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Stability enhancement of a grid connected wind farm by using fuzzy logic and D-STATCOM

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ABSTRACT

In recent time analysis of some major blackouts and failures of power system shows that the voltage instability problem has been one of the main reasons for these disturbances and networks collapse. In recent years, a remarkable and numerous improvements have been achieved because of electric energy generation by utilization of wind energy. However, these achievements are accompanied by several problems such as grid stability and security. The transient stability issues of the grid-connected wind farms have increased especially in case of severe disturbances and contingencies. Static analysis is used to analyze the voltage stability of the system under study, whilst the dynamic analysis is used to evaluate the performance of compensators. The static techniques used are Power Flow, V–P curve analysis, and Q–V modal analysis. In this study, Flexible Alternating Current Transmission system (FACTS) devices- namely, Static Synchronous Compensators (STATCOMs) and Static Var Compensators (SVCs)- are used as reactive power compensators, taking into account maintaining the violated voltage magnitudes of the weak buses within the acceptable limits defined in ANSI C84.1.

Keywords— *FACTS, STATCOM, Wind turbine, Fuzzy logic, PI, ANN, Ultra capacitor*

1. INTRODUCTION

Wind power and its potential that can be harnessed in the future to meet the current energy demand. With a detailed description of the wind turbine and the wind, generator focus has been given on the interconnection of the generators with the grid and the problems associated with it.

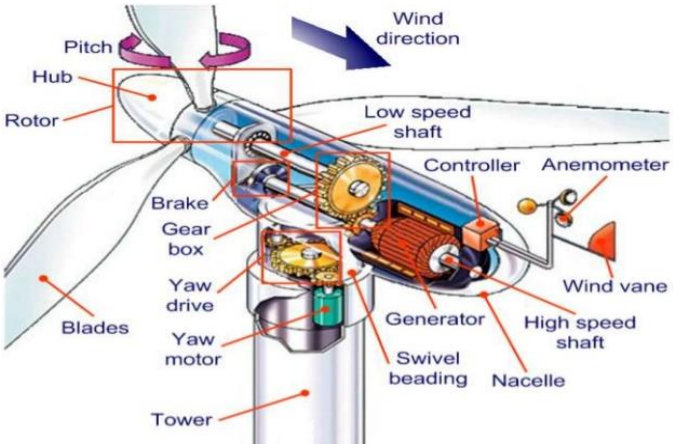

Fig. 1: Wind turbine working principle

The use of power electronics in the circuitry and their applications has also been emphasized. In the end, a voltage stability analysis has been done with respect to various models of the wind turbines to find the best way to clear faults and have optimum output. Increasing power demands and economic growth as well as the rapid increase of CO2 emission which creates the global warming problem has stimulated the desire for renewable energy sources like wind energy, solar energy etc. Electric power generation using wind turbines has attracted the attention of utilities due to high generation capacity and low maintenance and cost of such turbines. The most common type of wind turbine is the fixed speed turbine with squirrel cage induction generator directly connected to the grid. These wind turbines based induction generators require reactive power for compensation. The needed reactive power of induction generator can be provided either by the grid or self-capacitor bank in parallel with the generator stator

terminals [5]. If sufficient reactive power is not supplied, then the electromagnetic torque of wind generator decreases significantly. Then the difference between mechanical and electromagnetic torques becomes large and the wind generator and turbine speeds increase rapidly. As a result, the induction generator becomes unstable and it requires to be disconnected from the power system. However, the recent trend is to decrease the shutdown operation because a shutdown of a large wind farm can have a serious effect on the power system operation such as loss of generation and load demand, voltage and frequency variations, power imbalance [6]. If a disturbance occurs at the transmission line which connects the power system to a remote wind farm, the wind turbines usually do not participate in voltage or reactive power control; they are often disconnected and then reconnected after the power system restore the normal operating conditions [10]. With the recent development of FACTS devices, SVC and STATCOM have been used for transient stability augmentation of power system in order to support the power system voltage and reactive power during and after disturbances where they actually increase the electric torque produced by the fixed speed induction generators and makes generators less like to over-speed and thus to increase system stability [12].

2. LITERATURE SURVEY

Solar-energy utilization is growing in demand since the past decade due to the increase in energy needs and depletion of non-renewable sources. But the problem with solar energy is that it's not constant; it keeps on fluctuating depending upon the weather conditions such as solar irradiation, temperature, thus a battery is always connected between the load and the solar panel so as to act as a secondary source. Since, brighter the sunlight, more voltage the solar cells would produce an excessive voltage could damage the batteries [1]. In order to effectively solve the shock and false error infrequently used perturbation method in maximum power point tracking (MPPT) for photovoltaic inverter, the working voltage of the PV array was adjusted to 80% at the initial stage of the maximum power point tracking (MPPT); During collecting its working current and voltage, the high-frequency noise was filtered by FIR filter, and the direction of disturbance was determined by three-point mode, and the step size was adjusted with the change of light intensity. The experimental analysis indicates that the stability, precision, and efficiency of the improved perturbation method were developed obviously [2]. Solar energy is an important alternative out of the various renewable energy sources. This paper presents a new modeling of Maximum power point tracking controller with variable irradiance and variable temperature, unlike the existed MPPT controller methods where either constant irradiance or constant temperature are considered as parameters. Using this proposed MPPT controller the parameters such as Power, voltage and current are analyzed using a simulation model and experimental validation [3]. MPPT is used to track maximum power, a DC-DC Boost converter is used to obtain the impedance matching between the PV array and the load. Although a huge number of approaches have been proposed in the literature, the methods based on perturbing and observe (P&O) technique are the most widely employed in commercial products. The reason lies in the fact that P&O can be implemented in cheap digital devices by ensuring high robustness and a good MPPT efficiency. This paper aims to presents the design and development of a photovoltaic system based on the enhanced P&O algorithm that allows improving the efficiency, stability, and accuracy of solar systems [4]. Transient stability analysis of a power system with wind generation has been addressed in this paper. The effects of automatic voltage regulators, power system stabilizers, and static synchronous compensators on transient stability of a power system are investigated. Various simulation results show that addition of power system stabilizer and static synchronous compensators reduce the rotor angle oscillations. However, the static synchronous compensator shows better damping characteristics and improves the stability of the wind integrated system [8].

3. PLANNING OF WORK/METHODOLOGY

There are various methodology will be used in this, which is Fuzzy logic and Artificial Neural Network, Ultra Capacitor, MPPT.

3.1 Artificial Neural Network (ANN)

We will start with the understanding of the formulation of a simple hidden layer neural network.

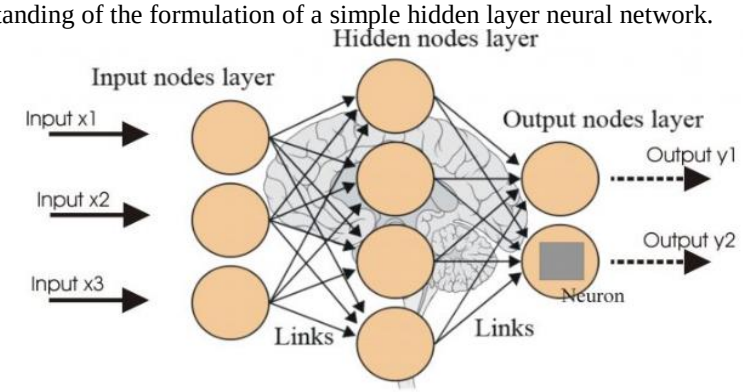

Fig. 2 Artificial Neural Network diagrams

ANN is rarely used for predictive modeling. ANN is generally used in cases where what has happened in past is repeated almost exactly in the same way. For example, say we are playing the game of Black Jack against a computer. An intelligent opponent based on ANN would be a very good opponent in this case (assuming they can manage to keep the computation time low). With time ANN will train itself for all possible cases of card flow.

3.2 Ultra capacitor

The working of the supercapacitor is given below: A supercapacitor differs from an ordinary capacitor in two important ways: its plates effectively have a much bigger area and the distance between them is much smaller because the separator between them works in a different way to a conventional dielectric. Like an ordinary capacitor, a supercapacitor has two plates that are separated.

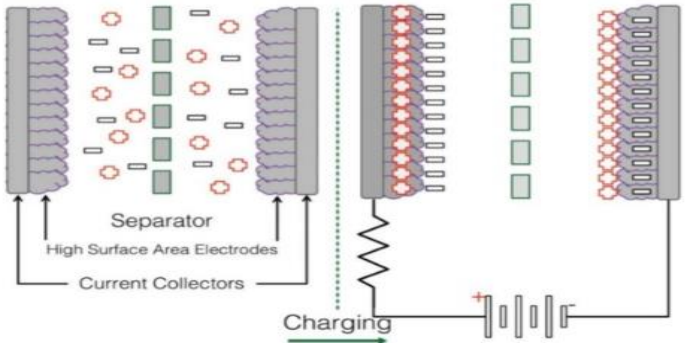

Fig. 3: Super capacitor working

3.3 Fuzzy Logic

Fuzzy logic is a form of many-valued logic in which the truth-value of variables may be any real number between 0 and 1. By contrast, in Boolean logic, the truth-value of variables may only be the integer values 0 or 1. Fuzzy logic has been employed to handle the concept of partial truth, where the truth value may range between completely true and completely false. Furthermore, when linguistic variables are used, these degrees may be managed by specific functions. Humans and animals often operate using fuzzy evaluations in many everyday situations.

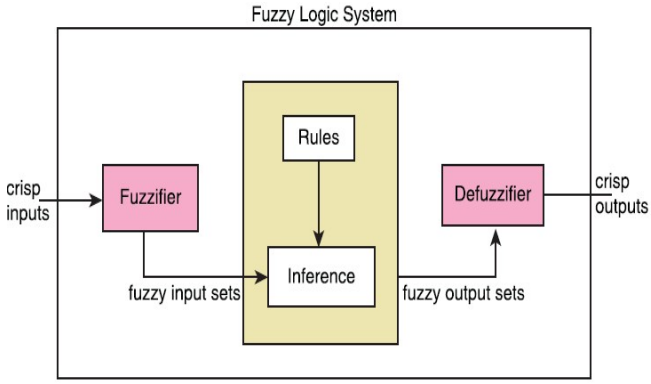

Fig. 4: Fuzzy logic

In the case where someone is tossing an object into a container from a distance, the person does not compute exact values for the object weight, density, distance, direction, container height and width, and air resistance to determine the force and angle to toss the object. Instead, the person instinctively applies quick "fuzzy" estimates, based upon previous experience, to determine what output values of force, direction, and vertical angle to use to make the toss.

3.4 Implemented methodology

Wind power is the fastest growing renewable energy, it is essential to determine problems associated with maintaining a stable power system when it is connected to the grid. In this article, a simple strategy is described to stabilize a grid-connected wind farm by controlling reactive power and minimizing voltage fluctuation using a simple 6-pulse Static. The STATCOM is controlled by using voltage control loop with a PI controller and Pulse Width Modulation with a carrier frequency of 9 times fundamental and varying dc voltage. Our motive for this project is to stabilize wind voltage and it will happen by providing a sufficient amount of reactive power to wind farm. And this amount of reactive power is generated by STATCOM and capacitor bank which is controlled by a PI controller. In our research work FUZZY + PI controller in STATCOM or capacitor bank will be implemented to provide a sufficient amount of reactive power to wind firm for gent stable output power and voltage. Matlab Software will be used to carry out the objective of our research. Proposed technique will be fuzzy plus PID controlled technique in STATCOM

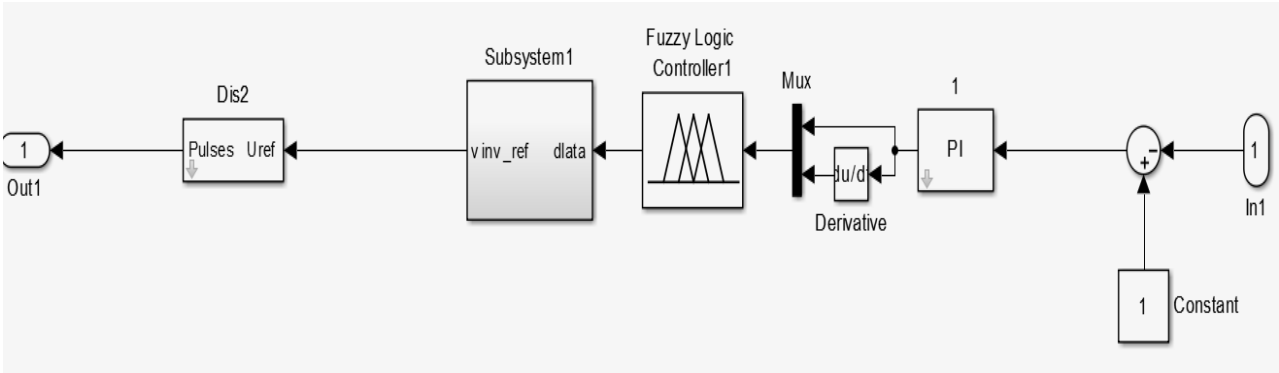

Fig. 5: Fuzzy plus proportional integrator part

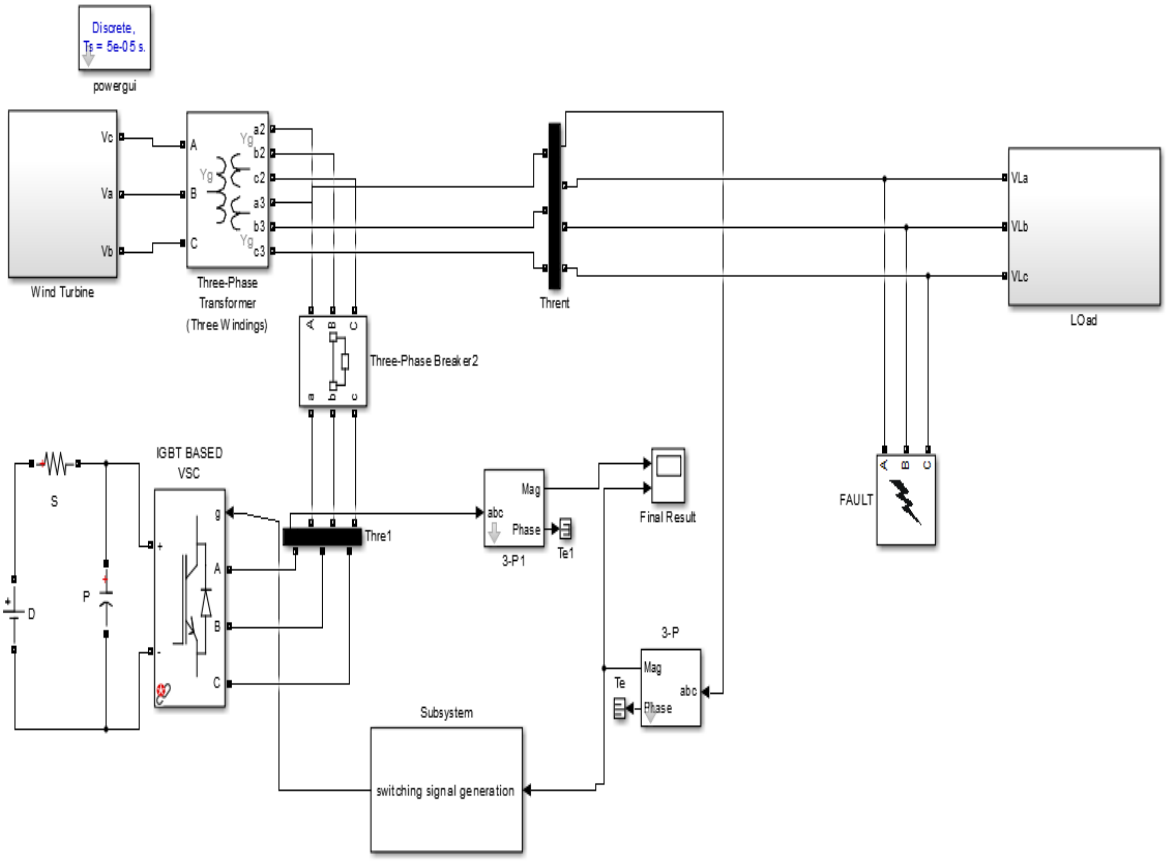

Fig. 6: Block diagram of system

4. SOFTWARE USED AND SIMULATION RESULT

4.1 Software

Proposed scheme have developed in MATLAB 2015a tool. In our dissertation work six 3-D data set of variable length are used to know the actual performance of the implemented algorithm for various parameters. Density-based Ad- DBSCAN technique used to measure accuracy, processing time, the radius of the cluster, no of the cluster formed.

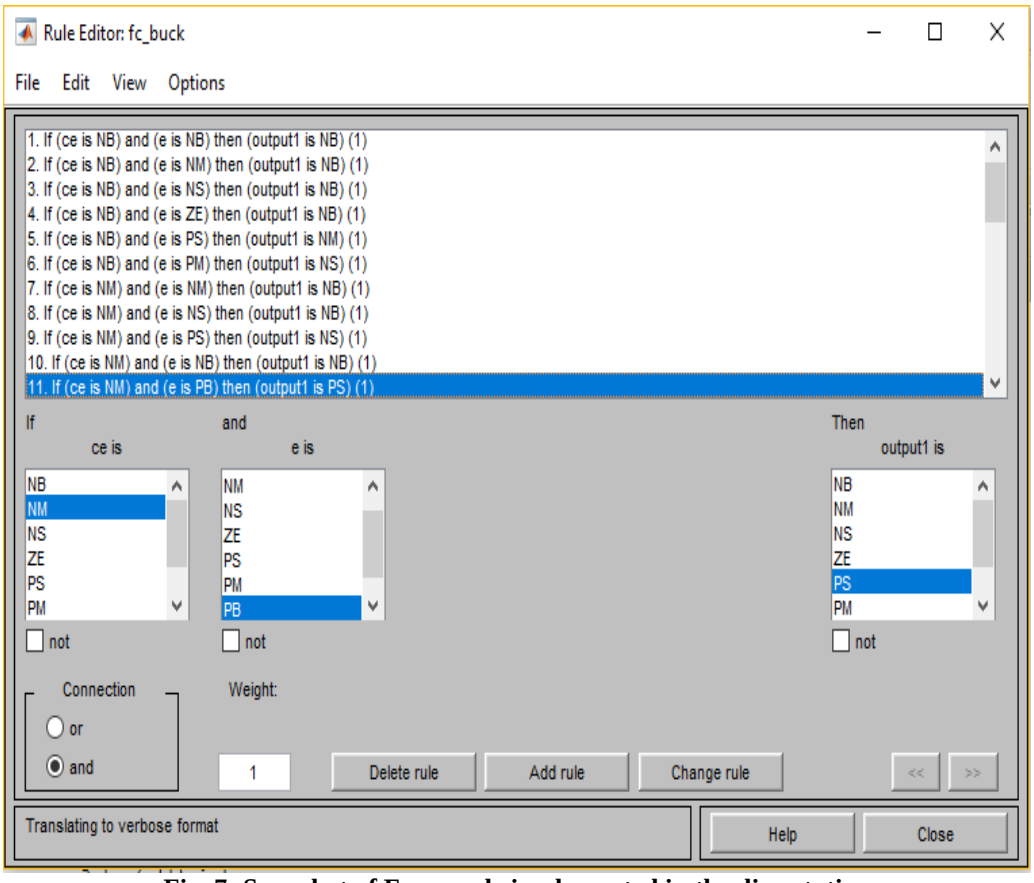

Fig. 7: Snapshot of Fuzzy rule implemented in the dissertation

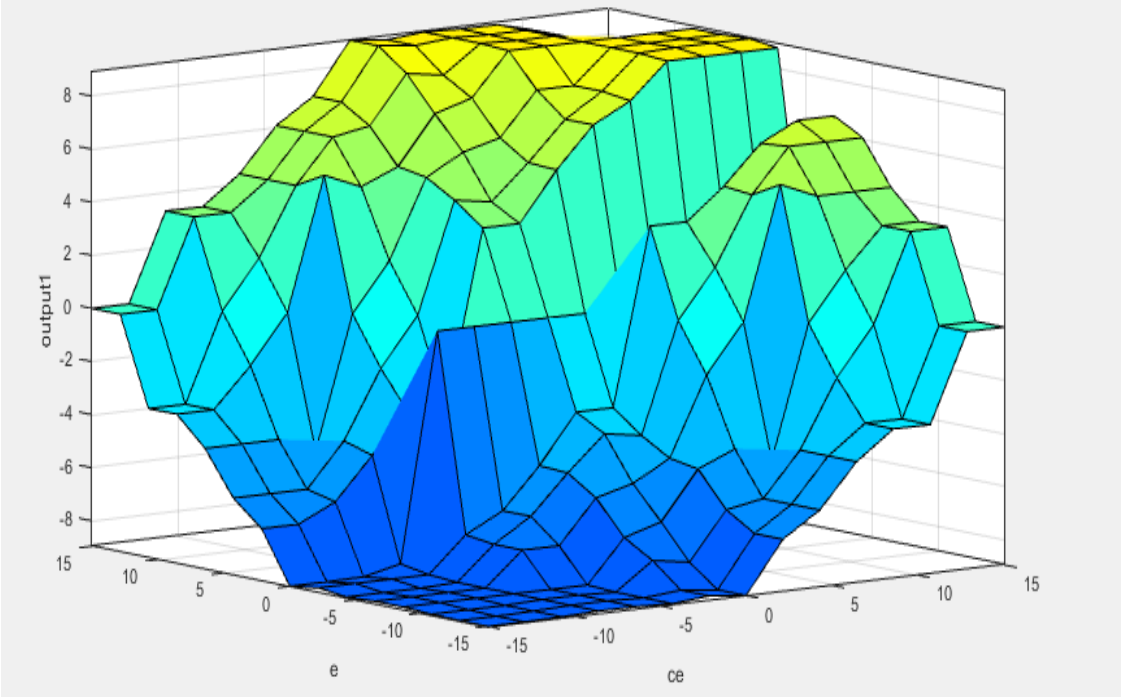

Fig. 8: 3D View of Fuzzy output Case 2

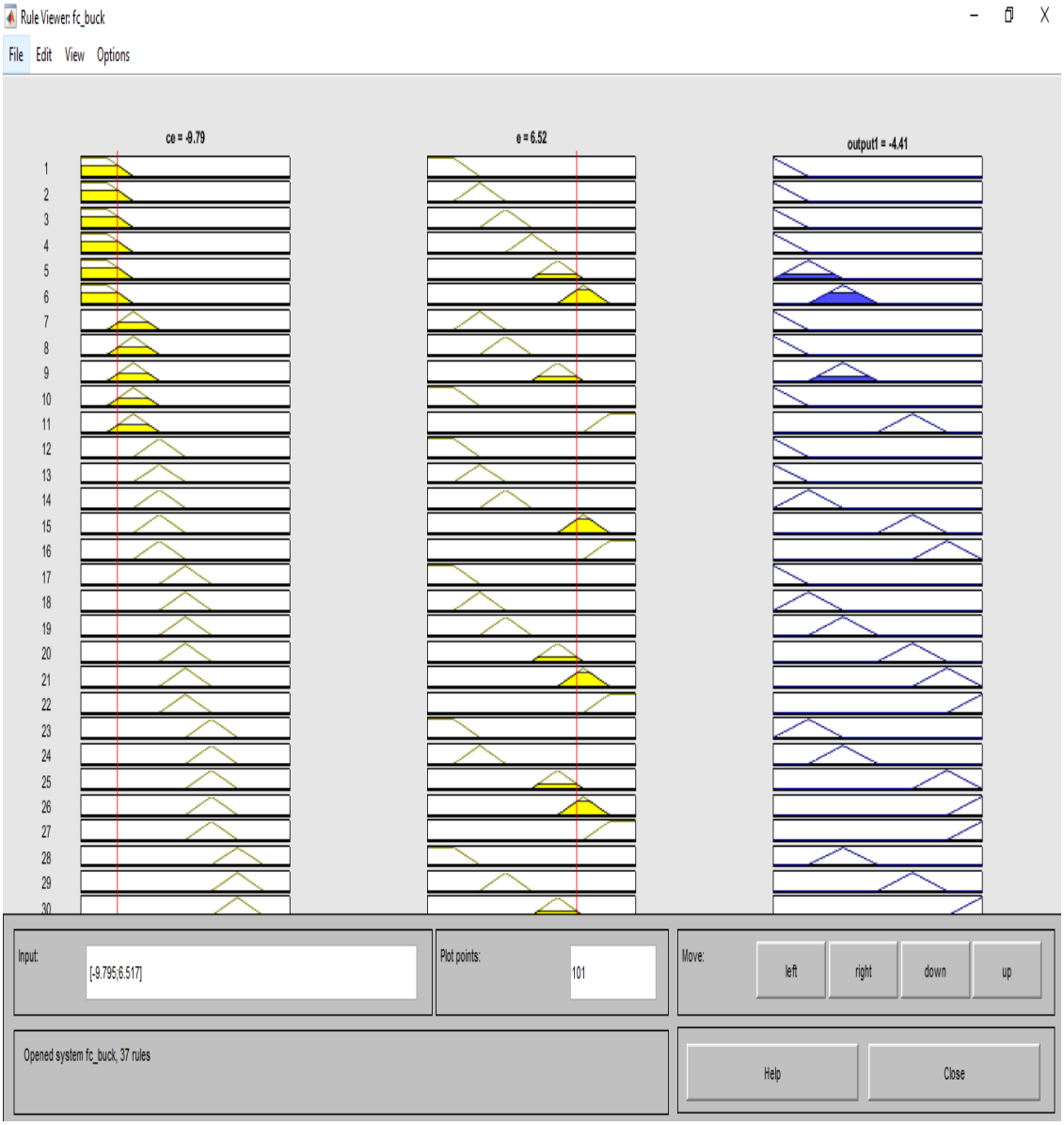

Fig. 9: Fuzzy output 1 for value of ce=-9.79 and e= 6.52, Output=-4.41

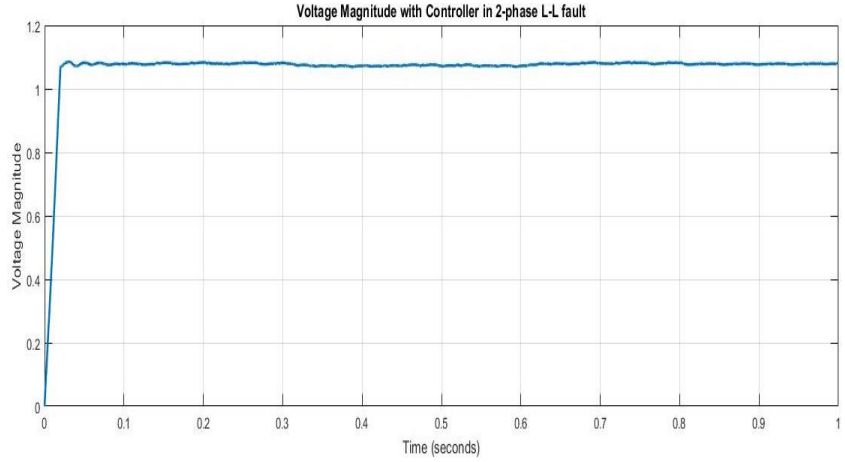

Fig. 10: Voltage magnitudes with a controller in 2 phase line to ground fault

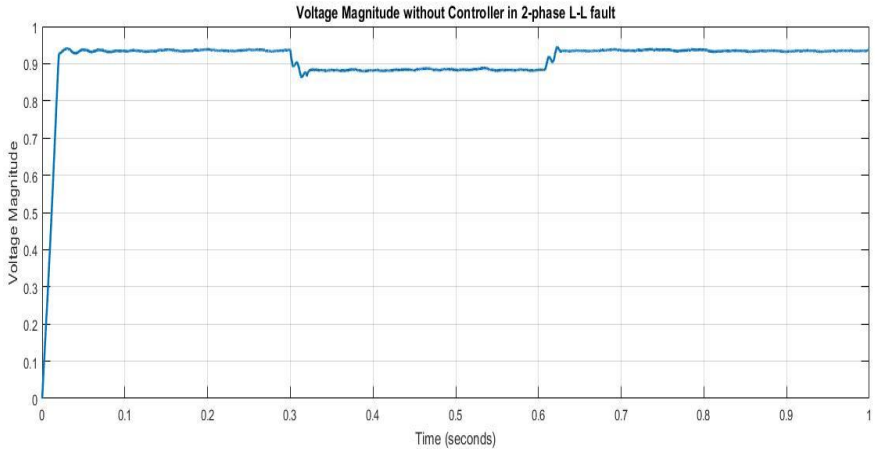

Fig. 11: Voltage magnitudes without a controller in 2 phase line to ground fault

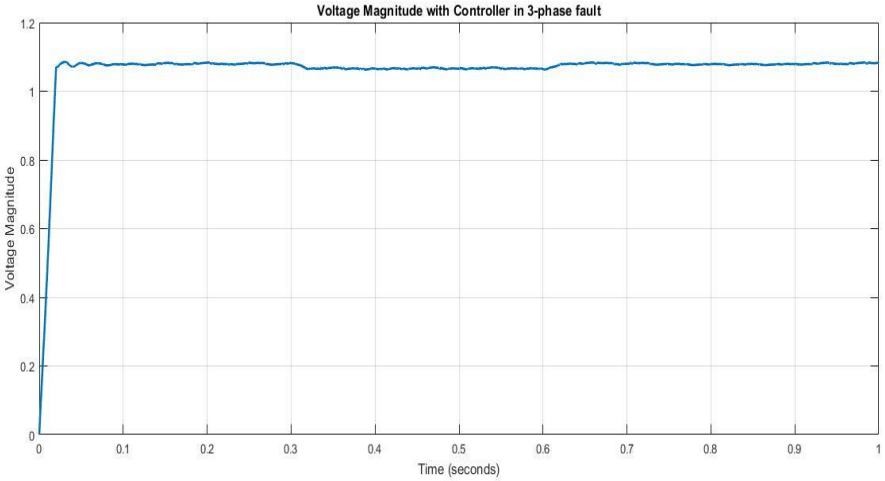

Fig. 12: Voltage magnitudes with a controller in 3 phase line to ground fault

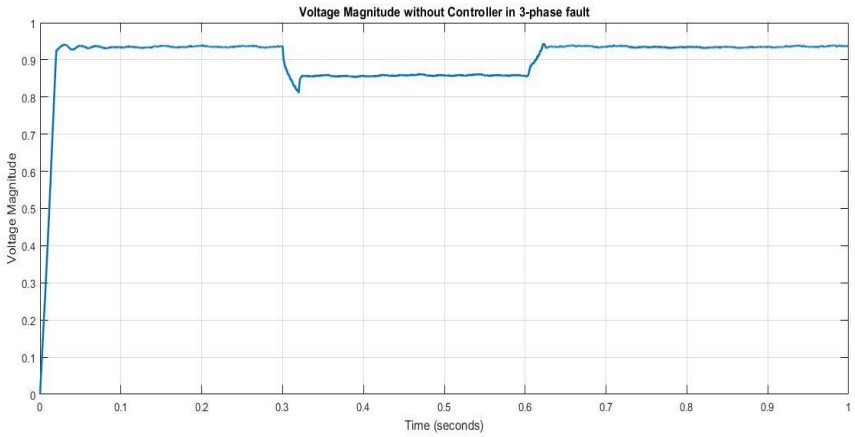

Fig. 13: Voltage magnitudes without a controller in 3 phase line to ground fault

5. CONCLUSION

With the pace of time, tremendous technology came into existence. Researcher always tries to develop the latest technology which will be beneficial for society having low cost, maximum efficiency and easy to understand. In our dissertation work fuzzy logic technique used with PI controller in a STATCOM to enhance the stability of a grid-connected wind farm. The supervisor varies the gain of the PI controller during the transient period in a way that improves the system performance. The system has been modeled and simulated in the MATLAB 2016a technical environment with a case study. In our research work, different cases have been a study for example with the controller and without a controller, with spwm and without spam and various fault cases. Simulation results show that there are some sections which are improved as compared with base paper. First of all, there is an enhancement in power quality and which is a very crucial factor. Besides this, there are some crucial factors which are enhanced in our research work like reactive power compensation (snag and swelling) executed very efficiently and maintain the voltage profile. Further, this research work can be extended with neural network and artificial intelligent on real-time data.

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