Improvement in Power System Security by using Hybrid Source in Grid With Statcom

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Abstract : Shortage of power has been one of the nightmare issues for humankind in the modern age, where demand of electricity is growing very rapidly for urbanization of country. Renewable energy sources is playing a lead role in tapering the difference between supply and demand. The most important necessity of power system is to maintain the system security when outages takes place in system. This paper propose using contingency analysis method to decide weakest bus of the system to place STATCOM optimally for maintaining security and enhancing voltage profile of the wind connected system, as shunt compensating device plays important role to improve the function of power system. The simulations are accompanied in PSAT for IEEE-9 bus system with and without STATCOM to analyze the effect of STATOM on security performance of the system.

IndexTerms **- System Security, wind energy system, Power Flow, FACTS, STATCOM, IEEE 9 bus system, MATLAB/PSAT**

I. Introduction

Today the electricity is one of our fundamental needs. As there is increases in the population day by day the demand of electricity is increases. The power system has to increase the generation capacity of existing system or to build new power system[1]. The working of new power system is exceptionally costlier choice, so the upgrade of existing system is the elective alternative. The power system works close to its basic working points of confinement to fulfill the expanding load demand[2]. The Renewable energy sources are those sources which are plentifully accessible in nature. With the increase in demand Renewable energy sources is an other option to our rising power demand we tend to discover approaches to supply to these demands[3]. The present day trend in the sustainable power source area is wind hybrid energy sources which are establishing lots of installation over the globe[4]. Wind power technology is one of the developing sustainable power source advancements. Control of power system is the most noteworthy problem to be concerned with[5]. Day by days the system is getting to be complex and stability issues are getting to be vulnerable. Voltage instability issues by and large increment as the different stochastic energy sources like solar, wind and so on are joined to the system. For the secure operation limits of violations of the power system is monitor by system operator[6]-[7]. We can state that the transmission clog happens[8], when the breaking points are violated because of sudden increment in load demand, generation outage or transmission line blackout and so forth[9]. The system stability and security are influenced because of blockage.

Voltage instability issues can be understood by giving satisfactory reactive power support at proper area in the system. For these reason different compensating device utilized by utilities, every one of which has its own particular limitations and characteristics. Voltage stability is the capacity of the power system to keep up sufficient voltage size with the end goal that the actual power exchanged by system load to that will increment. PV curve is broadly utilized as a part of industry for examining steady and insecure condition[10]-[11].

Power System Analysis Toolbox (PSAT) is a MATLAB toolbox for control and analysis in electric power system in MATLAB. It contain tools like power flow, small signal stability analysis, optimal power flow, time domain simulations and continuation power flow[12].It is use for small and medium of static and dynamic analysis of power system in MATLAB[13].

In this proposed paper detailed study has been carried out for grid interconnection system using hybrid wind power generation and STATCOM for improving power system security. The system is implemented of 9 bus,3 machine in which contingency analysis technique using Newton Raphson method is used to determine the weakest bus of the system and by using shunt compensating device i.e. STATCOM the voltage is improve across the bus. The PV curve is carried out to determine stable and unstable condition at the buses. By using MATLAB-PSAT software the results are validated.

II. OVERVIEW OF STATCOM

Synchronous voltage source with least and most extreme voltage extent limits is implied as STATCOM. Static Synchronous Compensator (STATCOM) is as shown in Fig 1.

To compensate the receiver end voltage of transmission line replacing of shunt capacitor bank is used. STATCOM offers various favorable circumstances over banks of shunt capacitors, for example, considerably more tightly control of the voltage compensation and increased line stability during load variations. For all intents and purposes a STATCOM is mounted to help electricity networks that have a poor power factor and frequently poor voltage control and the most aggregate utilize is for voltage security. A STATCOM is a voltage source converter based device, with voltage source behind a reactor.

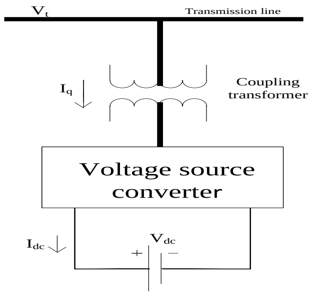


Figure 1: Static Synchronous Compensator (STATCOM)

With DC capacitor voltage source is made and subsequently a Static Synchronous Compensator has very less power capability. In the event that a reasonable energy storage device is associated over the dc capacitor STATCOM active power capability expanded. The reactive power at the terminals of Static Synchronous Compensator relies upon the sufficiency of voltage source. In the rule of the STATCOM yield voltage can be regulated such that the reactive power of the STATCOM can be changed.

III. MODELING FOR CONTINGENCY ANALYSIS USING NEWTON RAPHSON METHOD

The contingency is known by an unpredictable condition in the power system. To maintain power system to be secure, it must have continuity in supply to load without any loss. For this security analysis is performed to create different control prodcedure to ensure the avoidance and survival of crisis condition and to work the system at least cost. Whenever the pre determined working breaking points of the power system gets violated the system is said to be in crisis condition. These violations of the breaking points result from contingencies occurring in the system. Contingency in a power system leads to instability of whole power system, and influences the reliability, security and continuity. A blackout refers to the transitory suspension of power. And contingency can be defined as the possible circumstance or blackout which is conceivable yet can't be anticipated with assurance. A contingency is basically an outage of a transformer,generator and or line, and its effects are monitored with exact security limits.

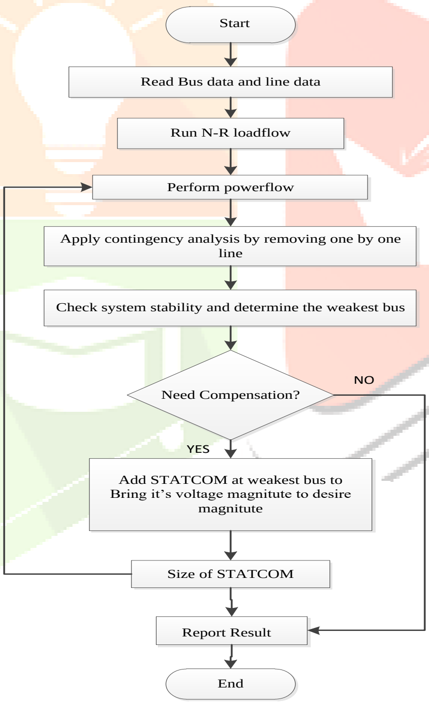


Figure 2: Flow Chart of Contingency analysis using Newton Raphson method

The Newton Raphson method is very popular due to its less iterations with fast convergence. The Newton Raphson has great generality and flexibility, hence the load flow forms the central method for different recently methods developed to optimize the power system operation, analysis of transient stability, system-state assessments and evaluation of security. The position of nonlinear simultaneous equations with an equal number of unknowns is solve by interactive algorithm of Newton Raphson. Flow chart or contingency analysis using Newton Raphson method with STATCOM is as shown in fig.2.

IV. PV CURVES ANALYSIS

The below fig.3 shows the PV curve, the change in power transfer from one bus to another bus which influences the bus voltages are find out by the PV curve. The power system is widely operated in the upper part of PV curve.

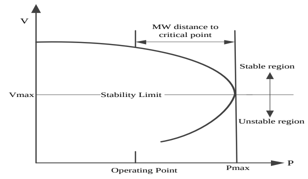


Figure 3: Real power voltage (P-V) curve

V. TEST SYSTEM

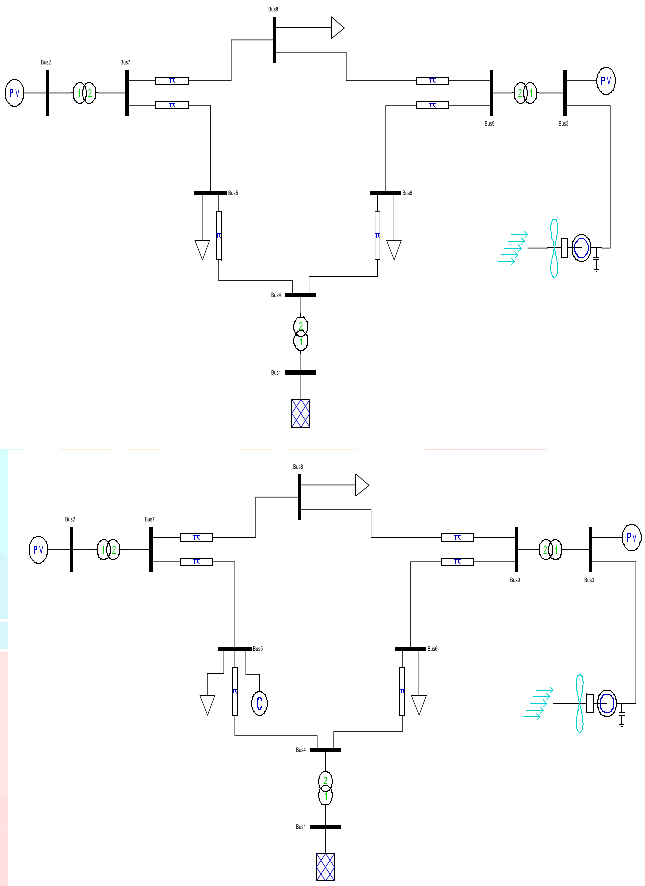


Figure 4: IEEE 9 bus test system without STATCOMand with STATCOM in PSAT

Above fig.4 shows system model consist of one slack bus, two PV generator connected in Bus1, Bus2 and Bus3 respectively. The system model consist of three step up transformers connected between Bus1-4, Bus2-7 and Bus3-9. One wind generator having constant speed synchronous output is connected in Bus3.The three loads are connected in Buses5, 6 and 8. The FACTS device i.e. STATCOM is connected in Bus 5. The modeling of system is done in MATLAB/PSAT software.

The details of test system components is as follow:

TABLE 1:GENRATOR AND TRANSFORMER DATA

Sr no.	Device	Ratings
1	Generator 1	247.5MW,16.5KV
2	Generator 2	192MW,18KV
3	Generator 3	128MW,13.8KV
4	Transformer 1	77MW,16.5/230 KV
5	Transformer 2	163MW,18/230KV
6	Transformer 3	86MW,13.8/230KV
7	Three phase series RLC load at bus 5, 6 and 8	134.62 MW,94.86 MW,105.94 MW

TABLE 2: TRANSMISSION LINE DATA

BUS	R(pu)	X(pu)	Y(pu)
4 to 5	0.017	0.092	0.079
6 to 9	0.039	0.17	0.179
5 to 7	0.032	0.161	0.153
7 to 8	0.0085	0.072	0.0745
8 to 9	0.0119	0.1008	0.1045
4 to 6	0.017	0.092	0.079

TABLE 3:SYSTEM RATING

Wind Generator:

MVA=10MVA
Voltage Rating=13.8 KV
Pole=4, Gear ratio=1/89
Blade number=3,
Nominal wind speed=15 m/s , Air density=1.225 Kg/m3
Filter time constant=4 sec.

STATCOM Rating:
MVA rating=100MVA, Voltage rating =400KV
Frequency = 50Hz
Gain, K_r=50,Time constant, T_r=0.1

VI. RESULTS AND GRAPHS

By using PSAT the IEEE 9 Bus system is modeled. Each line is Removed one by one to calculate maximum loading parameter by using CPF. Identification of severe line is carried out which leads to unstable of the system.Results are shown below:

Without STATCOM:

Table 4: Voltages across bus after outage of transmission lines without STATCOM

Voltage of bus (p.u)	**Transmission line removal between bus x and y**					
	7 to 8	6 to 9	8 to 9	4 to 5	5 to 7	4 to 6
Bus1	1	1	1	1	1	1
Bus2	1	1	1	1	1	1
Bus3	1	1	1	1	1	1
Bus4	0.91863	0.90013	0.92096	0.96862	0.86605	0.94069
Bus5	0.85382	0.83558	0.85775	**0.71057**	0.74455	0.87557
Bus6	0.88983	0.847997	0.89775	0.93359	0.83992	0.82932
Bus7	0.96683	0.95473	0.95102	0.93267	0.97235	0.9597
Bus8	0.86335	0.93498	0.90834	0.91678	0.93307	0.92839
Bus9	0.9288	0.96729	0.96692	0.95519	0.94209	0.94171

Table 5: Severity order for transmission line removal

Severity order	Bus	Maximum Loading Parameter(λ)
1	7 to 8	0.2536
2	8 to 9	0.2694
3	6 to 9	0.2732
4	5 to 7	0.2779
5	4 to 6	0.2972
6	4 to 5	0.2986

Table 4 shows the severity order of transmission lines,the most severe line in the system is found out by Maximum Loading Parameter (λ). The values are arrange in ascending order of all bus.

Fig.6, 7, 8 & 9 shows voltages magnitude in per unit, voltage Phase in radians, Real Power in MW and Reactive Power in MVAR respectively, at different buses without outage of any transmission line using power flow without using STATCOM.

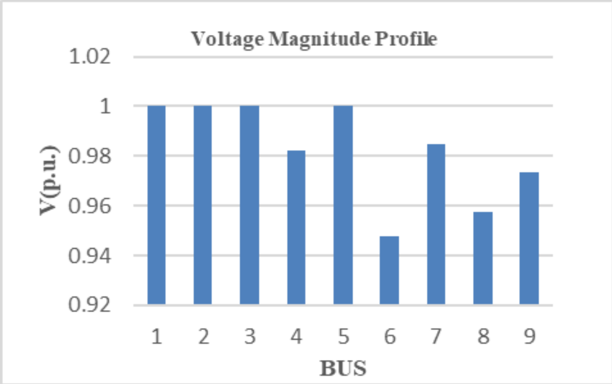


Figure 6: Voltage magnitude profile without STATCOM

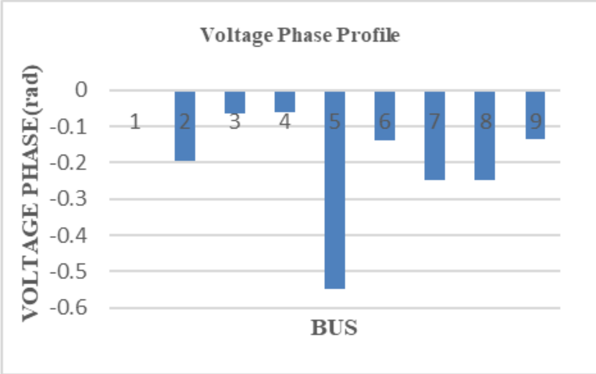


Figure 7: Voltage phase profile without STATCOM

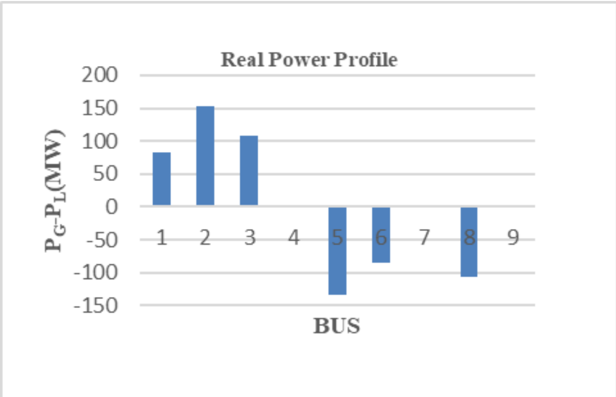


Figure 8: Real power profile at each bus without STATCOM

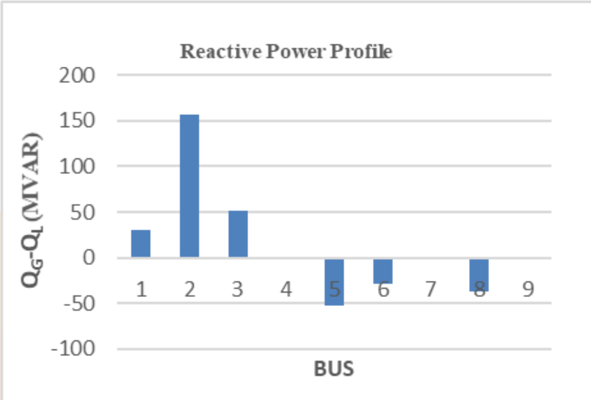


Figure 9: Reactive power profile without STATCOM

With STATCOM:

Table 6:Voltages across bus after outage of transmission lines with STATCOM

Voltage of bus (p.u)	Transmission line removal between bus x and y					
	7 to 8	6 to 9	8 to 9	4 to 5	5 to 7	4 to 6
Bus1	1	1	1	1	1	1
Bus2	1	1	1	1	1	1
Bus3	1	1	1	1	1	1
Bus4	0.92836	0.90513	0.92396	0.98201	0.87605	0.95096
Bus5	0.89328	0.85584	0.87755	**1**	0.76445	0.87755
Bus6	0.9283	0.87597	0.92775	0.94747	0.86992	0.87932
Bus7	0.98683	0.97473	0.965102	0.98502	0.97535	0.9697
Bus8	0.93035	0.95498	0.91534	0.95756	0.94607	0.94839
Bus9	0.96288	0.94729	0.97692	0.97366	0.96209	0.95171

Table5 shows the voltage magnitude of at all bus in per unit by considering outage of line with STATCOM. The line is removed one another one and after analyzing it is found that the voltage magnitude profile at bus 5 is increased as compare to other transmission line removal.

Fig.10, 11, 12 & 13 shows voltages magnitude in per unit, voltage Phase in radians, Real Power in MW and Reactive Power in MVAR respectively, at different buses without outage of any transmission line using power flow with using STATCOM.

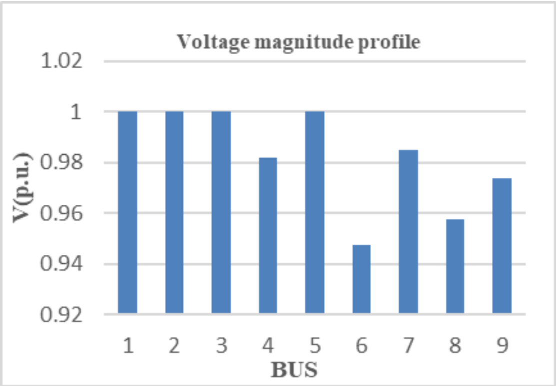


Fig.10.Voltage magnitude profile at each bus with STATCOM

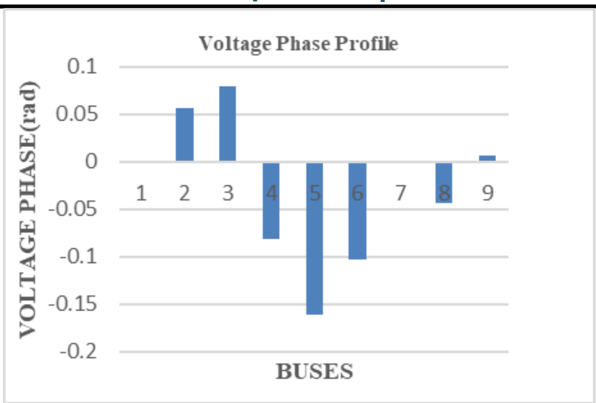


Fig.11. Voltage phase profile with STATCOM

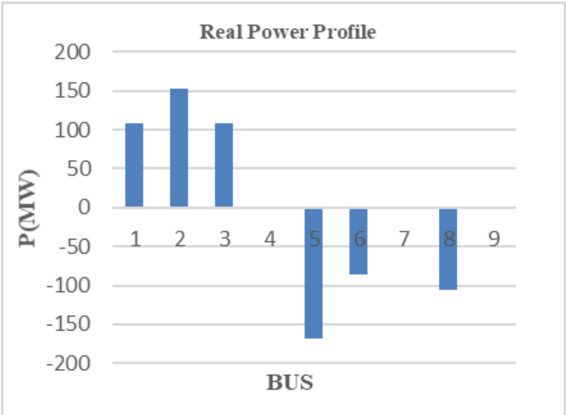


Fig.12.Real power profile at each bus with STATCOM

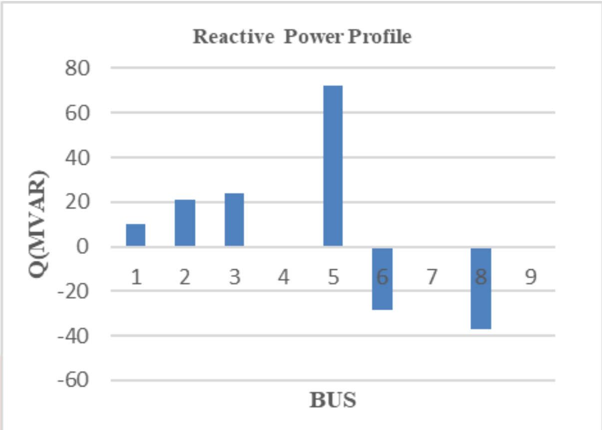
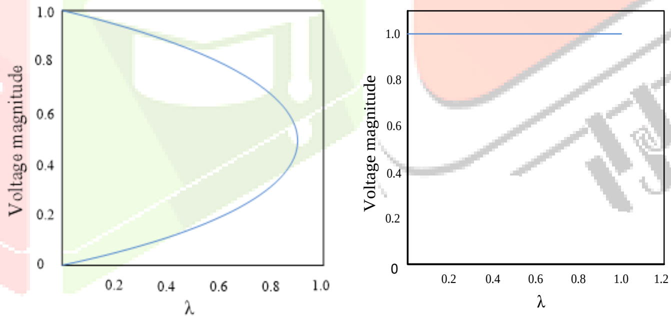


Fig.13. Reactive power profile with STATCOM

PV CURVE:

PV curve for voltage magnitude with and without STATCOM as shown in fig.14 below. STATCOM is placed at bus 5 hence voltage get improved.



Without STATCOM With STATCOM

Fig.14.PV curve without and with STATCOM at bus 5

VII. CONCLUSION

In this proposed paper detailed study has been carried out for grid interconnection system using hybrid wind power generation and STATCOM for improving power system security. The implementation and testing of entire design model is done in MATLAB-PSAT software. The contingency analysis using Newton Raphson method is carried out for outage of transmission line and the line is removed one after one with original values by taking different lines. All the system buses is connected with respect to maximum loading parameter(λ) and it is found that line connected between 7 and 8 has least loading parameter while transmission line between 4 to 5 has highest loading parameter. In this paper, bus number 5 is found to be as weakest bus compare to other bus of the system. The result of IEEE 9 bus test system have clearly show that how STATCOM device increased the voltage level of area.PV curve analysis is done for the stability of the system by connecting STATCOM at weakest bus and the security of power system is been improved.

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