Available online at: http://www.ijmtst.com/vol5issue07.html

International Journal for Modern Trends in Science and Technology
ISSN: 2455-3778 :: Volume: 05, Issue No: 07, July 2019

Stability Improvement in Grid Connected Multi Area System using ANFIS Based SVC Controller

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To Cite this Article
Gurivelli Swetha and K Polayya, "Stability Improvement in Grid Connected Multi Area System using ANFIS Based SVC Controller", *International Journal for Modern Trends in Science and Technology*, Vol. 05, Issue 07, July 2019, pp.-55-59.

Article Info
Received on 02-June-2019, Revised on 18-July-2019, Accepted on 20-July-2019, Published on 23-July-2019

ABSTRACT

Generally, the non-conventional energy sources are being extensively used in case of power electronic converter based distribution systems. This paper mainly focuses on the wind energy system integrating with grid connected system and also improvement of power quality features. The wind energy power plant is modelled based on associated equations. For improving this power quality problems, this paper proposes the concepts of shunt converter controllers. This paper also proposes the concepts of ANFIS based Static Compensator. And also the results are compared for this cases. Thus with such a control, a balanced load currents are obtained even in the presence of non-linear load. The experimental setup is done in Matlab and verified the simulation results.

KEYWORDS: *SVC, distributed generated system (DG), distribution system, and renewable energy, Fuzzy Logic.*

I. Introduction

Generally, with increase in the power demand due to increase in population, utilization, the Generation of power was really a challenge now a day. Due to high utilization of non-conventional energy sources [1] as a one of the distribution energy source, may causes the stability problems such as voltage regulation and other power quality problems. Therefore, the power electronic based forced commutated converters are preferred in distribution system for maintaining the system stability, reliable performance and efficient work and also improving the quality of power at coupling junction point.

The current distortions in non-linear load may result same distortions in the system voltages and in some cases also shows the serious effect on power system. Generally, the problems in power system are more complicated and also have difficult to identify the problem when we integrate the wind energy system with grid connection [2]. If this problems continuous, it's mainly causes the damage of system and also reduces the system efficiency. By controlling the system parameters such as magnitude of voltage, transmission impedance and load angle then we maintain the power flow. The power flow controlling device is a device which is used for varying and controlling the system parameters [3].

A shunt device is a compensating device i.e. which is connected between the grid connected point called as PCC and the ground [4]. Shunt device either can absorb or generate the reactive power for controlling the magnitude of voltage at point of common coupling.

The reactive power compensation is also one of the application of shunt converter devices [5]. Figure 1 shows the basic diagram for the shunt connected inverter based grid connected system [6].

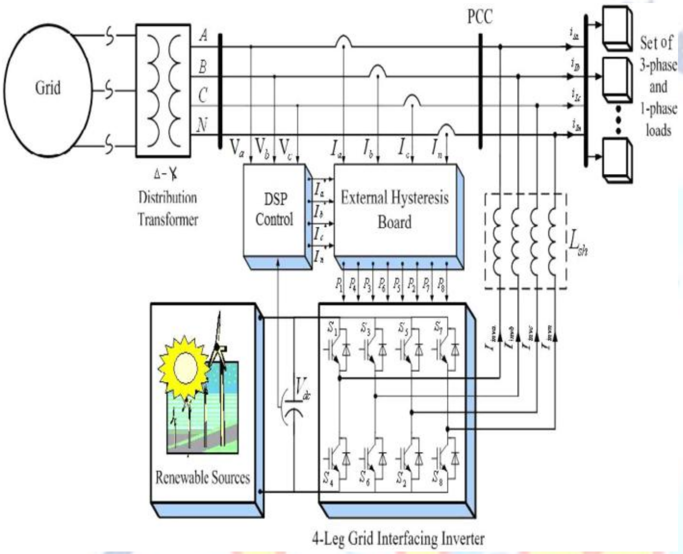

Fig 1: Diagram for Proposed System.

II. Grid Interconnection of Wind Energy System

Recently grid connected wind system have been spreading in residential areas and in industrial areas. So we have to find a suitable MPPT technique that gives a better power output when connected is to find out. For a grid connected system there are certain factors that have been considered such that DC-AC conversion with highest output power quality with the proper design of filters System main controlling factors like MPPT. Grid interface inverters which transfers the energy from the wind energy generation system to the grid by maintaining constant of dc link voltage. For a grid connected system the utility network mainly demands for better power quality and power output. In the case of voltage fluctuations control of grid parameters is very difficult. So for a wind system that is connected to a grid first stage is the boosting stage and the second stage is DC-AC converter [7]. An output filter is usually employed which reduces the ripple components due to switching problems. The problem associated with the grid connected system is that the dc link voltage that must be oscillates between the two levels which depends on the operating climatic conditions (ambient temperature & irradiance) in which inverter which acts us a power controller between the dc link and the utility. Dc link is generally used to isolate between the grid side and the inverter side so that we can control both wind system and grid separately. All the available power that can be extracted from the wind system is transferred through the grid [8]-[9].

2.1 Wind Energy System:

The generation of electrical power is obtained mainly in two ways i.e one is conventional source and other is non- conventional energy sources. The generation of electricity using non-renewable resources such as coal, natural gas, oil and so on, shows great impact on the environment by production of pollution from their general gases. Hence, by considering all these conditions the generation of electricity is obtained from the renewable energy sources.

Basically, out of all renewable energy sources the wind turbine plays an important role for generating electricity. And also from economical point of view the wind turbine has low maintainece cost because it needs no fuel so that it is pollution free. Mostly, in present world 50-60 percent [13] of energy is generated from wind turbine as compared with all other renewable energy sources.

The typical layout of wind power generation as shown below.

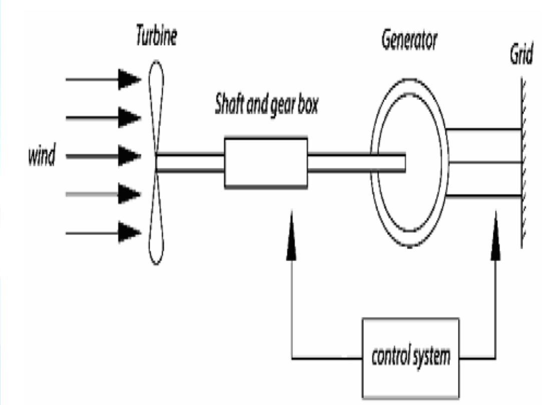

Fig.2 basic schematic diagram of wind turbine

The wind turbine converters wind energy to electrical energy and the generator mechanical shaft power is obtained by the following expression:

$$P_m = 0.5\rho A C_p v^3$$

And the coefficient of power also plays a key role for wind system and the basic minimum value of power coefficient is 0.5. The power coefficient is obtained by the ratio of tip speed ratio to pitch angle. The pitch angle is the angle to which the blades of turbine is arranged based on their longitude axis and changing of wind direction. The tip speed ration is defined as ratio of linear speed of the rotor to the wind speed.

Fig.3 shows a typical waveform for coefficient of power with respect to the tip speed ratio. The maximum achievable range of TSR is from 0.4 to 0.5 for turbine with high speed and from 0.2 t0 0.4 for turbine with low speed [14].

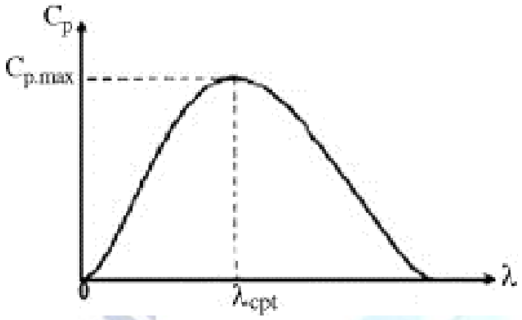

Fig 3: Power coefficient Vs Tip Speed Ratio

2.2 SVC and its Control Technique:

It is a power quality device, which employs power electronics to control the reactive power flow of the system where it is connected. As a result, it is able to provide fast-acting reactive power compensation on electrical systems. In other words, static var compensators have their output adjusted to exchange inductive or capacitive current in order to control a power system variable such as the bus voltage.

Moreover, the term static is used to distinguish the SVC from its rotating counter parts like the synchronous generators and/or motors.

- Unity power factor at the source side.
- The Dc voltage is obtained for STATCOM is generated from Solar Cells.

The major and most important component of the family of static var compensator [15] is Thyristor Switched Capacitor. It is an equipment which is used for reactive power compensation in power systems. It is a combination of capacitor bank which is connected in series with the anti-parallel thyristor valve and a small current limiting inductor [16]

The thyristor switched capacitor is commonly a three phase system which is connected in either star or delta. As compared with thyristor controlled reactor the thyristor switched capacitor produces less harmonics thereby no need for extra filter circuits. Due to this reason the thyristor switched capacitor is mostly used in static var compensator family and used for only reactive power this can lead to less economic [16].

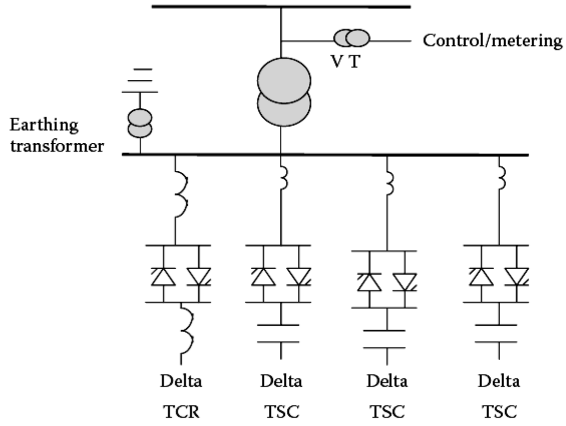

Fig 4: Thyristor Switched Capacitor

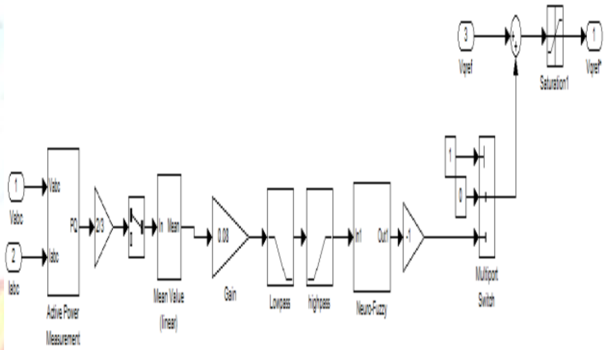

Fig 5: Control Diagram for SVC

III. FUZZY LOGIC CONTROLLER

Fuzzy control system is a mathematical system which is completely based on fuzzy logic. Fuzzy controllers which are directly use the fuzzy rules. Fuzzy rules are conditional statements, gives the relationship among all fuzzy variables. The logic involved in the fuzzy controller [17] can deal with concepts that cannot be expressed as true or false. In below figure Fuzzy Logic Controller block diagram is shown.

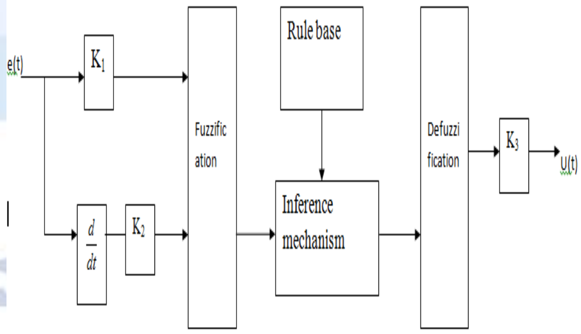

Fig.6 Fuzzy Logic Controller block diagram

The fuzzy set is defined by a function that maps objects in a domain of concern to their membership value in the set. Such a function is called membership function and is usually denoted by Greek symbol "μ". Figure 6, shows the selection of number of inputs and outputs in the form of membership functions in order to design FIS [18].

IV. SIMULATION STUDY

Case 1: Simulation result with use of TSC Converter

The simulation is done based on the fig 1, and it shows in figure 7 and the obtained power quality is shown below simulation waveforms.

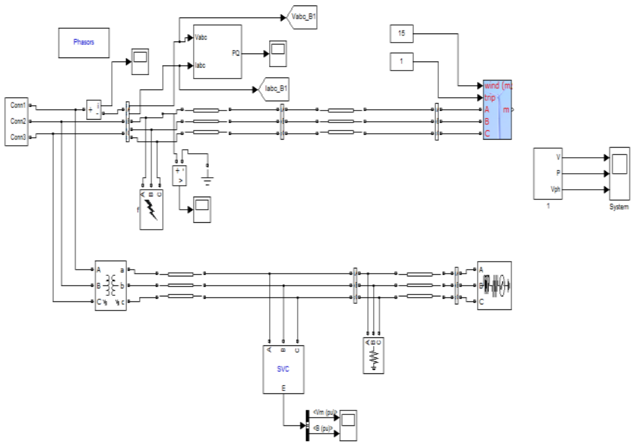

Fig 7: Simulation Diagram with SVC

Case 1: With and Without SVC Controller

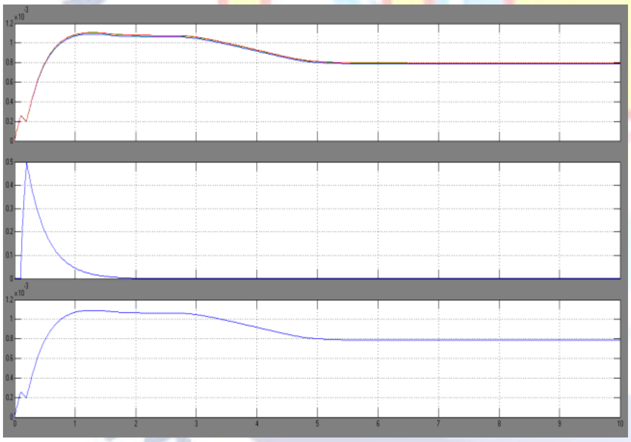

Fig 8: Simulation Result for Multi area system without SVC (a) Voltage, (b) Power and (c) Phase voltage

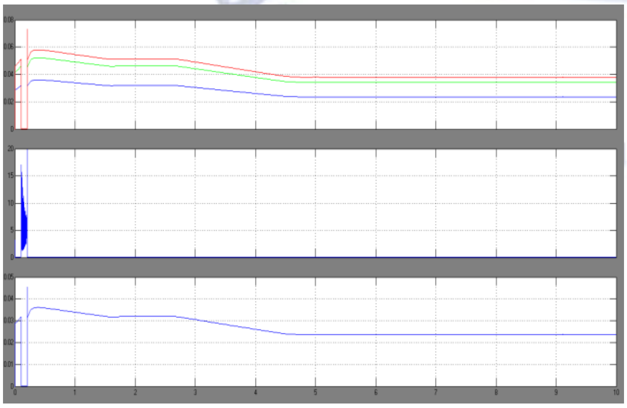

Fig 9: Simulation Result for Multi area system with SVC (a) Voltage, (b) Power and (c) Phase voltage

Case 2: With SVC and Fuzzy Logic Controller

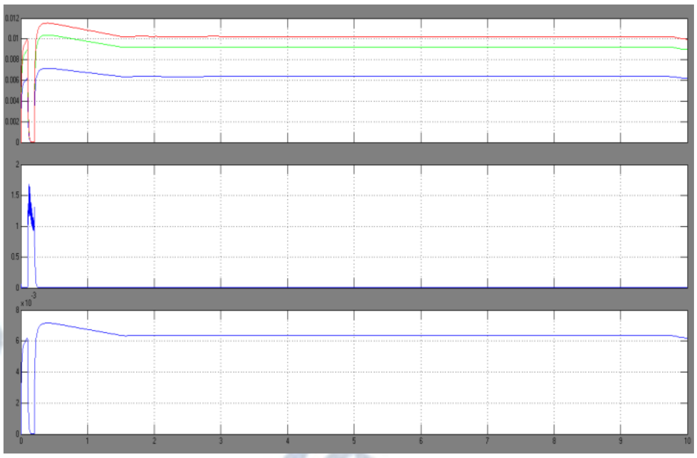

Figure 9: Simulation Result for Multi area system with SVC and Fuzzy Controller (a) Voltage, (b) Power and (c) Phase voltage

V. CONCLUSION

The paper summarized the following points, mainly quality, reliability and stability issues get generated with the interconnection of many distributed generation system in Grid. Power stability issues like voltage frequency and load angle variation in DG connections. An advanced control device is required for the connection of distributed generation in a network; control device should have a property to secure high reliability and stability of the power system. In this paper, SVC mechanism is controlled with ANFIS controller. This controller along with SVC improves the voltage profile and the transient stability of buses connected with grid occurred. The designed controller is tested on a 3 machine 5 bus Simulink model in MATLAB. The Simulation tests are performed on buses terminal voltage. The ability of designed controller in contrast with the conventional SVC can be seen that the ANFIS controller has enhanced the transmission line power stability during the disturbances whereas the ANFIS based controller provides reliable and stable working. In future genetic algorithm can be used to improve the working and mechanism of SVC to improve the voltage profile and the transient stability of buses of any power system.

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