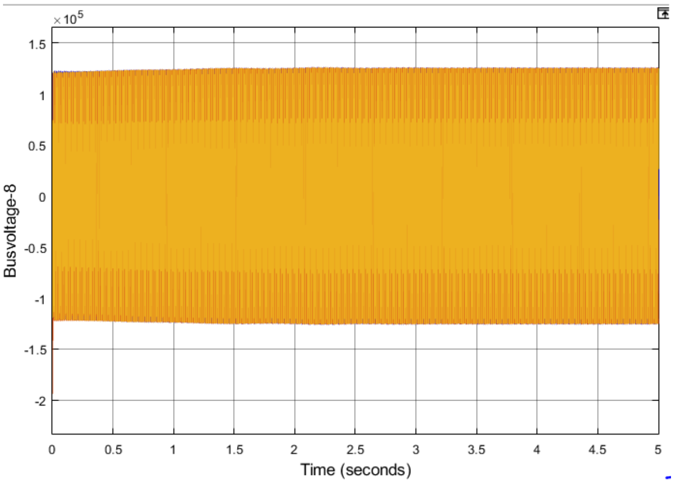

Fig (24) Graph between 8th Bus Voltage and Time

Bus – 9

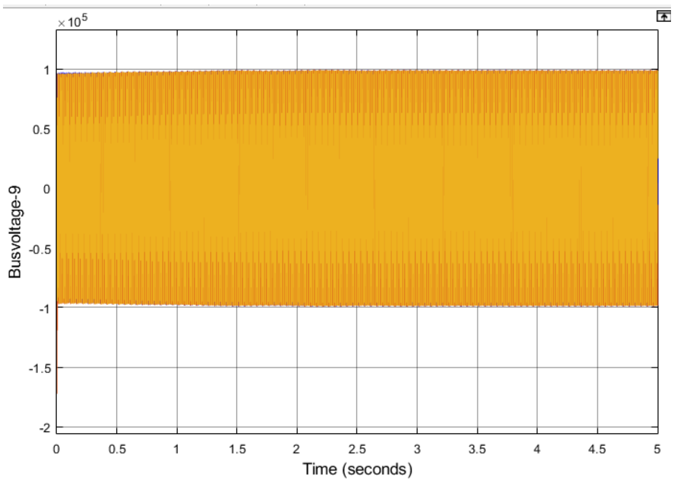

Fig (25) Graph between 9th Bus Voltage and Time

IX. CONCLUSION

One of the challenges identified in the operation of microgrid is voltage stability. So we will analysis the voltage profile of IEEE 9 bus test bed system. A micro-grid is normally composed of relatively small-distributed generators supplying an islanded distribution network. Although a micro-grid may not be a complex interconnected power system similar to a transmission network, but it has some characteristics that makes it undergo instability problems when it is exposed to disturbances. The standard 9 Bus microgrid available in IEEE papers is developed and simulated in the project considering different cases by using the Stability Indices such as VCPI, VSI and PTSI. Voltage stability assessment is carried out in PSAT toolbox. In the microgrid 9 bus system, load is connected to the bus 9. Active power is varied from 10 percent to 50 percent and Voltage stability index (VSI) of each bus is calculated. It is observed that voltage profile suddenly drops at 50 percent of load Increase. Values of show that if index shows 1 value system is stable and index shows 0 Value system is unstable. Thus if load increases by 50 percent of normal load, system Will be unstable system voltage point of view. In other words, system has overload capacity of 50 percent. Overall simulation results show that it can benefit to voltage stability assessment of future electricity grid. Thus it has potential applications in the area of voltage support the modern power system structure.

REFERENCES

[1] R. Majumder, "Some aspects of stability in microgrids," IEEE Transactions on Power Systems, vol. 28, no. 3, pp. 3243–3252, Aug 2013.

[2] A. Tamersi, G. Redman, and M. Aghazadeh, "Enhancement of microgrid dynamic voltage stability using microgrid voltage stabilizer," in Southeast on, 2011 Proceedings of IEEE, March 2011, pp. 368–373.

[3] N. Hatziargyriou, H. Asano, R. Iravani, and C. Marnay, "Microgrids," Power and Energy Magazine, IEEE, vol. 5, no. 4, pp. 78–94, July 2007.

[4] L. Y. Wang, M. Polis, C. Wang, and F. Lin, "Voltage stability and robustness for microgrid systems," in Control Conference (ECC), 2013 European, July 2013, pp.2038–2043.

[5] M. Akbari, S. M. M. Tafreshi, and M. A. Golkar, "Voltage control of a hybrid ac/dc microgrid in stand-alone operation mode," in Innovative Smart Grid Technologies- India (ISGT India), 2011 IEEE PES, Dec 2011, pp. 363–367.

[6] T. E. D. C. Huayllas, D. S. Ramos, and R. L. VasquezArnez, "Microgrid systems: Current status and challenges," in Transmission and Distribution Conference and Exposition: Latin America (T D-LA), 2010 IEEE/PES, Nov 2010, pp. 7– 12.

[7] B. Kroposki, T. Basso, and R. DeBlasio, "Microgrid standards and technologies, in Power and Energy Society General Meeting - Conversion and Delivery of Electrical Energy in the 21st Century, 2008 IEEE, July 2008, pp. 1–4

[8] J. A. P. Lopes, C. L. Moreira, and A. G. Madureira, "Defining control strategies for microgrids islanded

operation," IEEE Transactions on Power Systems, vol. 21, no. 2, pp. 916–924, May 2006.

[9] M. S. I. M. D. K. Jan von Appen1, Chris Marnay2 and A. von Scheven1, "Assessment of the economic potential of microgrids for reactive power supply," Ernest Orlando Lawrence Berkeley National Laboratory, Tech. Rep., 2011.

[10] S. C. S. Chowdhury and P. C. T. Institution, "Microgrids and active distribution networks," in IET Renewable energy series 6 Microgrids and, April 2009, pp. 35–53.

[11] J. Carrasco, L. Franquelo, J. Bialasiewicz, E. Galvan, R. Guisado, M. Prats, J. Leon, and N. Moreno-Alfonso, "Definition and classification of power system stability," IEEE Transactions on Power Systems, vol. 19, no. 4, may 2004.

[12] B. C. K. Saleh A. Gareh1, "Voltage stability assessment for distributed generation in islanded microgrid system,"Journal of Electrical and Electronic Engineering, vol. 2, march 2014.

[13] P. S. Tobias He, Philipp Satchel, "Stability assessment of isolated micro-grid powered by distributed combined heat and power micro-units," Preprints of the 18th IFAC World Congress Milano (Italy), Sep. 2011.

[14] G. R. Kenan Hatipoglu1, Ismail Fidan2, "Dynamic voltage stability enhancement of a microgrid with static and dynamic loads using microgrid voltage stabilizer.

[15] F. D. S. Z. Basilio Gentile, John W. Simpson-Porco and F. Bullo, Automatic Control Laboratory, Swiss Federal Institute of Technology (ETH) Z urich, Switzerland,vol. 2, Dec. 2012.

[16] S. C. S. Chowdhury and P. C. T. Institution, in modeling, stability analysis and control of microgrid, Feb 2010.

[17] S. R. A. S. Rohikaa Micky R., Lakshmi R., "Assessment of voltage stability in Microgrid," International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT), Aug. 2016.

[18] R. Dugan and T. McDermott, "Distributed generation," Industry Applications Magazine, IEEE, vol. 8, no. 2, pp. 19– 25, Mar 2002.

[19] L. Robert, A. Abbas, M. Chris, and J. Stephens, "Integration of distributed energy resources: The CERTS microgrid concept," US Department of Energy, Tech. Rep., April 2002.