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Voltage Stability Analysis of Microgrid.

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ABSTRACT
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. In the short-term (fast)voltage stability, the voltage collapses in seconds or even less, while for long-term (slow) voltage stability, the system voltage collapse takes more time, say minutes to hours.A micro-grid is normally composed of relatively small-distributed generators sup- plying 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, Power Flow Control, Stability.

1. INTRODUCTION
Microgrid is a cluster of local resources, energy storage systems and loads operating as 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 reclosure actions. microgrid can be operated in three modes as follows (i) Grid connected mode, (ii) Islanded mode (iii) Transmition to grid connected mode. One of the major technical issues to be addressed in the process of integration is the control and management of the non-dispatch able renewable energy sources, like wind and solar energy, which has an unpredictable behavior. Another major concern is the assessment of the impact of such sources on the overall grid security and reliability.

Major management and operational issues related to microgrid are as follows

- For maintaining power quality, active and reactive power balance must be main- tained within the microgrid on a short-term basis.
- microgrid should operate stand-alone in regions where utility supply is not avail- able 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.
- Generation, supply and storage of energy must be suitably planned with respect to load demand on the microgrid and long-term energy balance.
- 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.
- Economic operation should be ensured through generation scheduling, economic load dispatch and optimal power flow operations
- 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.

1.1 Problem Identification
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 utilitybackup. 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. it is observe that voltage stability is most important

issues in microgrid, so we can analysis the voltage stability in microgrid.

2. VOLTAGE STABILITY AND ITS ASSESSMENT

2.1 Power System Stability

Power system stability is the ability of an electric power system, for a given initial operating condition, to regain a state of operating equilibrium after being subjected to a physical disturbance, with most system variables bounded so that practically the entire system remains intact.

The definition applies to an interconnected power system as a whole. Often, how- ever, the stability of a particular generator or group of generators is also of interest. A remote generator may lose stability (synchronism) without cascading instability of the main system. Similarly, stability of particular loads or load areas may be of interest; motors may lose stability (run down and stall) without cascading instability of the main system. The power system is a highly nonlinear system that operates in a constantly changing environment; loads, generator outputs and key operating parameters change continually. When subjected to a disturbance, the stability of the system depends on the initial operating condition as well as the nature of the disturbance. Stability of an electric power system is thus a property of the system motion around an equilibrium set, i.e., the initial operating condition. In an equilibrium set, the various opposing forces that exist in the system are equal instantaneously or over a cycle. Power systems are subjected to a wide range of disturbances, small and large. Small disturbances in the form of load changes occur continually; the system must be able to adjust to the changing conditions and operate satisfactorily. It must also be able to survive numerous disturbances of a severe nature, such as a short circuit on a transmission line or loss of a large generator. A large disturbance may lead to structural changes due to the isolation of the faulted elements. At an equilibrium set, a power system may be stable for a given (large) physical disturbance, and unstable for another. It is impractical and uneconomical to design power systems to be stable for every possible disturbance. The design contingencies are selected on the basis they have a reasonably high probability of occurrence. Hence, large-disturbance stability always refers to a specified disturbance scenario. A stable equilibrium set thus has a finite region of attraction; the larger the region, the more robust the system with respect to large disturbances. The region of attraction changes with the operating condition of the power system. The response of the power system to a disturbance may involve much of the equipment. For instance, a fault on a critical element followed by its isolation by protective relays will cause variations in power flows, network bus voltages, and machine rotor speeds; the voltage variations will actuate both generator and transmission network voltage regulators; the generator speed variations will actuate prime mover governors; and the voltage and frequency variations will affect the system loads to varying degrees depending on their individual characteristics. Further, devices used to protect individual equipment may respond to variations in system variables and cause tripping of the equipment, thereby weakening the system and possibly leading to system instability [8] [15].

If following a disturbance the power system is stable, it will reach a new equilibrium state with the system integrity preserved i.e., with practically all generators and loads connected through a single contiguous transmission system. Some generators and loads may be disconnected by the isolation of faulted elements or intentional tripping to preserve the continuity of operation of bulk of the system. Interconnected systems, for certain severe disturbances, may also be intentionally split into two or more islands to preserve as much of the generation and load as possible. The actions of automatic controls and possibly human operators will eventually restore the system to normal state. On the other hand, if the system is unstable, it will result in a run-away or run- down situation; for example, a progressive increase in angular separation of generator rotors, or a progressive decrease in bus voltages. An unstable system condition could lead to cascading outages and a shutdown of a major portion of the power system. Power systems are continually experiencing fluctuations of small magnitudes. However, for assessing stability when subjected to a specified disturbance, it is usually valid to assume that the system is initially in a true steady state operating condition.

2.2. Classification of Power System Stability

Power system stability is essentially a single problem; however, the various forms of instabilities that a power system may undergo cannot be properly understood and effectively dealt with by treating it as such. Because of high dimensionality and complexity of stability problems, it helps to make simplifying assumptions to analyses specific types of problems using an appropriate degree of detail of system representation and appropriate analytical techniques. Analysis of stability, including identifying key factors that contribute to instability and devising methods of improving stable operation, is greatly facilitated by classification of stability into appropriate categories Classification, therefore, is essential for meaningful practical analysis and resolution of power system stability problems. Such classification is entirely justified theoretically by the concept of partial stability

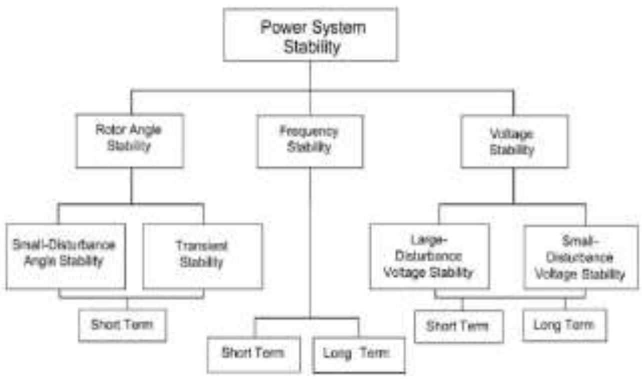

Fig.No1.Classification of power system stability

2.2 Assessment of Voltage stability

A Microgrid is a cluster of local resources, energy storage systems and loads operating as a single controllable source. The disturbance in a Microgrid can be initiated by any type of fault, line tripping or by any event which can cause single or even multiple re- closure actions. A Microgrid can be operated in three modes (i) grid connected mode, (ii) islanded mode (iii) transition to grid connected mode. One of the major technical issues to be addressed in the process of integration is the control and management of the non-dispatchable renewable energy sources, like wind and solar energy, which has an unpredictable behaviour. Another major concern is the assessment of the impact of such sources on the overall grid security and reliability. As synchrophasor measurement devices are nowadays deployed for operation sense making, decision making and implementing controls, intelligent monitoring tools like voltage indices would create a better situational awareness of the smart grid. Voltage instability problem is distinguished by system voltage profile, heavy reactive line flows, inadequate reactive power support and heavily loaded power systems. As pointed out in the reference, many indices have been developed to detect voltage instability in static steady state security assessment. But with the penetration of distributed generators and storage devices an online dynamic security assessment would enhance the microgrid reliability. It takes into consideration a set of 11 parameters to classify any possible islanding condition. But the limitation is that the response depends on the circuit topology and with the addition of new DG, the simulations are to be redone. An islanding detection is performed using frequency difference method and phase angle difference method using the data from PMU in.The importance of voltage stability and its evaluation based on indices for an electric power system is examined [20].

There are three main groups of islanding detection techniques. The first one passive scheme makes decisions based on local measurements of voltage and current signals. Under/over frequency, under/over voltage, rate-of-change of frequency, rate-of-change of power, vector surge and harmonic distortion indices are included. The second tech- nique is the active scheme which includes impedance measurement, voltage phase jump, voltage phase shift, frequency shift and harmonic distortion. The last scheme includes the communication techniques and telecommunication devices that are designed to trip DRs when islands are formed. The passive methods rely on local measurements at the side of the Distributed Generation (DG) to find sudden changes in electrical parame- ters. Active methods use power system operation and applying small perturbations for significant changes in system parameters when the DG is islanded. The performance of these indices is evaluated in a microgrid [17] [4]. The schematic representation of the applicability of the indices and the simulation environment is shown in fig 2.

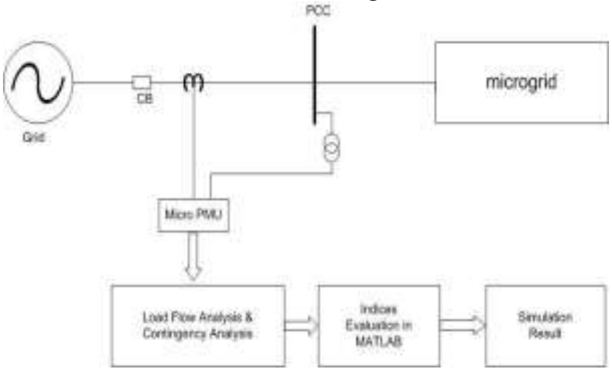

Fig No 2 The schematic representation of the stability analysis tool with the PMU

3. 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 sub- jected 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 engineer- ing 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

3.1 9 bus microgrid test bed

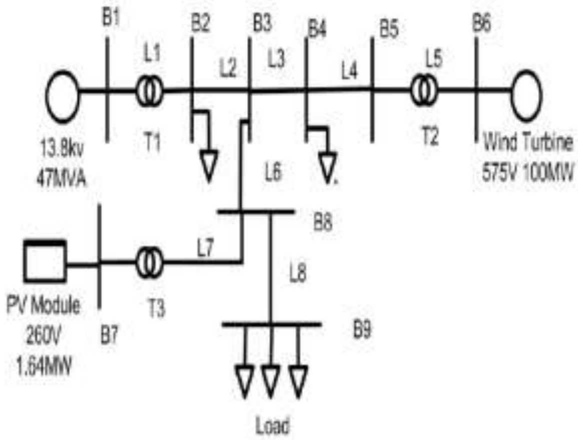

Fig No 3: 9 Bus Microgrid Test Bed

Network Statistics
Buses: 9
Lines: 8Transformers: 3
Generators: 1
Loads: 5
Number of Iterations: 21
Maximum P mismatch [p.u.] 0.034495406

Maximum Q mismatch [p.u.] 0.162776573 Power rate [MVA] 100

Table No 1: Power Flow Results

Bus	V	phase	P gen	Q gen	P load	Q load
	[p.u.]	[rad]	[p.u.]	[p.u.]	[p.u.]	[p.u.]
Bus1	1	0	0.076274	0.126251	0	0
Bus2	0.92815	-0.04431	8.24E-06	1.59E-06	0.08	0.06
Bus3	0.914577	-0.04189	1.91E-07	1.61E-08	0	0
Bus4	0.916115	-0.03085	4.88E-06	1.38E-06	0.04	0.03
Bus5	0.922278	-0.01806	-1.5E-06	9.48E-08	0	0
Bus6	1	0.131969	0.079997	0.049197	0	0
Bus7	1	2.656	0.003956	0.018054	0	0
Bus8	0.896512	-0.0524	1.43E-06	-3.9E-08	0	0
Bus9	0.88798	-0.06298	2.08E-05	4.47E-06	0.048	0.036

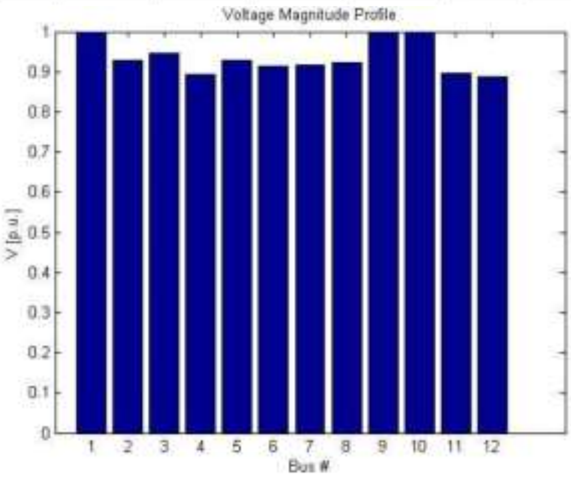

Fig .4. Voltage Magnitude

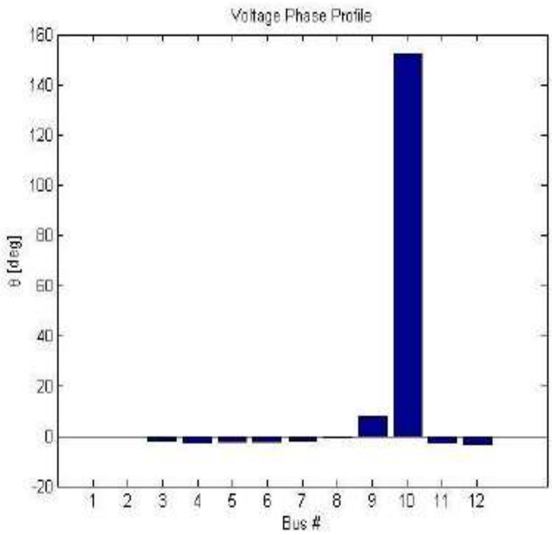

Fig. 5.: Voltage Profile

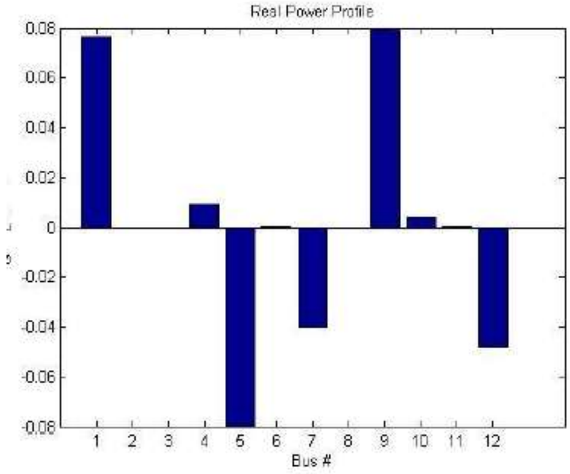

Fig.No 6 Real Power Profile

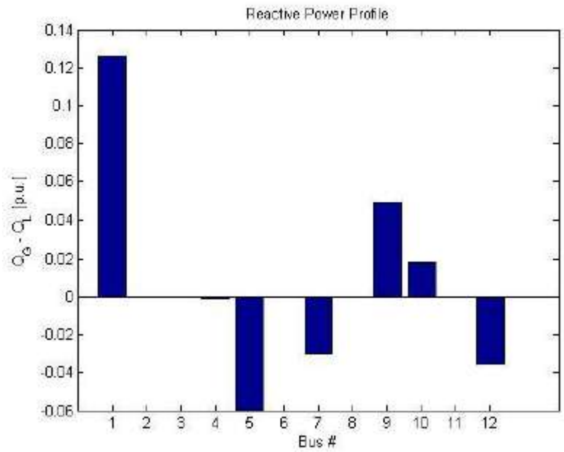

Fig.No 6 Reactive Power Profile

3.2 Case

Power Flow of 9 bus microgrid system when active power increases of load at bus 9 by 10 percent to 50 percent.

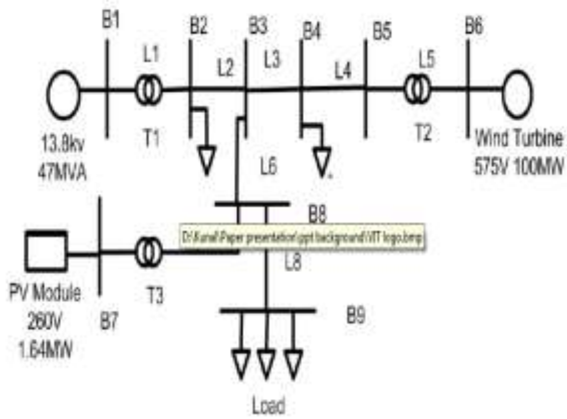

Fig No 7 Active Power Increases of Load

NETWORK STATISTICS
Buses: 9
Lines: 8
Transformers: 3
Generators: 1

Table No 2: Power Flow Results

Bus Voltage	load Inc.10%	load Inc.20%	load Inc.30%	load Inc.40%	load Inc.50%
Bus1	1	1	1	1	1
Bus2	0.618722	0.060617	0.932454	0.628493	0.004349
Bus3	0.473449	0.000001	0.920488	0.495743	0.000001
Bus4	0.525217	0.000001	0.921487	0.540198	0.000001
Bus5	0.55965	0.000001	0.927262	0.574197	0.000001
Bus6	1	1	1	1	1
Bus7	1	1	1	1	1
Bus8	0.237796	0.002272	0.905129	0.283278	0.000001
Bus9	0.263498	0.002219	0.894182	0.268472	0.000001

Loads: 5
Number of Iterations: 21
Maximum P mismatch [p.u.] 0.02070367
Maximum Q mismatch [p.u.] 0.04930823
Power rate [MVA] 100

by referring above table it is seen that when we have to increase active power of load which is connected to bus9 by 10,20,30,40,50 percent the voltage profile of the buses is drop down upto 40 percent of load and it will unstable at 50 percent load.

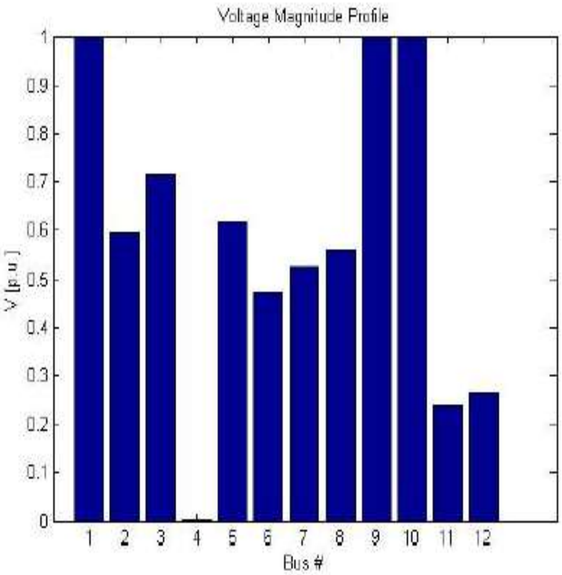

Fig.No 8: Active Power Inc.of load at bus 9 by 10 Percent

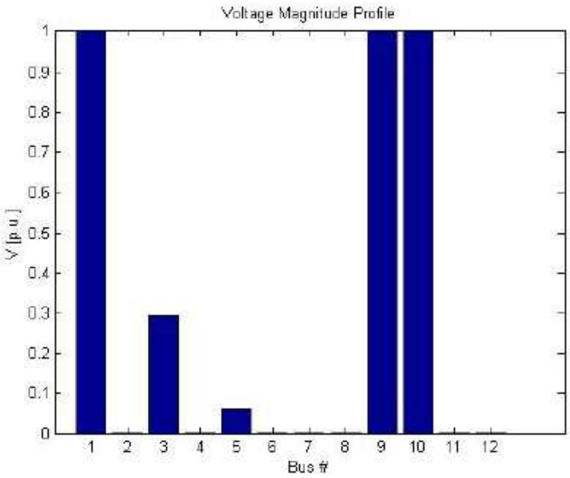

Fig No 9: Active Power Inc.of load at bus 9 by 20 Percent

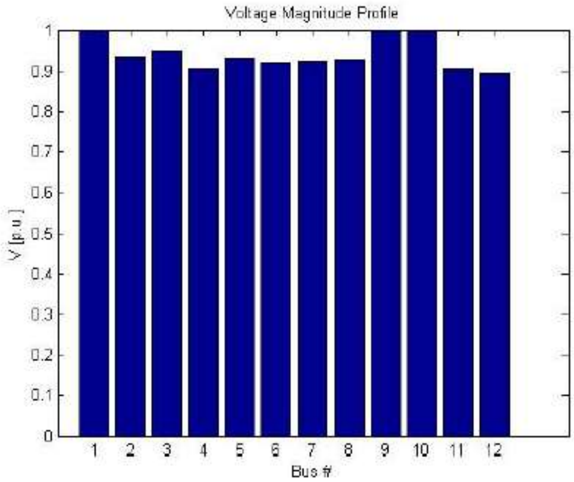

Fig No 10 Active Power Inc.of load at bus 9 by 30 Percent

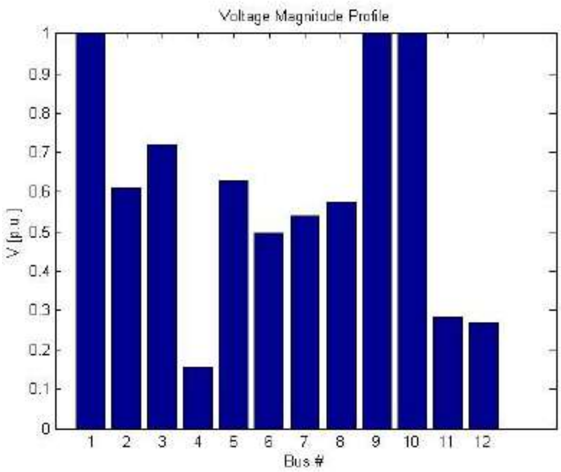

Fig No 11 Active Power Inc.of load at bus 9 by 40 Percent

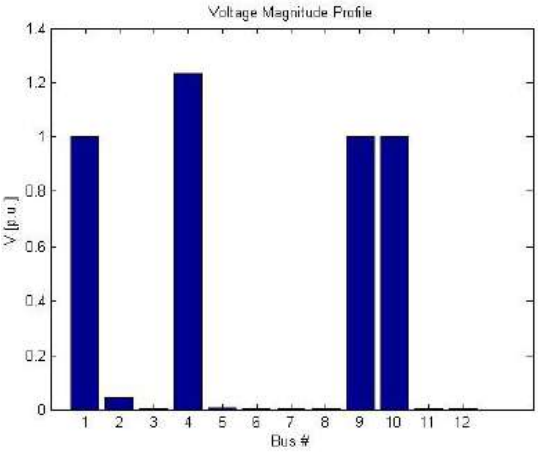

Fig No 12 Active Power Inc.of load at bus 9 by 50 Percent

CONCLUSION

. Voltage stability indices are compared with voltage profile of all the buses to analysis voltage stability of microgrid.

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 sup- plying 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

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