Impact Factor (SJIF): 4.542

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444
Volume 4, Issue 4, April-2017

Performance of FACTS Devices in Distribution Network Connected With Wind Power Generation

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Abstract: *This paper describes the power quality problems associated with the wind turbine based distributed generation systems and how the FACTs devices such as STATCOM and SVC plays a vital role in power quality improvement of Distributed Generation System. The intention of the paper is to analyze a reactive power control ability and Voltage profile Improvement ability of STATCOM and SVC connected with same topological and operational conditions with SCIG wind Generator. The FACT device Static Compensator (STATCOM) and Static Var Compensator (SVC) are connected with load bus. Matlab/Simulink is used to compare the work performance of the FACTs Devices. Paper demonstrated the simulation results for with and without STATCOM and SVC for Grid connected distributed generation system.*

Keywords: *Distributed Generation (DG), FACTs, SVC, STATCOM.*

I. INTRODUCTION

Due to modernization electrical power industries are under goes to restructuring side. For quality of power supply power system is reform and privatization is introduced for better use of technology for continuity and reliable power supply [9]. The electrical power system has played a critical role in the development of human civilization. It has become a basic necessity in the lives of humans. These requirements will grow continuously and to cope up with the demand, it has to be achieved through best utilization of maximum energy resources and components to generate electricity for satisfying customer needs. With the increase in power demand, renewable energies such as wind turbines, solar panels and wave power plants have started to play a bigger role in the global energy system.

In this paper, it is suggested to use the FACT Device such as STATCOM and SVC for grid connected wind farm system to improve the stability of the Distribution system with dispersed Generation [1]. Generally, stability means the capability of power system to hold synchronism during occurrence of a severe transient disturbance such as fault in equipment and transmission line or loss of generation or lumped load. The objective of this paper is to do simulation and analysis of distributed generation (DG).Analyze the Impacts of the FACTs devices on DG units on voltage stability. For this objective first developed the distributed generation based model and simulated with the different types of FACTs Devices in MATLAB/Simulink and observed the voltage stability and reactive power control of that DG in faulty condition (with and without FACTs devices).

II. STATIC VAR COMPENSATOR (SVC)

Static Var Compensator (SVC) is a power quality device, which employs power electronics to control the reactive power flow of the scheme where it is connected. As a result, it is capable of delivering fast reactive power compensation to the electrical power system networks. In other words, static var compensators have their output variable to interchange inductive or capacitive current in order to control a power network variables such as the bus voltage. In addition, the term static is used to separate the SVC from it rotating counterparts like the synchronous generators and/or motors. The simple action of SVC is a compensator to regulate the voltage by controlling the amount of reactive power absorbed from or injected into the power system [10]. The benefits of Static Var Compensators include:

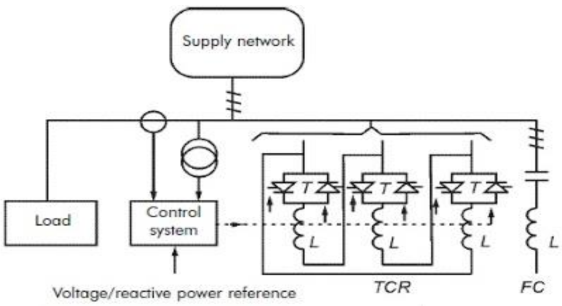
- Exploit power compensation
- Near-instantaneous response to power system voltage variations
- Adding customer's economic benefits
- Remove harmonics and decrease voltage distortion with appropriate shunt filters
- Load balancing on three-phase systems

Design and Configurations

There are two common configurations of static var compensators and each will be described below.

1. Thyristor-controlled Reactors with Fixed Capacitors (TCR/FC)

This SVC design is having two parallel branches connected on the secondary side of a coupling transformer. One of the branches is having reactors that are controlled by AC Thyristor switches. The reactors are connected in delta for three-phase applications. The other branch would either be fixed capacitor banks or shunt filters. The variation of reactive power is adjusted by controlling the thyristor's firing instants and the current that flows by the reactance.



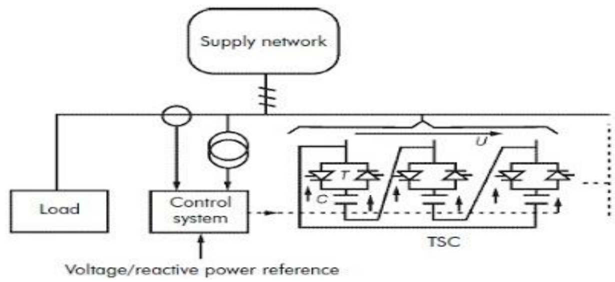


Figure 1. Thyrsitor-controlled Reactors with Fixed Capacitors   *Figure 2. Thyristor-switched Capacitors (TSC)*

2. Thyristor switched capacitors (TSC)

In this static var compensator design, the capacitor banks are connected phase-to-phase, with each section switched by thyristors. Therefore, levels of variation of the reactive power can be attained, but not a continuous change similar to that of a TCR. By providing a suitably large number of small sections, the required level of reactive power variation with a single step can be achieved. Synchronization of switching and initial pre-charging of the capacitors limits the transients typically associated with capacitor switching. Generally, the reaction time for symmetrical operation does not exceed 20 ms.

III. Static Synchronous Compensator (STATCOM)

Static Synchronous Compensator is a shunt device, which uses force-commutated power electronics (i.e. GTO, IGBT) to control power flow and increase transient stability on electrical power systems. It is also an associate of the so-called Flexible AC Transmission System (FACTS) campaigns. The STATCOM fundamentally executes the same function as the static VAR compensators but with some benefits.

The term Static Synchronous Compensator is derived from its abilities and effective principle, which are similar to those of rotating synchronous compensators (i.e. generators), but with relatively faster operation. In the case of two AC sources, which have the same frequency and are connected through a series reactance [11], the power flows will be:

- Real Power flows from the leading source to the lagging source.
- Reactive Power flows from the higher to the lower voltage magnitude source.

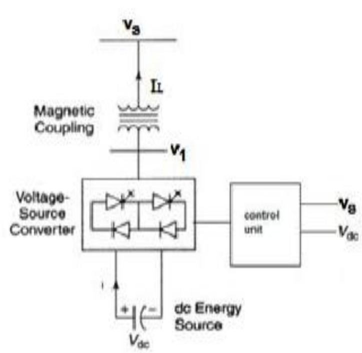


Figure 3. STATCOM Circuit Diagram

IV. SINGLE LINE DIAGRAM AND DESCRIPTION

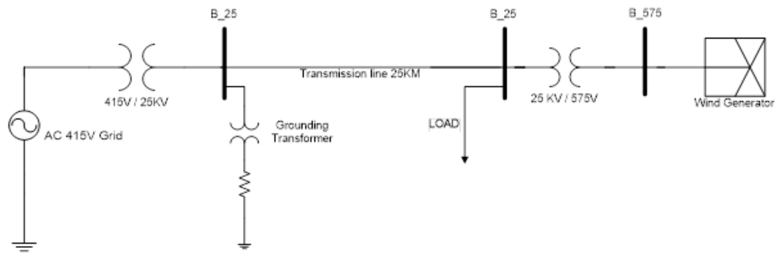


Figure 4. Single line Diagram of Distribution System Connected with Wind Turbine

As shown in fig. 2, wind farm consisting of one 1.5-MW wind turbines is connected to a 25-kV distribution system exports power to a 415V grid through a 25-km 25-kV feeder. The 1.5-MW wind farm is simulated by 1.5 MW wind-turbines. Wind turbines use squirrel-cage induction generators (IG). The stator winding is connected directly to the 50 Hz grid and the rotor is driven by a fixed-pitch wind turbine. The pitch angle may control in order to limit the generator output power at its nominal value for winds exceeding the nominal speed (9 m/s). In order to generate power the IG speed must be slightly above the synchronous speed. Speed varies approximately between 1 pu at no load and 1.005 pu at full load. Reactive power absorbed by the IGs is partly compensated by capacitor banks connected at each wind turbine low voltage bus (200 kvar for 1.5 MW turbine).
The rest of reactive power required to maintain the 25-kV voltage at bus B25 close to 1 pu will be provided by Different FACTs Devices used for the comparative study of performance. 25km long distribution line is taken with grounding transformer and distribution transformer of 25v/415v.

V. MATLAB SIMULATION MODEL AND RESULT WITHOUT FAULT AND FACTs DEVICE

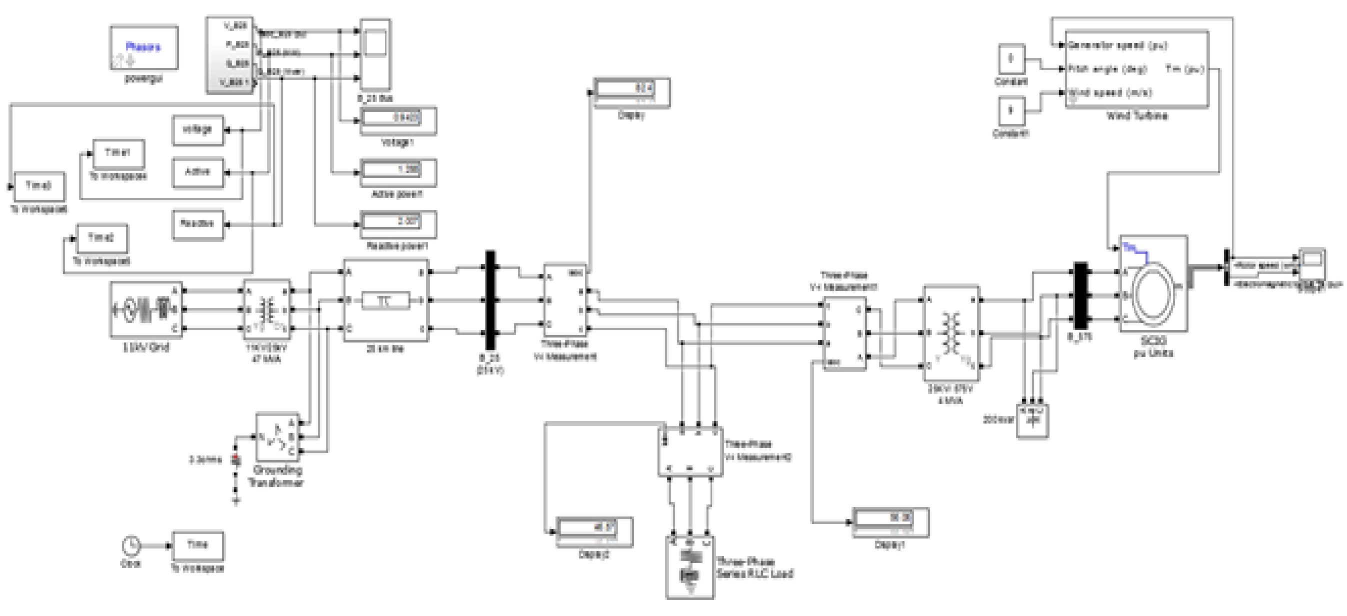


Figure 5. Matlab Simulation Model

RESULT

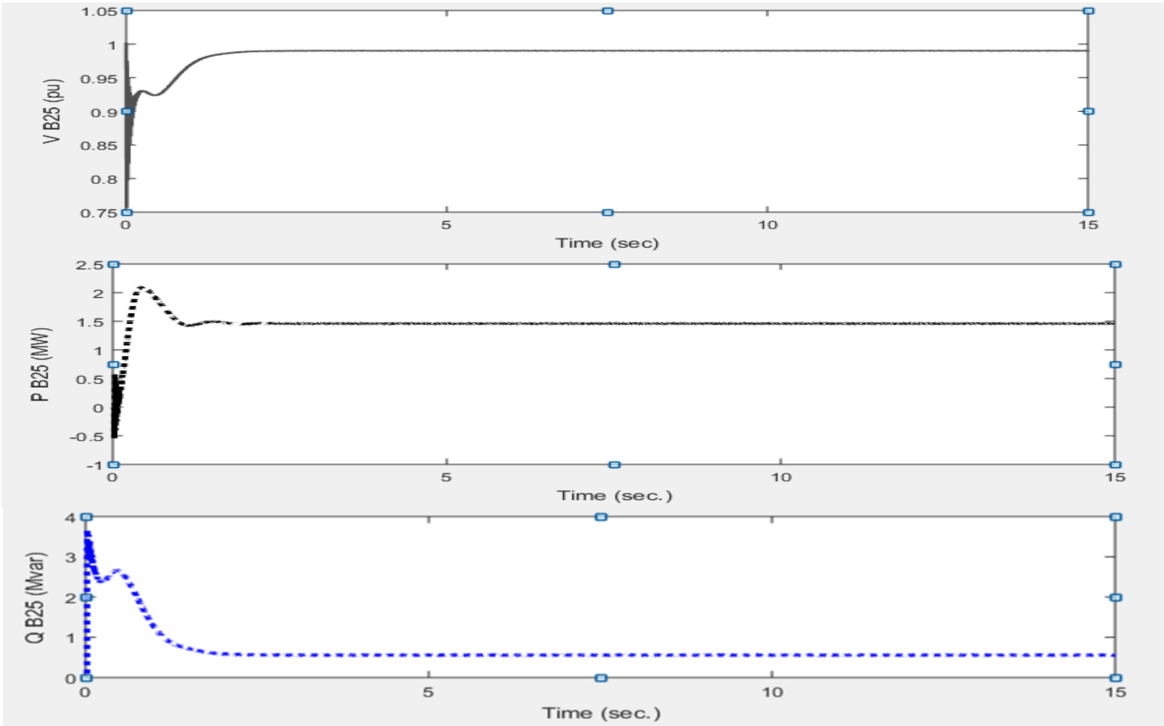


Figure 6. ***Simulation Result Waveform Without Fault and FATCTs***

VI. MATLAB SIMULATION MODEL AND RESULT WITH FAULT AND STATCOM

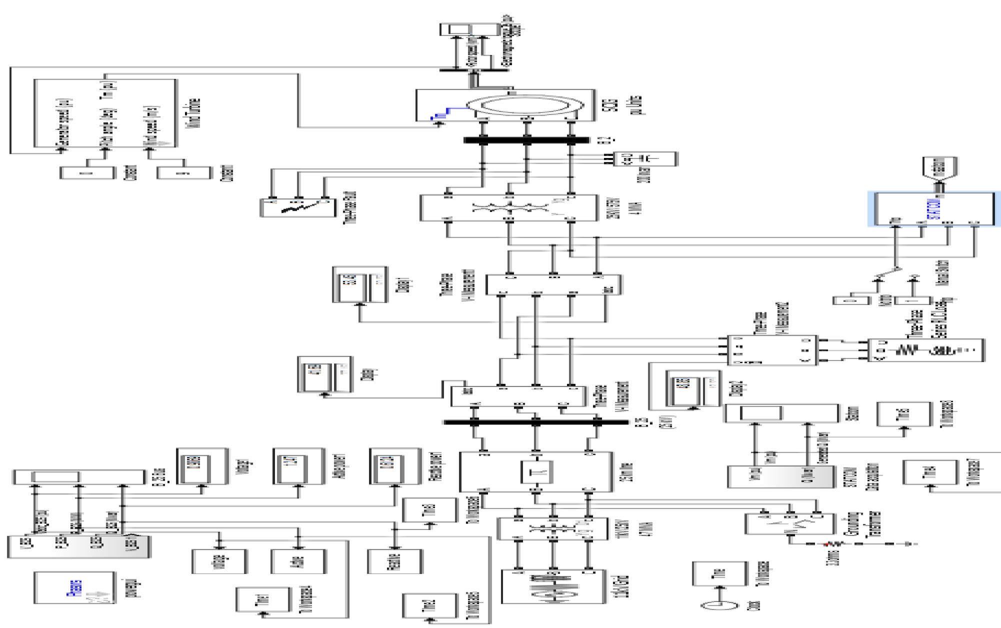


Figure 7. Matlab Simulation Model with STATCOM

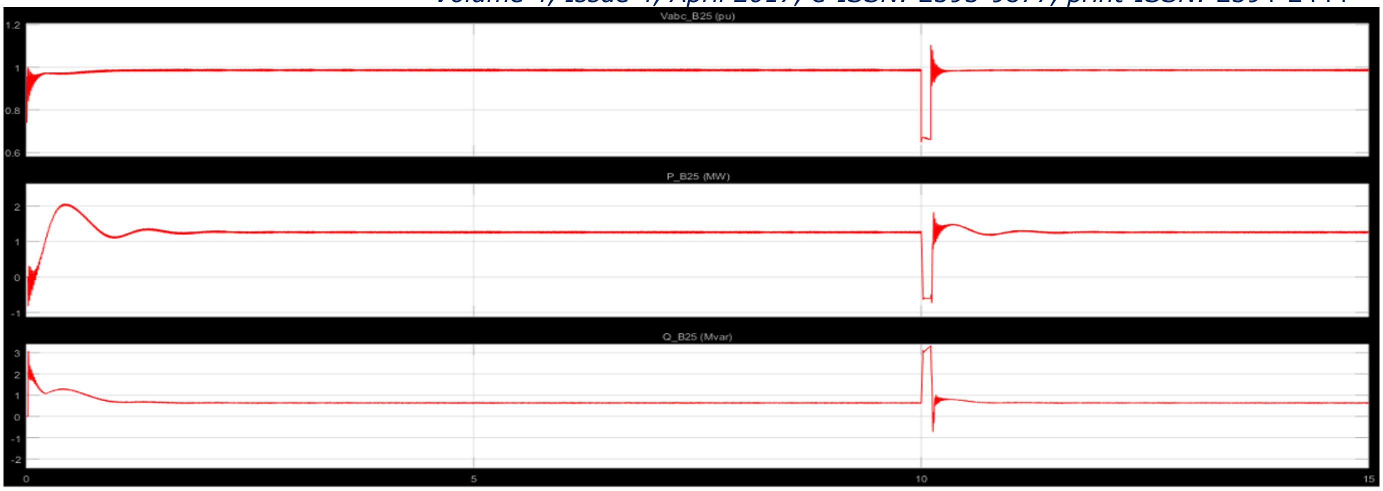


Figure 8. Simulation Result Waveform With Fault and STATCOM

VII.MATLAB SIMULATION MODEL AND RESULT WITH FAULT AND SVC

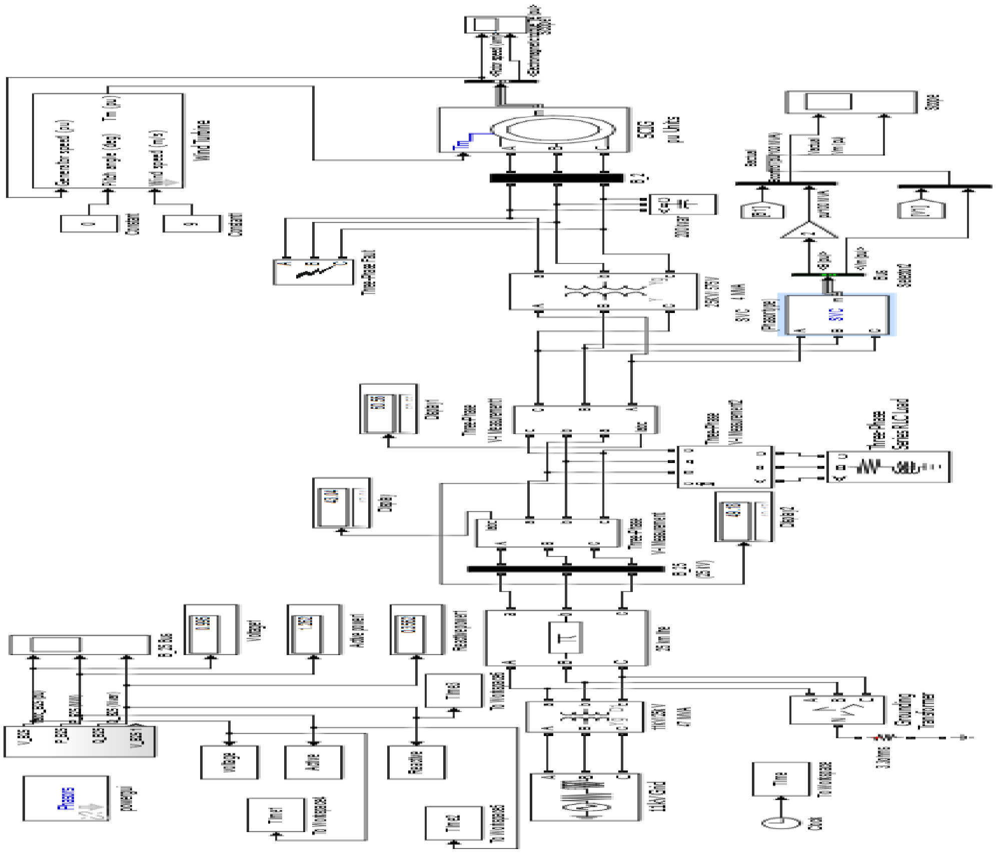


Figure 9. Matlab Simulation Model with SVC

RESULT

Figure 10. Simulation Result Waveform With Fault and SVC

VIII. CONCLUSION

Fault is done between 10sec to 10.11sec and Voltage profile is decreased to 0.65pu because at the point of 10.11sec the reactive power requirement is maximum. Voltage profile is improved up to 1.02pu.The operating time of STATCOM is found 5ms and of SVC is 11Ms.So, STATCOM is Preferable in the said topological and operational condition with compare to SVC.

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