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Voltage Profile Improvement for 16 bus Distribution Systems with DFIG Wind Turbine using PSAT by FVSI Index

Mr.B.Anil Kumar,Assistant professor[1],Mr.S.Divakar Babu, P.G Scholar[2],Dr.Shaik Rafi Kiran,HOD[3]

[1] Department of Electrical and Electronics of Engineering, Sri Venkateswara college of Engineering, Tirupati.
Email id: anilkumar.b@svcolleges.edu.in
[2]Department of Electrical and Electronics of Engineering, Sri Venkateswara college of Engineering, Tirupati.
Email id:divakarbabuyadav@gmail.com
[3]Department of Electrical and Electronics of Engineering, Sri Venkateswara college of Engineering, Tirupati
Email id: rafikiran@gmail.com

Abstract---*As power systems become more intricate and heavily loaded, along with economical and environmental constraints, voltage instability becomes an increasingly serious problem, leading systems to operate close to their operating limits. The power system is operated nearer to their stability limits due to economic and environmental reasons. The voltage instability phenomena occur in both transmission systems and distribution systems. Voltage instability in power distribution systems could lead to voltage collapse and causes the stability problem and power blackouts. The weakening of voltage stability level will limit the growth of load served by distribution companies. To detect the weakest line with respect to a bus using the conventional based approach of the Fast Voltage Stability Index (FVSI), a repetitive power flow solution is performed while varying the reactive power load at a particular load bus. Thus the integration of double fed induction generator (DFIG) wind turbine in the distribution system has increased to high penetration levels. The ultimate goal of this paper is to study the impact of DG units under varied penetration level on some issues, such as voltage stability, voltage profiles for each bus. In this work, firstly we have analyzed IEEE-16 bus distribution system under the standard test data & after that analyzed IEEE-16 bus distribution system with DFIG wind turbine compensation under the standard test data. In this work DG source used in distribution systems is wind turbine.*

Keywords-- Voltage Stability, FVSI, DFIG wind turbine, PSAT ,…etc.

I. INTRODUCTION

Modern power system is very large and Complex and characterized by incessant increase in electrical load demands on the power system engineers in maintaining a reliable system economically [1][2]. In the heavily loaded network, the current drawn from the source would increase. So voltage drop [3,4] and system losses [6,7] are increase. Growing concern over the environmental impacts for improvement of distribution network to an increment in a number of DG units in commercial and Domestic systems are prior. Electrical distribution system power output is noted that the non optimal size and non optimal placement of DG units may leads to poor voltage profile and high power loss [8] which may damage to the consumer equipment. So the line stability parameter is more predominant in considering the optimal placement and size of DG units [11].

The main function of a distribution system is to provide quality of power to individual consumer premises. The performance of distribution system becomes insufficient to regain the reduction in voltage magnitude and increased distribution losses. The distribution system is classified into two types.

1. Primary distribution system and
2. Secondary distribution system.

The domestic load at which the voltage magnitude are taken from the secondary distribution levels are off 230V AC but while considering the industrial Loads the system is under primary distribution system which are ranges up to 15 KV. In this work we assume the Loads of primary distribution system operated at 11KV.

The distribution systems are two types of configurations.

1. Radial distribution system and
2. Ring main distribution system.

In early days in electrical power distribution system different feeders radially came out from the substation and connected to the primary of distribution transformer, but radial electrical power distribution system has one major drawback that in case feeder failure, the associated consumers would not get any power. To overcome this problem introducing a ring main electrical power distribution system all the buses are connected in closed loop. The consumer won't suffer from supply lack, because two paths are ready to meet demand.

In this paper the line stability can be calculated by using FVSI (fast voltage stability index) at each bus which is interconnected and the placement of DG can be determined using the values that are obtained from FVSI [17]. The 16- bus distribution system and the input data illustrated and the results are tabulated with and without DG.

In this paper a free tool of MATLAB is used to design the system which is power system analysis Toolbox (PSAT) [20] for analyzing the voltage profiles and the variation of voltage profiles. Hence the paper stresses more upon making the voltage profile as 1 per unit (p.u.) for simplicity for a 16-bus radial distribution system.

1.1 Objective

The main objective of this work is as follows:

1. Improvement of voltage profile for 16 bus distribution system with and without DG placement.
2. To perform Fast Voltage Stability index (FVSI) Calculation and provide suitable location to placement of DG unit.
3. To make PSAT a simple tool for continuous power flow for an radial distribution system.
4. To perform continuous power flow using PSAT with and without doubly fed induction generator as distributed generation model.

1.2 Problem Statement:

Distribution systems plays a dominant role in delivering supply to consumers and control of power at primary distribution level. Most of the consumers in distribution system are suffering with low voltage profiles at load end. To overcome this problem the placement of distributed generation (DG) [4-6] are placed in recent days in distribution systems. By this improvement of voltage profile and reduction in distribution losses and the real power transfer can be maximized due to controlling of reactive power variations in the distribution system.

In order to place distributed generation we need to know the design values of distributed generation system from the standard reference values. This reference values are used to get desired values of voltage profile as 1 per unit (p.u.). To achieve this nominal operating values of designed parameters for a doubly fed induction generator model has been considered. In this paper 16-bus distribution system has been considered and test data taken from the reference are stated.

1.3 Voltage Stability in Power System

The voltage instability is a dynamic process where in contrast to rotor angle (synchronous) stability, voltage dynamics mainly involves loads and the means for voltage control. Voltage collapse is also defined as a process by which voltage instability [9][10] leads to very low voltage profile in a significant part of the system. Voltage instability limit is not directly correlated to the network maximum power transfer limit.

The ability of a power system to maintain acceptable voltages at all buses in the system under normal condition and after being subjected to a disturbance. In the normal operating condition the voltage of a power system is stable, but when the fault or disturbance occurs in the system, the voltage becomes unstable this result in a progressive and uncontrollable decline in voltage. Voltage stability is sometimes also called load stability. Voltage collapse may be total or partial blackout. The terms voltage instability and voltage collapse are often used interchangeably. Voltage Security is the ability of a system, not only to operate stably, but also to remain stable (as far as the maintenance of system voltage is concerned) following any reasonably credible contingency or adverse system change.

1.4 Double Fed Induction Generator(DFIG):

Doubly-fed electric machines are basically electric machines that are fed with ac currents into both their stator and rotor windings. Most doubly-fed electric machines in industry today are three-phase wound-rotor induction machines. Doubly-fed induction generators (DFIGs) are most widely used to produce electricity in wind turbines.

The main advantage of doubly-fed induction generators when used in wind turbines is that they allow the amplitude and frequency of their output voltages to be maintained at a constant value, no matter the speed of the wind blowing on the wind turbine rotor. Because of this, doubly-fed induction generators can be directly connected to the ac power network and remain synchronized at all times with the ac power network. And other advantage is the ability to control the power factor (e.g., to maintain the power factor at unity).

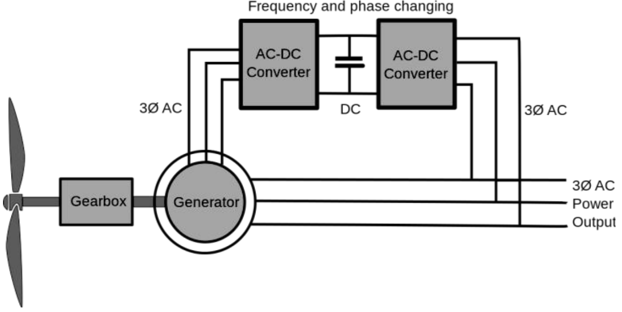

Fig 1: Doubly-fed electric machine connected to Grid.

when the magnetic field at the rotor rotates in the same direction as the generator rotor, the rotor speed N_{rotor} and the speed $N_{\emptyset\, rotor}$ of the rotor magnetic field subtract from each other. The frequency f_{stator} of the voltages induced across the stator windings of the generator can thus be calculated using the following equation:

$$f_{stator} = \frac{N_{rotor} \times P}{120} + f_{rotor}$$

Conversely, when the magnetic field at the rotor rotates in the direction opposite to that of the generator rotor. The frequency f_{stator} of the voltages induced across the stator windings of the generator can thus be calculated using the following equation:

$$f_{stator} = \frac{N_{rotor} \times P}{120} - f_{rotor}$$

Principle of a double fed induction generators are similar to AC electrical generators, but have additional features which allow them to run at speeds slightly above or below their natural synchronous speed. The principle of the DFIG is that rotor windings are connected to the grid via slip rings and back-to-back voltage source converter that controls both the rotor and the grid currents. Thus rotor frequency can freely differ from the grid frequency (50 Hz). By using the converter to control the rotor currents, it is possible to adjust the active and reactive power fed to the grid from the stator independently of the generator's turning speed.

The old approach is allowing variable wind turbine speed is to accept whatever frequency the generator produces, convert it to DC, and then convert it to AC at the desired output frequency using an inverter. Doubly fed generators are one solution to this problem. Instead of the usual field winding fed with DC, and an armature winding where the generated electricity comes out, there are two three-phase windings, one stationary and one rotating, both separately connected to equipment outside the generator. Thus the term "doubly fed". One winding is directly connected to the output, and produces 3-phase AC power at the desired grid frequency. The other winding (traditionally called the field, but here both windings can be outputs) is connected to 3-phase AC power at variable frequency. This input power is adjusted in frequency and phase to compensate for changes in speed of the turbine

A doubly-fed induction machine has several advantages over a conventional induction machine in wind power applications. First, as the rotor circuit is controlled by a power electronics converter, the induction generator is able to both import and export reactive power. This has important consequences for power system stability and allows the machine to support the grid during severe voltage disturbances. Second, the control of the rotor voltages and currents enables the induction machine to remain synchronized with the grid while the wind turbine speed varies. A variable speed wind turbine utilizes the available wind resource more efficiently than a fixed speed wind turbine, especially during light wind conditions. Third, the cost of the converter is low when compared with other variable speed solutions because only a fraction of the mechanical power, typically 25-30%, is fed to the grid through the converter, the rest being fed to grid directly from the stator.

Wind turbines are basically divided into two types : fixed-speed wind turbines and variable-speed wind turbines. In fixed-speed wind turbines, three-phase asynchronous generators are generally used. Because the generator output is tied directly to the grid, the rotation speed of the generator is fixed (in practice, it can generally vary a little, since the slip is allowed to vary over a range of typically 2% to 3%).

II. LOAD FLOW

Load Flow Studies (LFS) [13] is the heart of most power system planning studies and also the starting point for transient and dynamic stability studies. The load flow problems model the nonlinear relations among bus power injections, power demands, and bus voltages and angles, with the network constants providing the circuit parameters[7]. Load Flow is necessary for planning, operation, economic scheduling and exchange of power between utilities. The principal information of LFS [12,13] is to find the magnitude and phase angle of voltage at each bus and the real and reactive Load flowing in each transmission lines. To finish this studies there are several methods of mathematical calculations which consist plenty of steps depend on the size of system. This process is difficult and takes a lot of time to perform by hand. LFS software package develops by the author use Power System Analysis Toolbox (PSAT)[20].

Usually Load flow study uses simplified notation such as a per unit system and one line diagram, and focuses on various forms of AC power (i.e.: reactive, real and apparent) rather than voltage and current. The advantage in studying LFS is in planning the future expansion of power systems as well as in determining the best operation of existing systems. LFS is being used for solving Load flow problem by Newton Raphson method [14] and Fast decoupled load flow method.

2.1 Newton-Raphson Method

The Newton-Raphson method [14,15] is widely used for solving non-linear equations. It transforms the original non-linear problem into a sequence of linear problems whose solutions approach the solutions of the original problem[7]. Let G = F(x, y) be an equation where the variables x and y are the function of arguments of F. G is a specified quantity. If F is non-linear in nature there may not be a direct solution to get the values of x and y for a particular value of G. In such cases, we take an initial estimate of x and y and iteratively solve for the real values of x and y until the difference is the specified value of G and the calculated value of F(using the estimates of x and y) i.e. ΔF is less than a tolerance value. The procedure is as follows Let the initial estimate of x and y be x0 and y0 respectively.

Using Taylor series, we have

$$G = F(x^0, y^0) + \left|\frac{\partial F}{\partial x}\right|_{x0,y0} \Delta X + \left|\frac{\partial F}{\partial y}\right|_{x0,y0} \Delta y \ \ldots(1)$$

Where

the terms $\frac{\partial F}{\partial x}$ and $\frac{\partial F}{\partial x}$ are calculated at X^0 and Y^0.

$$G - F(x^0, y^0) = \frac{\partial F}{\partial x}\Delta X + \frac{\partial F}{\partial y}\Delta Y \qquad \ldots\ldots(2)$$

In the matrix form it may be written as

$$\Delta F = \begin{bmatrix} \frac{\partial F}{\partial x} & \frac{\partial F}{\partial y} \end{bmatrix} \begin{bmatrix} \Delta x \\ \Delta y \end{bmatrix} \qquad \ldots\ldots\ldots\ldots\ldots(3)$$

Or

$$\begin{bmatrix} \Delta x \\ \Delta y \end{bmatrix} = \text{inv} \begin{bmatrix} \frac{\partial F}{\partial x} & \frac{\partial F}{\partial y} \end{bmatrix} \Delta F \qquad \ldots\ldots\ldots\ldots..(4)$$

After the first iteration x is updated to $x^1 = x^0 + \Delta x$ and y to $y^1 = y^0 + \Delta y$. The procedure is continued till after some iteration both ΔF is less than some tolerance value ε. The values of x and y after the final update at the last iteration is considered as the solution of the function F. For the load flow solution , the non-linear equations are given by equation (3).Using (3) we get the equation of real power and reactive power in matrix form as

$$\begin{bmatrix} \frac{\partial P}{\partial \delta} & \frac{\partial P}{\partial v} \\ \frac{\partial Q}{\partial \delta} & \frac{\partial Q}{\partial v} \end{bmatrix} \begin{bmatrix} \Delta\delta \\ \Delta|V| \end{bmatrix} = \begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} \qquad \dots\dots\dots..(5)$$

Size of the matrix = NB + (NB - (NV+1)) – 1
= 2(NB – 1) – NV
where,
(NB - (NV+1) is the number of PQ buses.
NV the number of PV buses.
NB is the total number of buses.

The matrix of equation (5) consisting of the partial differentials, is known as the Jacobian matrix and is very often denoted as [J]. ΔP is the difference between the specifies value of P, i.e. (Psp) and the calculated value of P using the estimates of δ and |V| in a previous iteration. We calculate ΔQ similarly. The Newton Load flow is the most robust power flow algorithm used in practice. However, one drawback to its use is the fact that the terms in the Jacobian matrix must be recalculated each iteration, and then the entire set of linear equations in equation (5) must also be resolved each iteration. Since thousands of complete Load flow are often run for planning or operations study, ways to speed up this process were revised.

III. VOLTAGE STABILITY INDICES

3.1 Estimation of Voltage Stability Indices formulation

The condition of voltage stability in a power system can be characterized by the use of voltage stability index. This index can either referred to a bus or a line. Voltage stability indices[16] are derived from the basic power flow equation and uses the changes of some certain physical quantities to study the system stability. Voltage stability analysis is mainly conducted to predict the point of voltage collapse using the proposed fast voltage stability index (FVSI). These indices are simple, easy to implement and computationally inexpensive. Voltage stability indices can be used for both on-line and off-line studies.

3.2 Fast Voltage Stability Index (FVSI)

Musirin derived a voltage stability index[17-19] based on a power transmission concept in a single line. The 2-bus power system model is shown in below Figure and this is used to derive FVSI[17].

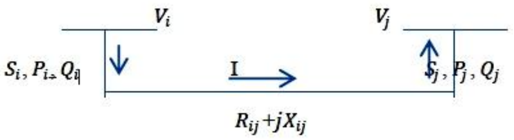

Fig 2: Single line diagram of 2-bus distribution system.

The current through the line is given by

$$I_{Line} = \frac{V_i\angle\delta_i - V_j\angle\delta_j}{R + jX} \qquad \dots\dots\dots(17)$$

The apparent power at bus 2 is given as

$$S_j = V_j\angle\delta_j I^*_{LINE} \qquad \dots\dots\dots(18)$$

Rearranging the equation (18) gives

$$I_{Line} = \frac{P_j - jQ_j}{V_j\angle - \delta_j} \qquad \dots\dots\dots(19)$$

From equation (17) and (19)

$$\frac{V_i\angle\delta_i - V_j\angle\delta_j}{R + jX} = \frac{P_j - jQ_j}{V_j\angle - \delta_j}$$

$$[V_i\angle\delta_i * V_j\angle - \delta_j] - V_j^2 = [R + jX] * [P_j - jQ_j] \qquad \dots\dots\dots..(20)$$

Separating real and imaginary parts gives

$$V_iV_j\cos(\delta_i - \delta_j) - V_j^2 = RP_j + XQ_j$$

And, …….(21)

$$-V_iV_j\sin(\delta_i - \delta_j) - V_j^2 = XP_j - RQ_j \qquad \dots\dots\dots..(22)$$

Substituting P_m from equation (22) into equation (21) gives a quadratic equation of V_m at the receiving end bus is given as

Set the discriminant be greater than or equal to zero.

$$V_j^2 - \left[\frac{R}{X}\sin(\delta) + \cos(\delta)\right]V_iV_j + \left[X + \frac{R^2}{X}\right]Q_j = 0 \qquad \dots\dots\dots\dots.(23)$$

The condition to obtain real roots for V_m is

$$\frac{4Q_jXZ^2}{V_i^2(R\sin(\delta) + X\cos(\delta))} \leq 1$$

Since δ is too small $\delta = 0$, R sin(δ) ≈0 and X cos(δ) ≈ X

FVSI can be defined as:

$$FVSI_{line} = \frac{4Q_jZ^2}{V_i^2X} \qquad \dots\dots\dots\dots.(24)$$

Where Z and X are line impedance and line reactance, $Q_j$is the reactive power at the receiving end, and V_i is the sending end voltage. FVSI gives index value closest to 1 will be the most critical line of the bus and may lead to the whole system instability. The calculated FVSI can also be used to determine the weakest bus on the system. The determination of the weakest bus is based on the maximum load allowed on a load bus.

IV. RESULTS ANALYSIS

4.1 Introduction of PSAT (Power System Analysis Toolbox)

This paper describes the Power System Analysis Toolbox (PSAT), an open source MATLAB and GNU/Octave based software package for analysis and design of small to medium size electric power systems. PSAT includes power flow, continuation power flow, optimal power flow, small signal stability analysis, and time-domain simulation, as well as several static and dynamic models, including non-conventional loads, synchronous and asynchronous machines, regulators, and FACTS. PSAT is also provided with a complete set of user-friendly graphical interfaces and a Simulink-based editor of one-line network diagrams. Basic features, algorithms, and a variety of case studies are presented in this paper to illustrate the capabilities of the presented tool and its suitability for educational and research purposes. Power System Analysis Toolbox (PSAT) is a Matlab toolbox for electric power system analysis and control. Newton-Raphson (NR) method, Fast decoupled methods (both BX and XB), Runge-Kutta method, Simple robust method are the available algorithmic options provided by PSAT to conduct power flow analysis. Both theoretically and practically NR algorithm converges faster to the solutions than the others, which is why we applied it to our system.

4.2 IEEE-16 Bus Radial Distribution System Modeling:

This section illustrates the modeling and implementation of the 16-bus test system, which is given below. The single line diagram if IEEE 16-bus test system given in fig 3.

The FVSI Analysis is done to a 16-bus radial distribution system. The base values used are 100 MVA and 11 kV. A DG size is considered in a range of 1 kW to–30 kW. In this study, it is considered that the DG is operated at unity power factor. The first bus is considered as the feeder of electric power from the generation/transmission network. The voltage stability analysis were performed on IEEE 16 bus bar test system without DFIG shown below fig (4).

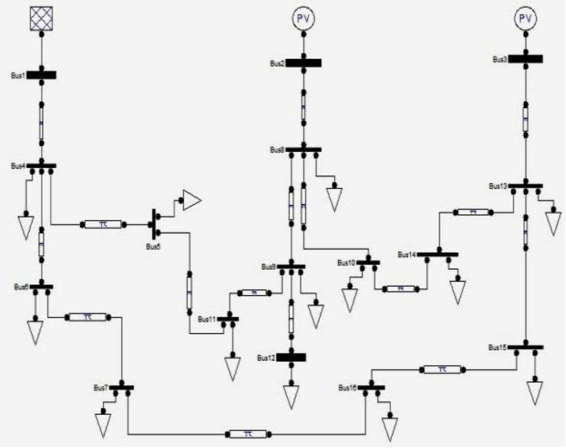

Fig. 4: The PSAT Simulink model of IEEE 16-Bus distribution system.

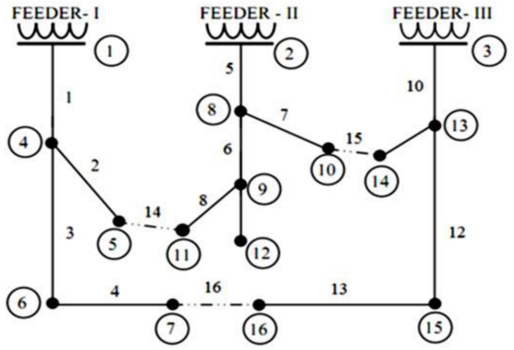

Fig 3: single line diagram of 16-bus system.

Table 1 : LINE AND LOAD DATA

Line No	**From bus i**	**To bus j**	**R(Ω) P.U**	**X(Ω) P.U**	**Receiving bus j**	
					P	**Q**
1	1	4	0.075	0.10	2.0	1.6
3	4	5	0.08	0.11	3.0	0.4
2	4	6	0.09	0.18	2.0	-0.4
5	6	7	0.04	0.04	1.5	1.2
7	2	8	0.11	0.11	4.0	2.7
8	8	9	0.08	0.11	5.0	1.8
9	8	10	0.11	0.11	1.0	0.9
6	9	11	0.11	0.11	0.6	-0.5
10	9	12	0.08	0.11	4.5	-1.7
15	3	13	0.11	0.11	1.0	0.9
14	13	14	0.09	0.12	1.0	-1.1
16	13	15	0.08	0.11	1.0	0.9
12	15	16	0.04	0.04	2.1	-0.8
4	5	11	0.04	0.04		
13	10	14	0.04	0.04		
11	7	16	0.12	0.12		

Table 2 :Power Flow Results for without DFIG:

Bus	V [p.u.]	Phase [rad]	Generation		Load	
			P gen [p.u.]	Q gen [p.u.]	P load [p.u.]	Q load [p.u.]
Bus1	1	0	21.17054	-25.0188	0	0
Bus2	1	0.011692	-10.5323	13.72	0	0
Bus3	1	0.012037	-9.96976	13.72	0	0
Bus4	0.999823	0.003093	-0.02744	-0.343	0.343	0.02744
Bus5	0.999636	0.004906	-0.02573	-0.5145	0.5145	0.025725
Bus6	0.999404	0.005391	-0.1372	-0.343	0.343	0.1372
Bus7	0.999512	0.006047	-0.02058	-0.02573	0.025725	0.02058
Bus8	0.999737	0.009674	-0.04631	-0.686	0.686	0.046305
Bus9	0.999868	0.007806	-0.00514	-0.00858	0.008575	0.005145
Bus10	0.999724	0.009843	-0.01544	-0.01715	0.01715	0.015435
Bus11	0.999695	0.005677	-0.01715	-0.1029	0.1029	0.01715
Bus12	0.999863	0.0078	-0.00343	-0.07718	0.077175	0.00343
Bus13	0.99969	0.010066	-0.01544	-0.01715	0.01715	0.015435
Bus14	0.99972	0.009905	-0.012	-0.01715	0.01715	0.012005
Bus15	0.999667	0.008467	-0.01544	-0.01715	0.01715	0.015435

Bus16	0.999555	0.007811	-0.01715	-0.0036	0.003602	0.01715

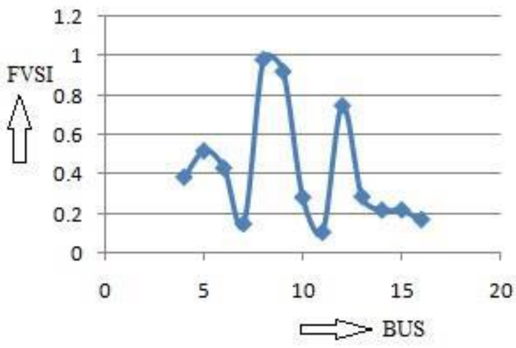

Fig 6 : Fast Voltage Stability Index point.

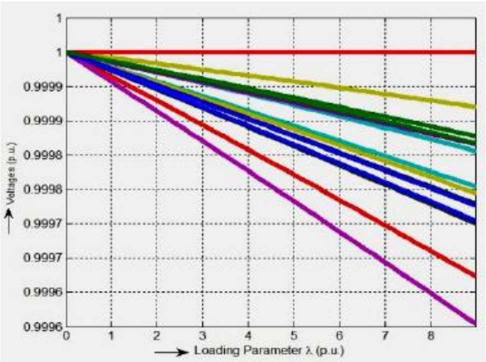

Fig 5: voltage profile without DFIG.

Figure 5 shows the GUI Voltage Profiles without DFIG Wind Turbine in PSAT. We observe that lack of voltage in the buses. So we can find weakest bus in the 16-bus distribution system.

4.3 Test results for after Placement of DFIG Wind Turbine:

From the results of FVSI calculations , By placement of DFIG Wind Turbine at bus-8 in 16-bus distribution system is shown in fig 7.

The FVSI Computational results are shown in Figure 6 by Graphical representation. In this figure indicates that they are the most critical bus bars in the system and Which bus of the tested system contribute more to the voltage collapse. This results gives the critical bus of this system is bus- 8 in the IEEE 16 bus bar test system. The fast voltage stability index [FVSI] permits the determination of the weakest bus in the system. The voltage stability margin can be easily calculated by FVSI Method. The suitable location to place the DFIG Wind turbine by using FVSI procedure the maximum value of the stability point is at Bus-8. For low voltage stability limit causes unstable.

By improving the system stability by using DG Unit to maintain a system stable. The Power Flow Results are tabulated in Table-3. From the tabulated results we see the improved Voltage Profiles and remaining input data is same.

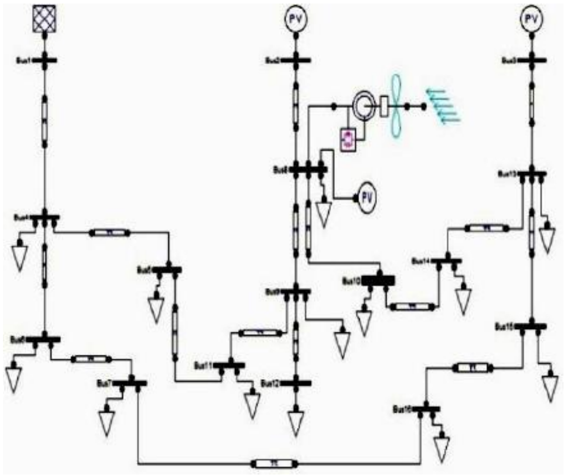

Fig 7 : 16-Bus with DFIG using PSAT.

Table 3 : POWER FLOW RESULTS WITH DFIG

Bus	V [p.u.]	Phase [rad]	Generation		Load	
			P gen [p.u.]	Q gen [p.u.]	P load [p.u.]	Q load [p.u.]
Bus1	1	0	-0.43511	-0.99936	0	0
Bus2	1	0.000207	-0.35222	0.001586	0	0
Bus3	1	0.000268	-0.70355	0.001586	0	0
Bus4	1.00009	5.09E-05	-3.2E-06	-4E-05	3.96E-05	3.17E-06
Bus5	1.00007	8.52E-05	-3E-06	-5.9E-05	5.95E-05	2.97E-06
Bus6	1	0.000112	1.491389	0.996751	3.96E-05	1.59E-05
Bus7	1.000227	0.000129	-2.4E-06	-3E-06	2.97E-06	2.38E-06
Bus8	1.000029	0.000177	-5.4E-06	-7.9E-05	7.93E-05	5.35E-06
Bus9	1.000049	0.000143	-5.9E-07	-9.9E-07	9.91E-07	5.95E-07
Bus10	1.000043	0.00019	-1.8E-06	-2E-06	1.98E-06	1.78E-06
Bus11	1.000064	0.000101	-2E-06	-1.2E-05	1.19E-05	1.98E-06
Bus12	1.000049	0.000143	-4E-07	-8.9E-06	8.92E-06	3.96E-07

Bus13	1.000058	0.000209	-1.8E-06	-2E-06	1.98E-06	1.78E-06
Bus14	1.000047	0.000195	-1.4E-06	-2E-06	1.98E-06	1.39E-06
Bus15	1.000127	0.000179	-1.8E-06	-2E-06	1.98E-06	1.78E-06
Bus16	1.000153	0.000162	-2E-06	-4.2E-07	4.16E-07	1.98E-06

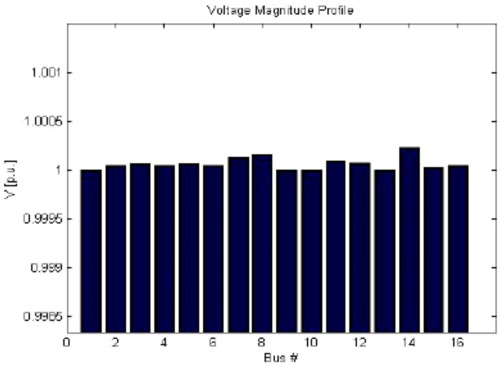

Fig 8: Voltage profiles with DFIG.

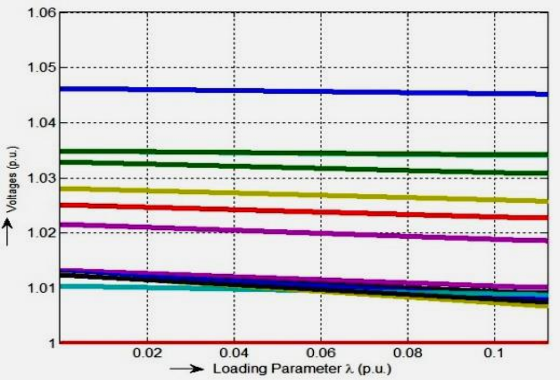

Fig 9: GUI Voltage profiles with DFIG.

In which fig (8) shows the bar representation of Voltage profiles with DFIG Wind Turbine. The fig (9) shows Graphical representation of voltage profiles with DFIG. From these results we can observe the improved Voltage Profiles at each bus. This can maintain the system stable operating condition at all times.

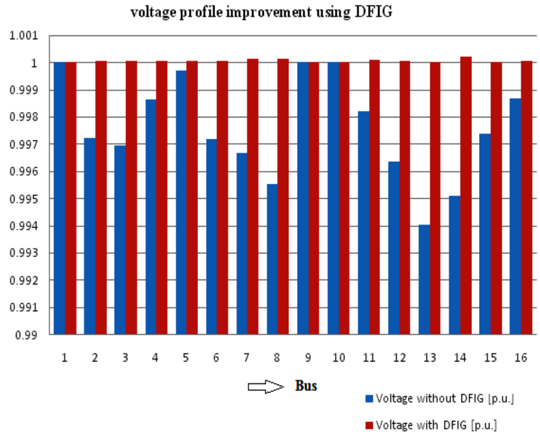

fig 10: Voltage comparison between without and with DFIG placement.

The placement of DFIG Wind Turbine which effect the all the system buses.In which Fig 8 shows the Comparison of Voltage Profiles between with and without DFIG Wind Turbine. So that from the results after placement of DG the system Stability and Security are improved. This increases the power transfer capability between lines and system will be maintain stable condition.

Table 4 : Comparison Power Loss with and without DFIG

From Bus	To Bus	Line	Without DFIG	With DFIG
			P loss [p.u.]	P Loss [p.u.]
Bus1	Bus4	1	0.060923	6.74E-05
Bus14	Bus13	2	0.000142	1.69E-06
Bus11	Bus9	3	0.027395	1.22E-05
Bus10	Bus14	4	6.27E-05	7.52E-07
Bus8	Bus9	5	0.020055	8.91E-06
Bus8	Bus10	6	0.000173	2.07E-06
Bus2	Bus8	7	0.024887	1.03E-05
Bus3	Bus13	8	0.023928	4.12E-05
Bus4	Bus6	9	0.016018	3.45E-05
Bus4	Bus5	10	0.018976	8.91E-06
Bus6	Bus7	11	0.007302	0.00086
Bus5	Bus11	12	0.009888	4.45E-06
Bus9	Bus12	13	3.61E-07	4.82E-15
Bus7	Bus16	14	0.016448	3.56E-05
Bus16	Bus15	15	0.007304	1.58E-05
Bus13	Bus15	16	0.014617	3.17E-05

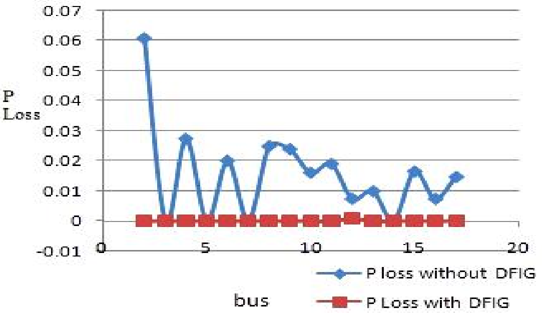

Fig 11: Comparison of P Loss with and without DFIG.

In Table (4) gives the Active power loss between the with and without DFIG Wind Turbine. Fig (11) shows Comparison of power loss between with and without DG. From these results we observe that loss reduction in distribution system after placement of DFIG Wind Turbine at bus-8.

V. CONCLUSION

This paper presents analysis of the performance of IEEE 16 bus test system. The shown simulations indicate that the bus-8 of IEEE 16 bus bar test system is considered the weakest bus in the system. The Voltage Stability indices estimated in this work is using Fast Voltage Stability Index (FVSI). Whose calculations are simple, accurate and fast . From which line is weak can be determined.

The Voltage profile improvement of the weak bus is done by placement of DG and several DG models are predefined in PSAT. In which DFIG model is taken as recent trend to achieve this work by this improvement of Voltage profile and reduction in line losses and also performance objectives of this work are achieved.

In Future scope the Voltage stability studies are considered utmost usage of renewable energy sources such as solar, ocean , Geo-thermal etc.

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Author’s Profile

B.Anil kumar is presently working as an assistant Professor in Sri Venkateswara College of Engineering, Tirupati. He Obtained M.Tech from K.L.University and B.Tech from K.L. College of Engineering. His Research interests include Power Quality, Renewable Energy Sources.

Mr S.Divakar Babu is currently pursing M.tech in the field of Power Systems in Sri Venkateswara College of Engineering, Tirupati. He completed graduation from Sri Venkateswara College of Engineering. His Research interests in the field of Renewable energy sources, FACTS, Power system.

Dr. Shaik Rafi Kiran ,a PhD from Jawaharlal Nehru Technological University Anantapur, Ananthapuramu, A.P, India. He has 17 years of teaching experience. At Present , He is serving as a Professor and Head of the department of Electrical and Electronics Engineering in Sri Venkateswara college of Engineering (SVCE),Tirupathi, Andhra Pradesh. He is a Life Member of ISTE. He has presented 25 research papers in reputed International Journals and Conferences .His research areas includes System Identification, Control Systems, Optimization Techniques and Power Systems.