iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** IV **Month of publication:** April 2018

DOI: http://doi.org/10.22214/ijraset.2018.4703

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IV, April 2018- Available at www.ijraset.com

Impact of Distributed Generation on Voltage Profile in Deregulated Distribution System by using Integration of Fuzzy Logic controller with SVC

Ramji Prasad[1], Dr. Sourabh Maheshwary[2], Mr. Ameer Faisal[3]
[1, 2] Doon College of Engineering & Technology Saharanpur U.P
[3]Krishna Institute of Engineering & Technology Ghaziabad, U.P
Dr. A.P.J. Abdul Kalam Technical University Lucknow, U.P
[1]Student M.Tech. 4th sem (Electrical Power System), [2]Ph.D., [3]M.Tech.

***Abstract:** in order to fulfill the rising electrical power demand, reliability, service quality and pollution reduction, the existing power grid infrastructure should be developed into a smart grid that has the flexibility to allow interconnection with the distributed generation. Although with the expansion of renewable energies as distributed generation (DG) has positive impact on voltage profile in Grid system, but integration of a large number of distributed generator causes voltage deviation beyond a controllable limit. Hence SVC is used in grid connected system to make system stable and more reliable by eliminating the fluctuation in voltage caused by sudden connection of DG in to the grid. But SVC takes more time to gain steady state. Thus to address the issue of time delay in gaining voltage stability, a fuzzy logic controller has been integrated along with SVC. A comparative analysis between SVC and integrated Fuzzy logic controller based SVC (FLCSVC) has been done towards addressing voltage stability issue. It has been found FLCSVC as superior than SVC.*
***Keywords:** Distributed Generation, Static Var compenastor, PI controller, Fuzzy logic controller, 5-Bus system.*

I. INTRODUCTION

With the rapid development of industries and growing of electric energy consuming continually, it is important to operate the system in safe mode and providing economic, reliable and significant quality power for society and industry. intensive use of fossil fuel consumption increases emissions of carbon dioxide and leads to global warming .Recently for the suppression of global warming and sustainable development, renewable energy such as wind generation and photovoltaic(PV) are getting attention worldwide. Therefore, rapid increase in the form of distributed generators as source of energy. Due to integration of distributed generation in power systems, reactive power could vary accordingly. This phenomenon may lead to voltage discrepancies and could affect system stability. SVC as one of the advance compensating devices for reactive power support can also be used for voltage improvement distributed Generated system (DGS) based on various renewable energy resources is the important approach to the development of clean energy, improving the reliability of power supply and enlargement of the power system capacity. Compared to the traditional centralized power supply system, DGS has many advantages: simple start-stop, good peak shaving, in order to load balance and less investment, yield quicker result, and able to fulfill power supply demand in the special occasion and less transmission loss, improving disaster level[4]. The large scale increase of DG into the DN has a major effect on DN planning and operation. As the power system network is growing in size and covering a vast geographical area, it has become essential to maintain stability between various parts of interconnected systems. The study of transient stability involves the effect of severe network planning a difficult task. Connection of DG fundamentally modifies DN operation and brings a variety of chronicle impacts with voltage rise being the major effect, specially in weak DN. This is because the commercial as well as the technical operating and planning framework within which DN's are presently managed were not conceived with DG in mind. This significantly limits the amount of DG that can be interconnected. Traditionally DN's were designed to operate radically without any generation on the network. The interconnection of DG on the DN may have an important impact on the flow of active and reactive power, on voltage and on fault current levels. In an attempt to overcome negative dynamic impacts caused by wind speed changes, the voltage regulation and reactive power compensation problem is approached here not only for a conventional aspect, but also a FACTS based as well [1]. Wind power plant induction generator is viewed as a consumer of reactive power. Its reactive power consumption depends on active power production. Traditionally, shunt capacitor banks are connected at the generator terminal to compensate its reactive power consumption disturbs. When stability is lost, there will be a wild fluctuation in voltage, current and power. during this time parallel operation may not work properly and the units may start trapping .the stability problem begins whenever there is an imbalance between the mechanical input and electrical power output or vice versa. Due to this disturbance, the tendency of the rotor is to accelerate or decelerate. When the rotor is accelerating or decelerating the speed is above or below the synchronous speed. Due to this variation in speed, the parallel operation may not happen satisfactorily. The objective of transient stability is to retain the load angle to its steady state value after the clearance of the disturbance. In this paper we have introduced a new model to improve the control mechanism of SVC with the help of Fuzzy logic controller. The designed model is tested on a 3 machine 5 bus power system model using MATLAB Simulation. We have analyzed it by using the new controller subjecting it to a three phase fault. It has been identified that the transmission power capability can be increased and the voltage profile can be improved by using reactive var compensation [11],[12]. Most of the reactive var compensation incorporate power electronics based static controllers and FACTS devices [7]. FACTS devices are characterized as series, shunt and combination of these two controllers [9],[6]. Reactive var compensation is generally used at the midpoint of the systems to prevent voltage instability as well as to damp power oscillations [13].The PI based controllers are not suitable for non-linearity. Unlike PI controller Fuzzy logic based controller has an advantage over PI controller under non-linear characteristics [8],[5]. The content is as follows: section II talks about the operation of SVC and its operating waveforms. Section III introduces the basics of Fuzzy logic controller; its input output membership functions, Rule base and Fuzzy Inference system. Section IV shows the results obtained through the Fuzzy logic based controller using SVC. Section V shows the conclusion obtained from the above results and future work to be done in the area of neural network based fuzzy logic controller.

II. SVC OPERATION, CONTROL AND WAVEFORMS

Static Var Compensator (SVC) is a shunt connected FACTS device, which can be used in Voltage control mode or Var control mode. Static term is used to indicate that SVC has no rotating part unlike synchronous machine. by controlling the reactive var of the system SVC is used in voltage control mode where it is connected. SVC have the capability of drawing leading or lagging var to control the voltage fluctuation or voltage regulation in the system. In case of dip in the voltage it supplies reactive power and if there is a rise in the voltage then it absorbs reactive power. So the SVC can be used as both source or sink of reactive Var in accordance to the need of system.

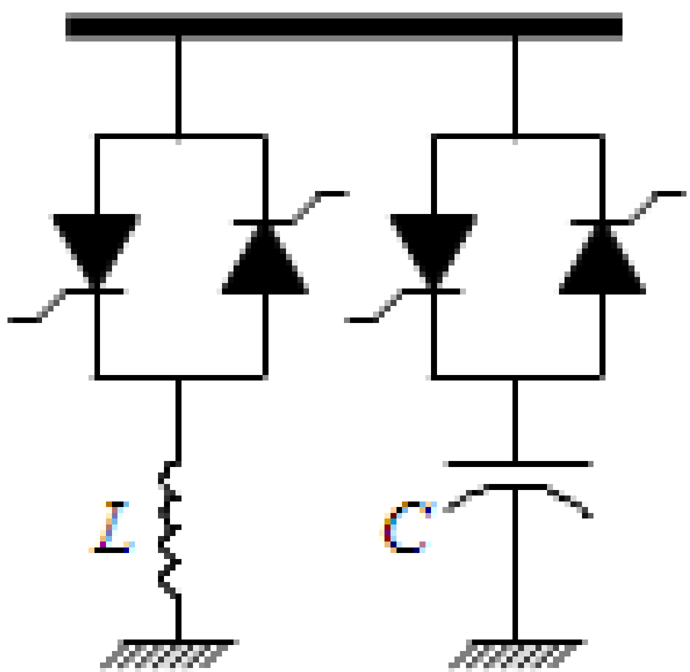


Fig. 1.Structure of SVC

As shown in fig.1 the SVC comprises of fixed or switched capacitor bank in parallel with switched reactor bank. The reactive power can be controlled by switching the capacitor bank with the help of Thyristor switched capacitor (TSC) and by controlling the reactor bank with the help of Thyristor controlled reactor (TCR).

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IV, April 2018- Available at www.ijraset.com

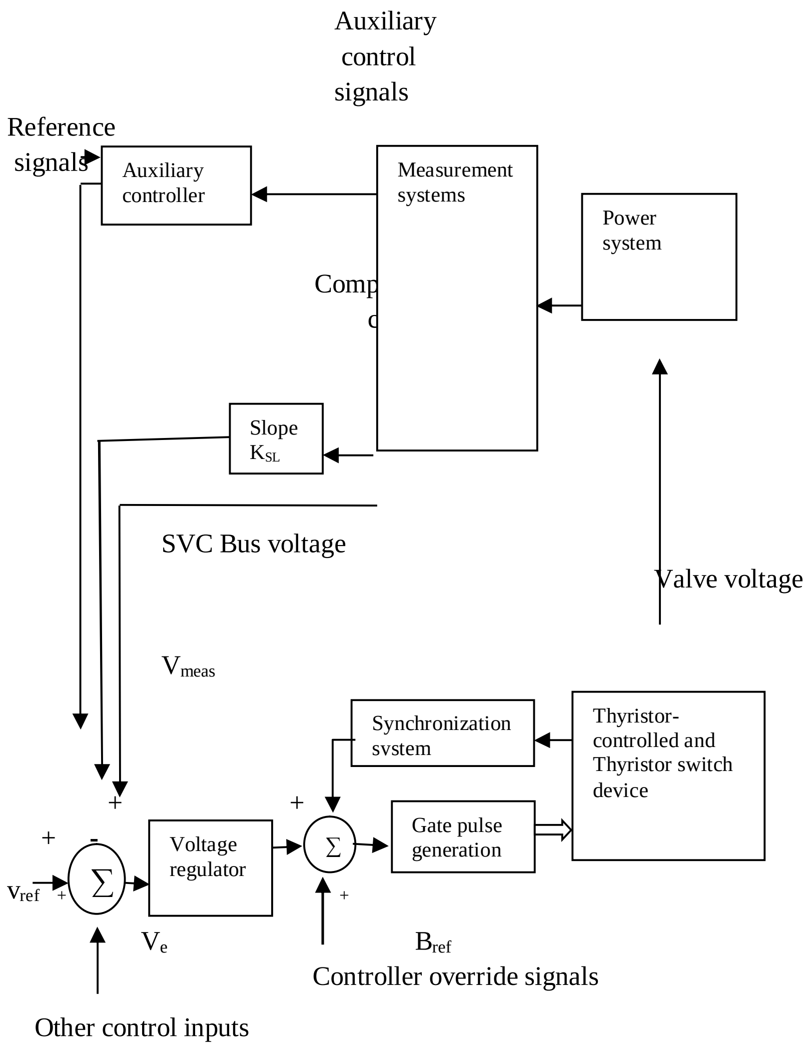


Fig. 2.diagram of an SVC control system

The control system of general SVC with TSC-TSR configuration[14]. incorporating voltage regulator and reactive power measurement is described in Fig.2. The diagram shows that the measurement system obtains current, voltage and other signals from the power system. The main objective measurement system's is confirm that all the inputs are proportional for stable operation, which is compulsory for the system. It has three distinct mode controls: voltage, reactive power and auxiliary. The voltage control maintains the system to the voltage within acceptable limits, especially at the point of common coupling (PCC), since it is very important for voltage regulation of the systems. for performing this, the voltage regulator processes that is all measured input variables must creates an output signal that is proportional to reactive-power compensation. The measured variables are then compared with the voltage reference signal, denoted as V_{ref}, and the error evolve as an input variable for the controller. The output of the controller creates a per-unit susceptance signal, which is denoted as B_{ref}, to reduce undesired signal error to zero in the steady-state operation; the signal is then transferred to the gate-pulse generation. The output signal (B_{ref}), derived from the voltage regulator, is transferred to the gate-pulse generation, which creates proper firing pulses for TCR-TSC of the SVC Fig.4. Subsequently the undesired susceptance signal is rectified and the desired susceptance output is available at the SVC bus Fig.5.

The operating waveforms are given below:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IV, April 2018- Available at www.ijraset.com

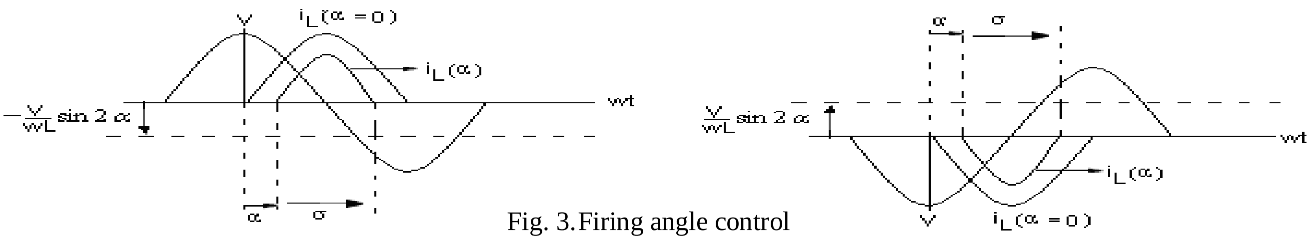


Fig. 3.Firing angle control

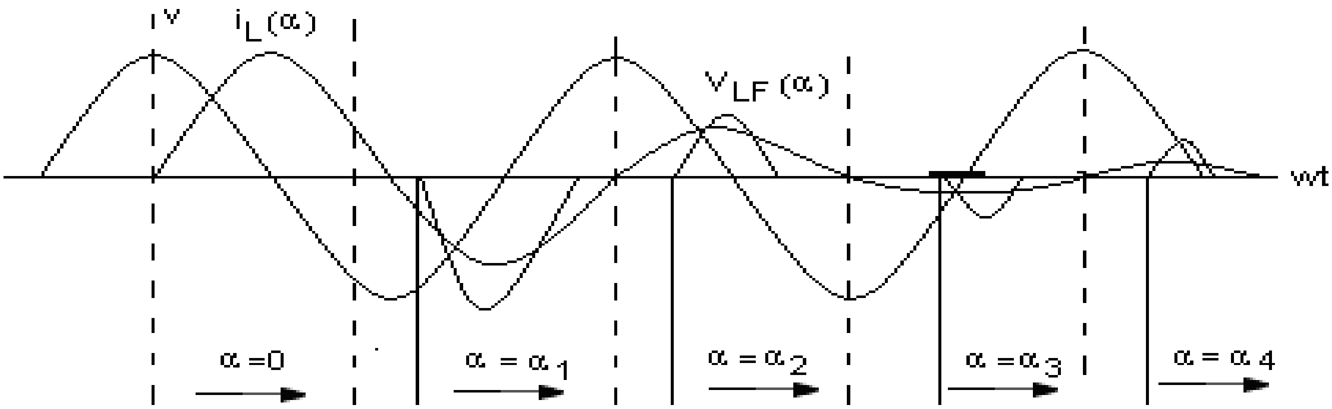


Fig. 4.Operating waveforms

Fig.3 shows the reactor current varied from its maximum value (at $\alpha = 0$) to zero value (at $\alpha = \pi/2$). Here the terms $i_L(\alpha)$ and $i_LF(\alpha)$ represent the reactor current and its fundamental

III. FUZZY LOGIC CONTROLLER

The work of Fuzzy Logic controller is rule based, where a set of rules shows a control mechanism to solve the effect of certain problems coming from power system. It is a Fuzzy code designed to control something, usually mechanical. They can be in software or hardware and can be used in anything from small circuits to large mainframes. Mostly a fuzzy controller has at least 2 inputs and one output. In this paper, the inputs to the fuzzy logic controller are the error in the voltage and change of error, while its output acts as the control signal.

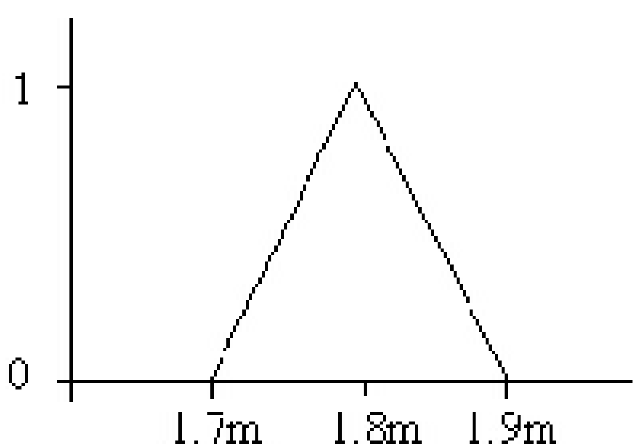
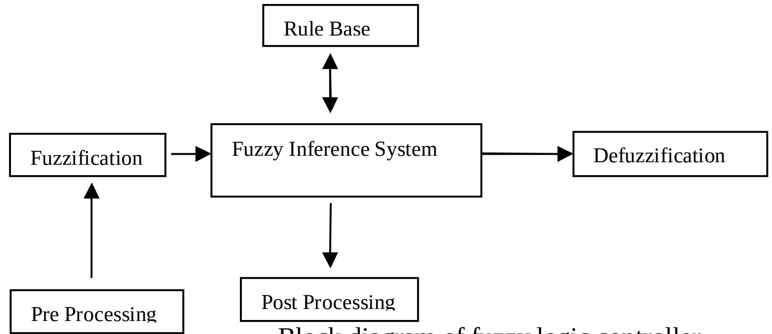


Fig. 5.Structure of Fuzzy Logic Controller

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IV, April 2018- Available at www.ijraset.com

Block Diagram of Fuzzy Logic Controller



Block diagram of fuzzy logic controller

A. Fis (fuzzy inference system) Consists of the Following Components

1) Input variables
2) Fuzzification through membership functions
3) Rule-base (if/then rules)
4) Defuzzification through membership function
5) Output variables

B. Input Variable

Input variables are employed as controlled variables, which have a certain fixed value called set point t make the system oscillation free and stable.

C. Fuzzification

Fuzzification is described as a conversion of real input to fuzzy set values. For eg. Medium(x) = 0 if X >=1.90 or X < 1.70 (1.90 – X)/0.1 if X >= 1.80 and X <1.9 (X – 1.70)/0.1 if X >= 1.70 and X < 1.80

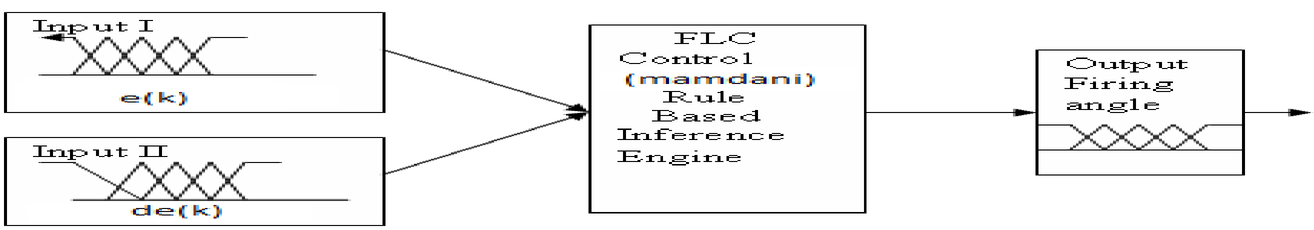


Fig. 6.Fuzzification of input

Different types of parameterized membership functions commonly used are

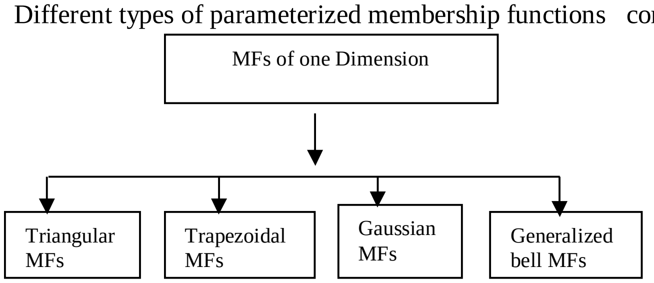


Fig. 7.Types of membership functions

C. Rule Base

The Rule Base is described as a “If Then” format wherein the ‘If’ side represents the condition and the Then ‘side’ represents conclusions.

Rule 1: If error in voltage, e(k) is LN and error change de(k) is OZ, then the output is LN.
Rule 2: If error in voltage, e(k) is OZ and error change

de(k) is OZ, then the output is OZ.

TABLE I. Rule Base Of Fuzzy Controller

e[k]			
	LN	**OZ**	**HN**

Where LN = LOW, OZ = OK, HN = HIGH

D. Defuzzification

The task of Defuzzification is to find one single crisp value which summarizes the fuzzy set which is obtained from the inference block. Different mathematical techniques that are used to perform this are. Centroid Method, (ii) Centre of Sums, (iii) Weighted Average Method

IV. RESULTS AND ANALYSIS

The network, shown in Fig.9. is the single line diagram of a 5-bus system connected to grid and SVC
nder investigation. The system, connected in a loop configuration, consists of five buses (B1 to B5) interconnected through transmission lines (L1, L2, L3) and two 500 kV/230 kV transformer banks Tr1 and Tr2. Line L1 is used as double circuit line to increase the power transfer capacity by lowering the inductance of line. Two power plants located on the 230-kV system generate a total of 2200 MW which is transmitted to a 500-kV 15000-MVA equivalent and to a 200-MW load connected at bus B3. A speed regulator, an excitation system as well as a power system stabilizer (PSS) is included plant models. In normal operation, most of the 1200-MW generation capacity of power plant 2 is exported to the 500-kV equivalent through three 400-MVA transformers connected between buses B4 and B5.

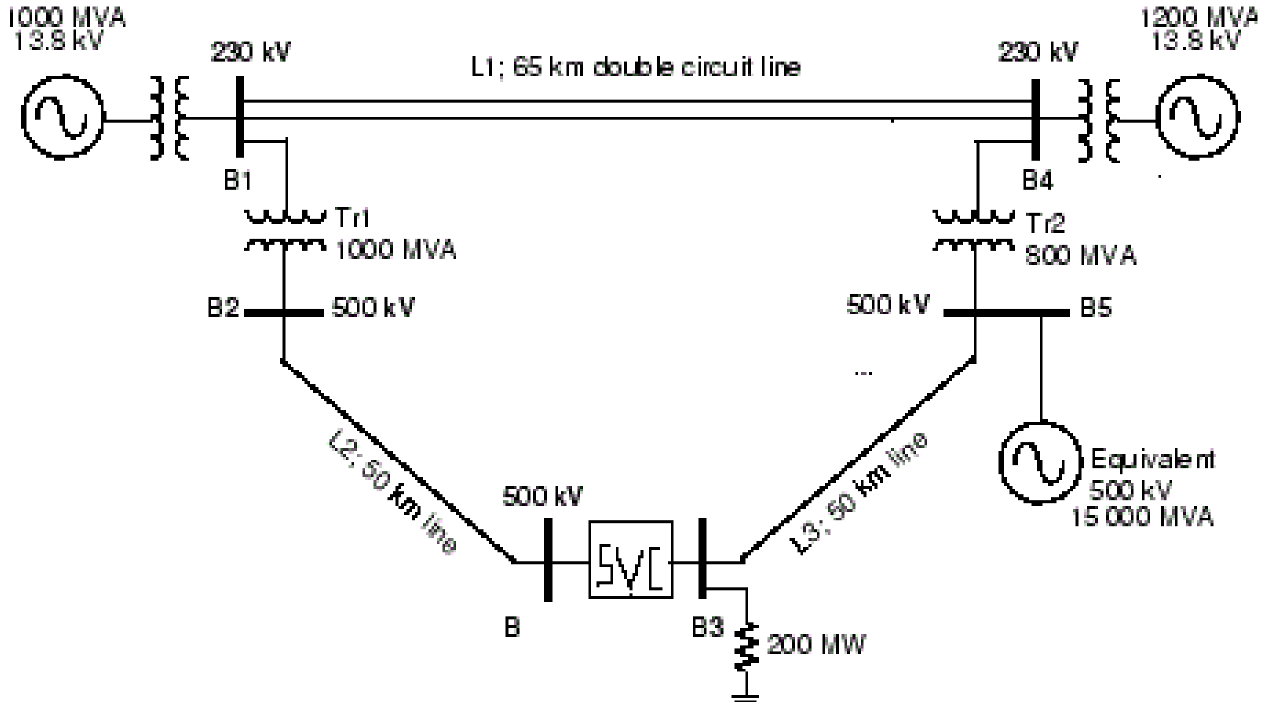


Fig. 8.Single Line diagram of 5-bus system with SVC

[2].However,VSC technology need use of self commutating semiconductor devices which are more costly, have higher losses and low voltage ratings when compared to the thyristors [3].

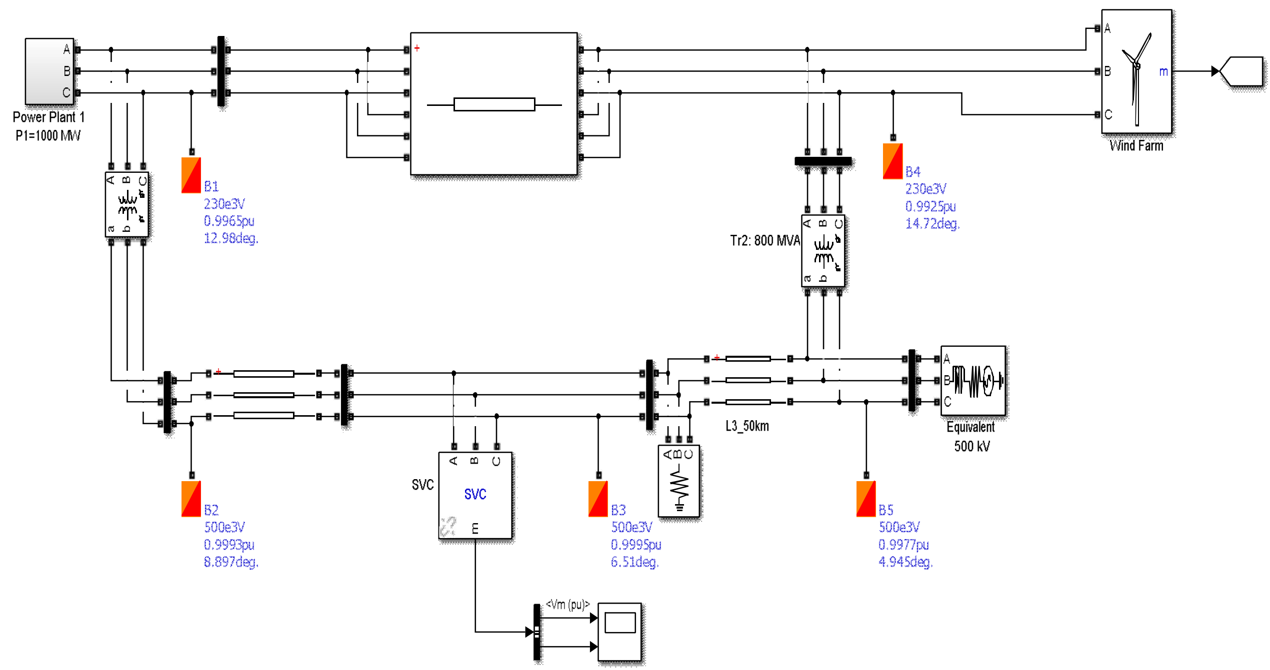


Fig. 9.Simulink model of 5- bus Grid connected system with DG and SVC

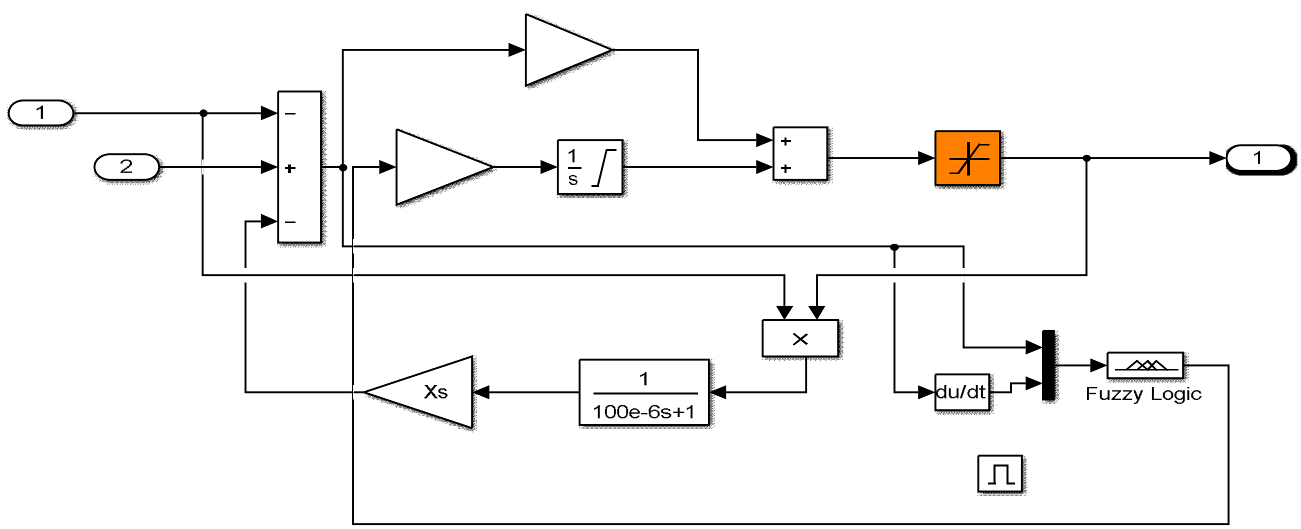


Fig. 10. Voltage regulation with the help of Fuzzy logic controller

is observed that, during the point of contact of the distributed generation system to the grid, the voltage experiences a considerable amount of transients in all the buses. For the sake of transient stability of buses we connect Fuzzy logic controller with PI controller as shown in Fig.11. along with SVC. The following graphs that have been plotted from the MATLAB Simulink platform is an attempt to summarize the impacts of SVC alone and with fuzzy logic controller on transient stability of five buses, 3 machine system. implementation of SVC improves voltage profile of all buses in the system but it takes about 2.6 seconds to filter out transients from buses. Fig.12. and Fig.13. Shows the graphs between buses voltage (p.u) Vs time (sec.). In order to achieve stability earlier, we introduce a fuzzy logic controller with SVC and observe that transients get filtered out after about 1.8 seconds and the voltages of all buses becomes constant equal to 1 p.u therefore making the system stable Fig.13.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IV, April 2018- Available at www.ijraset.com

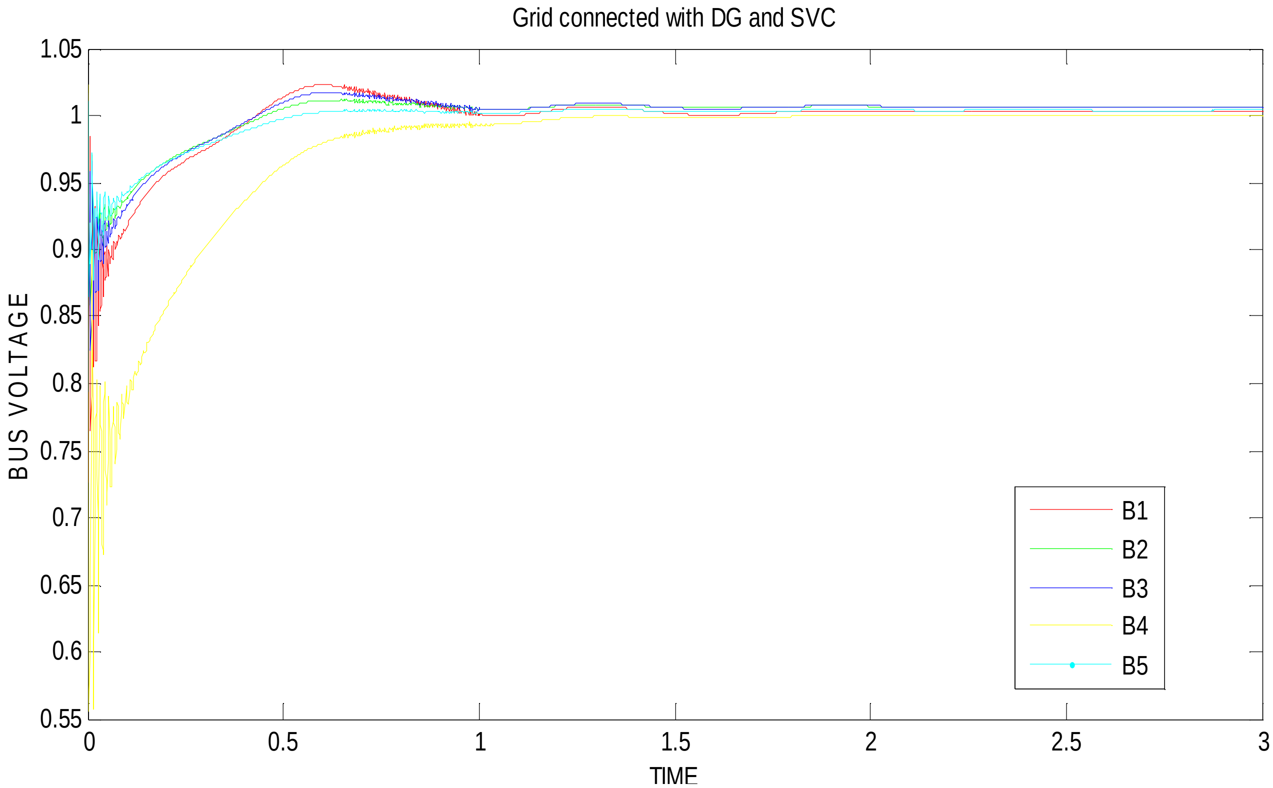


Fig. 11. 5-bus system Voltage Profile of grid connected With DG and SVC

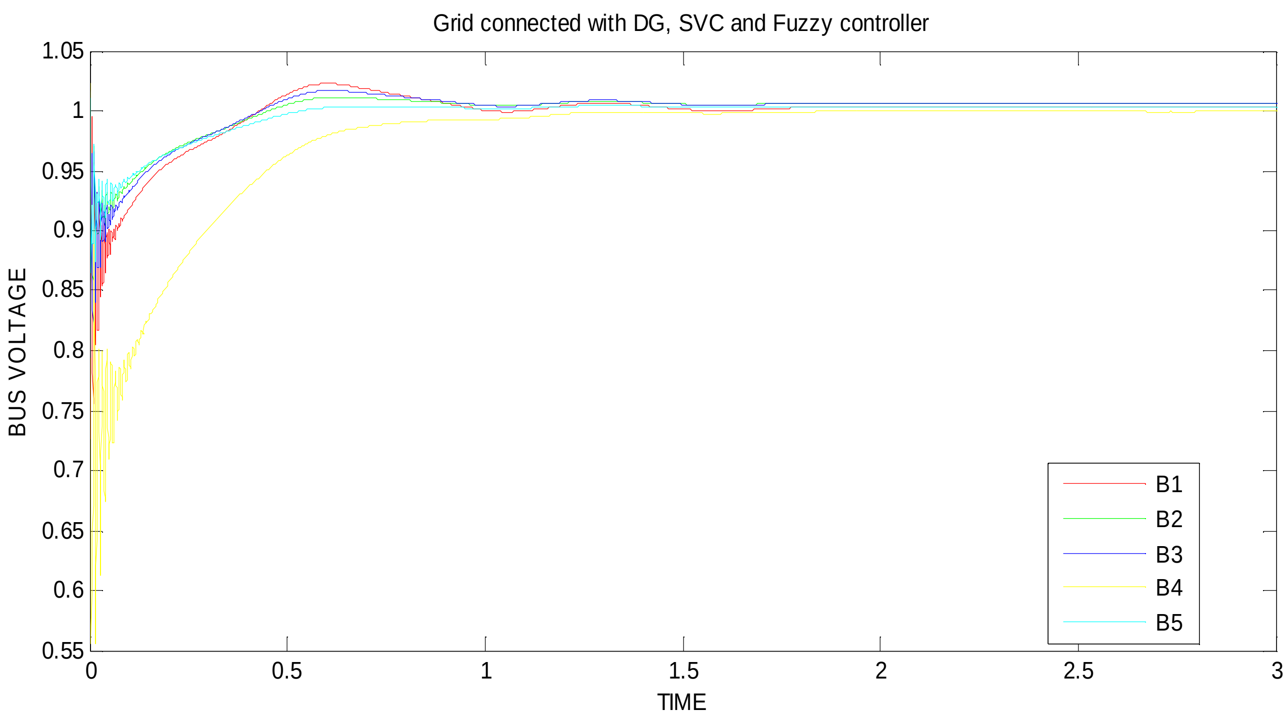


Fig. 12. 5-bus system voltage profile with grid connected ,SVC and fuzzy controller

V. CONCLUSION

Interconnection of a large number of distributed generation system in grid, definitely has set up a series of new problems, some of them firmly related to system power quality, reliability and stability. It is concluded that the introduction of distributed generation in a power system causes power stability issues in terms of the voltage, frequency and load angle of the grid to which the DG is connected. It is obvious that connecting distributed generation in a network requires an advanced control device which is demanding to secure high reliability and stability of the power system. In this paper, the SVC mechanism is controlled with fuzzy logic based 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 performance of designed controller is compared with the conventional SVC and it is seen that the fuzzy based controller has enhanced the transmission line power stability during the disturbances. The performance of the fuzzy logic based controller is reliable and is quite stable.

REFERENCENS

[1] Vito Calderaro, Vincenzo Galdi, Francesco Lamberti, and Antonio Piccolo, “A Smart Strategy for Voltage Control Ancillary Service in Distribution Networks”, IEEE Transactions on Power Systems, Vol. 30, No. 1, January 2015
[2] K. R. Padiyar, FACTS Controllers in Power Transmission and Distribution, New Age International, 2007
[3] X.-P. Zhang, C. Rehtanz, B. Pal, Flexible AC Transmission Systems: Modelling and Control, Springer, 2006, Berlin.
[4] Jia Yao-qin, Yang Zhong-qing, Cao Bing-gang, Research on Distributed Renewable Energy Power System, Power Electronics, 39(4): 1–4, 2005
[5] A.Kazemi and M.V.Sohrforouzani, “Power system damping using Fuzzy controlled FACTS Devices”, International conference on Power system Technology, POWERCON 2004, Singapore.
[6] P.L. So, T. Yu, “Coordination of TCSC and SVC for Inter area stability Enhancement” IEEE Trans. On Power Delivery , Vol. 9, No. 1, 2000.
[7] H. Ying, Tito Mamdami, “Fuzzy PI/PD Controllers as Nonlinear, Variable Gain PI/PD controllers”, International Journal of Fuzzy System, Vol. 2, No. 3, September 2000.
[8] C. A. Canlzares, Z. T. Faur, "Analysis SVC and TCSC Controllers in Voltage Collapse", IEEE Trans. Power Systems, Vol. 14, No. I, February 1999, pp. 158-165.
[9] A.A Edris, R Aapa, M H Baker, L Bohman, K Clark, “Proposed terms and definitions for flexible ac transmission system (FACTS)”, IEEE Trans. on Power Delivery, Vol. 12, No.4, 1997, pp.1848-1853
[10] B T Ooi, M Kazerrani, R Marcean, Z Wolanski, F D Galiana, D.Megillis, G. Joos, “Mid point sitting of FACTS devices in transmission lines”, IEEE Tran. On Power Delivery, Vol.1 No.4, 1997, pp. 1717-1722
[11] P. Kundur, Power System Stability and Control. New York, McGraw Hill, 1994
[12] IEEE Committee Report: 'Bibliography of static VAr compensators-Working Group 79.2 on static VAr compensators in A.C. substations committee', IEEE Trans., 1983, PAS-102, (12), pp. 3744-3752
[13] CIGRE working group 01 of study Committee 31: “Modelling of static shunt VAR systems (SVS) for system analysis”, Electra, 1977, 51
[14] Tarang sharma ,Anil Dahiya “Transient Stability Improvement in Transmission Line using SVC with Fuzzy Logic based TID Controller” IEEE conference IICEPE-2014

.