Enhanced Power and Neutral Current Elimination in DSTATCOM Based Distribution System using Modified Fuzzy Controller

Anju Tiwari[1] , Prof. Minal Tomar[2]
[1]*M-Tech Research Scholar Department of Electrical Engineering*
[2] *Sr. Asst. Professor Department of Electrical & Electronics Engineering*

Abstract - The Power Quality Analysis aspires to bring out electricity consumers for improved power quality with application of power electronics. The research work involves in-depth analysis of the interaction among loads, power networks and various power quality improvement devices. It ultimately leads to better design of mitigation devices like Distribution Static Synchronous Compensator (DSTATCOM) and Fuzzy Logic Controller (FLC) to alleviate various power quality related problems. While compensating, the transient response of the DSTATCOM is very important for nonlinearly varying and unbalanced loads. Conventionally, a Proportional Integral (PI) controller is used to maintain the DC voltage at the reference value. The transient response of this controller is very faster than compared to that of the conventional DC voltage controller. The Fuzzy Logic Controller (FLC) based DSTATCOM has been implemented and it has been verified that its transient response is better than the PI Controller response.

Keywords - DSTATCOM, FLC, Neutral Current, Load Balancing, Power Distribution.

I. INTRODUCTION

One of the most common power quality problems today is voltage dip. A voltage dip is a short time (10 ms to 1 minute) event during which a reduction in rms voltage magnitude occurs. It is often set only by two parameters, depth/magnitude and duration. The voltage dip magnitude ranges from 10% to 90% of nominal voltage (which corresponds to 90% to 10% remaining voltage) and with a duration from half a cycle to 1 min. In a three-phase system. voltage dip by nature is a three-phase phenomenon, which affects both the phase-to-ground and phase-to-phase voltages. A voltage dip is caused by a fault in the utility system a fault within the customer's facility or a large increase of the load current. like starting a motor or transformer energizing.

Improved power quality is the driving force for today's modern industry. Consumer awareness regarding reliable power supply has increased tremendously in the last decade. This has lead to an additional thrust to the development of small distributed generation. Small isolated DG sets have the capability to feed local loads and thus lads to improvement in reliability of power with low capital investment. These systems are also gaining increased importance in isolated areas where transmission using overhead conductors or cables is unrealistic or prohibitive due to excessive cost. Small generation systems in hilly terrains, islands, off shore plants. power distribution in rural areas, aircrafts etc. can be efficiently utilized even in developing countries.

However, these DG sets may have to be de-rated if induction motor loads are simultaneously started. One useful option is to use DSTATCOM in shunt configuration with the main system so that the full capacity of generating sets is efficiently utilized. DSTATCOM employs a voltage source converter (VSC) and generates capacitive and inductive reactive power internally. Its control is very fast and has the capability to provide adequate reactive compensation to the system.

II. DSTATCOM

DSTATCOM can he effectively utilized to regulate voltage for one large rating motor or for a series of small induction motors starting simultaneously. Induction motor loads draw large starting currents (5. 6times) of the full rated current and may affect working of sensitive loads.

Thyristor based systems were initially proposed for reactive power compensation and were used for voltage flicker reduction due to arc furnace loads. However, due to disadvantages of passive devices such as large size, fixed compensation. possibility of resonance etc.. the use of new compensators such as DSTATCOM is growing to solve lower quality problems.

The use of DSTATCOM for solving power quality problems due to voltage sags. flickers, swell etc has been suggested. The purpose of DSTATCOM is to provide efficient voltage regulation during short duration of induction motor starting and thus prevent large voltage dips.

A centralized grid for instance, aids much transmission and distribution congestion that makes it more inefficient and unreliable. Additionally, there is a contentious risk for failure to meet peak demand periods often served by inefficient power plants operating over a very short period of time (a few hours-per-year). These factors, added to increased power consumption due to population growth further stretch the traditional grid to its limits, raising serious concerns on economic impact of blackouts and interruptions being witnessed today. While most recently the Indian grids failure which affected half of the country with hundreds of millions hit by power cut caused by excessive power absorption, leading to massive snags in rail transport and medical facilities.

The distribution system is relatively perceived as an interface between the bulk and the custom powers, whose control objective is to strike a balance between the two for maintaining continuous healthy operation of the system. A good distribution control system is therefore expected to enhance the overall system efficiency through loss reduction and power quality control. Presently, distribution system equipment such as the tap changing transformers, synchronous machines, capacitor banks, static volt-ampere-reactive compensators (SVCs), and many other flexible ac transmission systems (FACTS) controllers at device level, including DSTATCOM are being applied for such control.

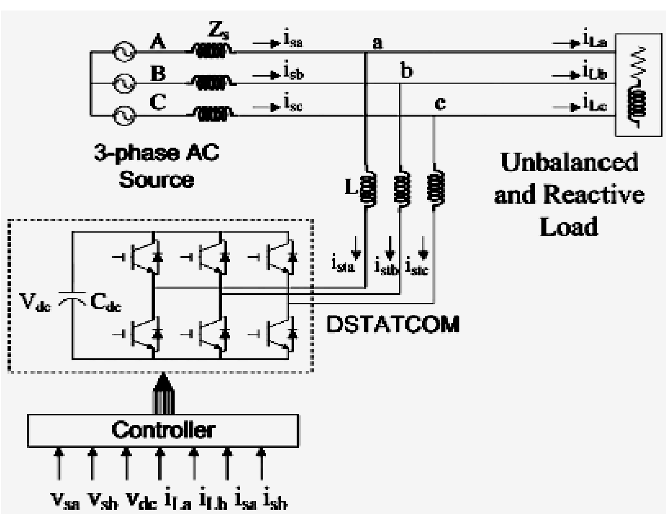

Fig. 1.1 Block Diagram of DSTATCOM

Though, there are numerous challenges facing the area at the moment in terms of the smart-grid de-centralizing functionality which include: voltage and reactive power compensation (now known as Volt-VAR optimization); distribution system automation (DSA); power factor correction (PF); phase current balancing; integrate-able low loss transformers (to improve efficiency), distributed resources (typically, between 1kW - 50MW), and dispersed energy storage facilities (normally sited at consumer loads), which call for radical change in the type of controllers designed in these equipment for general system power quality improvement. To understand this phenomenon, the losses regarding distribution lines and transformers have been classified into resistive and reactive components. While, resistive load losses are unavoidable, reactive load losses which emanate from capacitive and inductive circuit properties (cancelling each other) can be avoided. In a very large quantity, the reactive power increases distribution line currents being responsible for further energy losses. The distribution transformers often operate at efficiency higher than 98%, thus making their core losses negligible. Though, transmission and distribution system losses together constitute 9% of the total from generation to the consumer's feeder. Out of this figure only 2 - 3% of the losses is attributable to the feeder lines and coupling transformers. The current wave of smart grid evolution, a number of multinational electricity companies are actively investing into DSTATCOM technologies with the hope of integrating such within the smart grid context.

III. PROPOSED MODEL WITH FUZZY LOGIC

The simulation model proposed in this paper having DSTATCOM consists of the transformer, Voltage Source Converter and a fuzzy controller is shown in below Fig. 3.1 and 3.2 respectively. A static synchronous compensator (STATCOM) is one of the most operative solutions to regulate the line voltage. The STATCOM consists of a voltage source converter connected in shunt with the power system and permits to control a leading or lagging reactive power by means of correcting its ac voltage. A STATCOM for installation on a distribution power system called DSTATCOM, has been researched to clear voltage fluctuations and voltage flickers.

Fuzzy control is a control method based on fuzzy logic. Just as fuzzy logic can be described as “computing with words rather than numbers. Fuzzy control can be simply described as “control with sentence rather than equations”. Controllers based on fuzzy logic give the linguistic strategies control conversion from expert knowledge in automatic control strategies.

The development of control system based on fuzzy logic involves the following steps:

1. *Fuzzification strategy*
2. *Knowledge base*
3. *Rule base elaboration*

4. *Fuzzy inference*
5. *Defuzziffication strategy.*

Fuzzy Logic Controller has advantages over the PI Controller. It does not require an accurate mathematical model can work with imprecise inputs, it can handle non-linear functions and it is more robust. As per the simulation results presented in following sections show that the Fuzzy Logic Controller have a better dynamic behavior than the PI Controller.

The FLC based compensation scheme eliminates voltage and current magnitude of harmonics with good dynamic response.

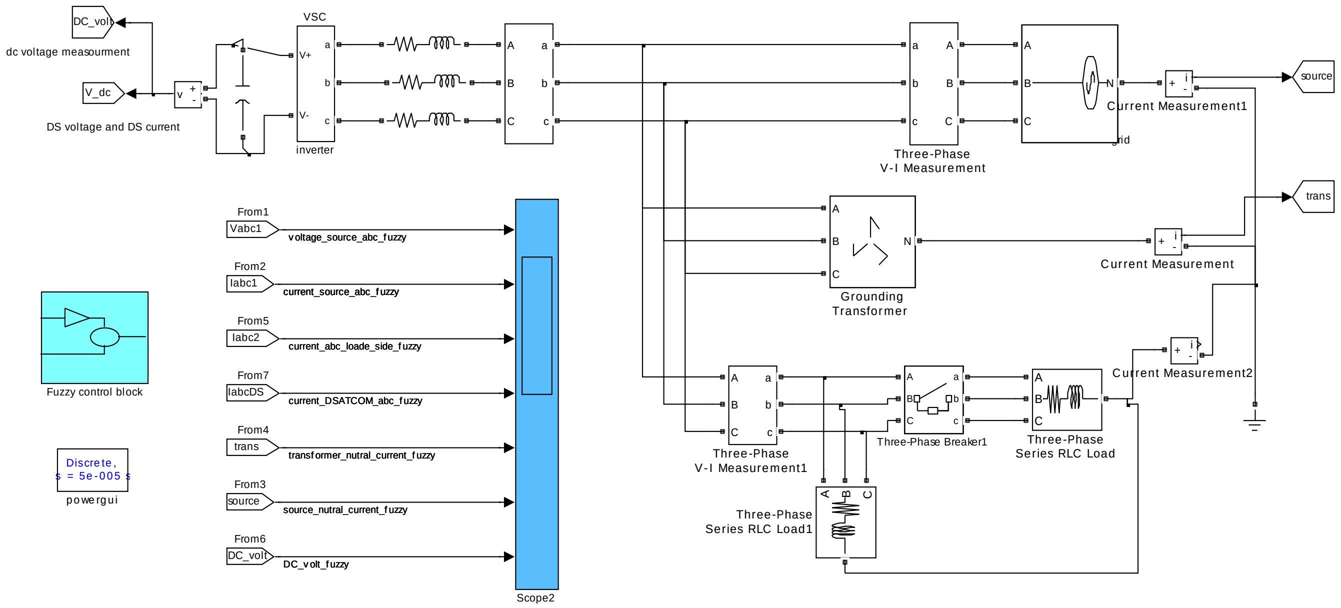

Fig. 3.1Proposed DSTATCOM Distribution Model with Fuzzy Control Block

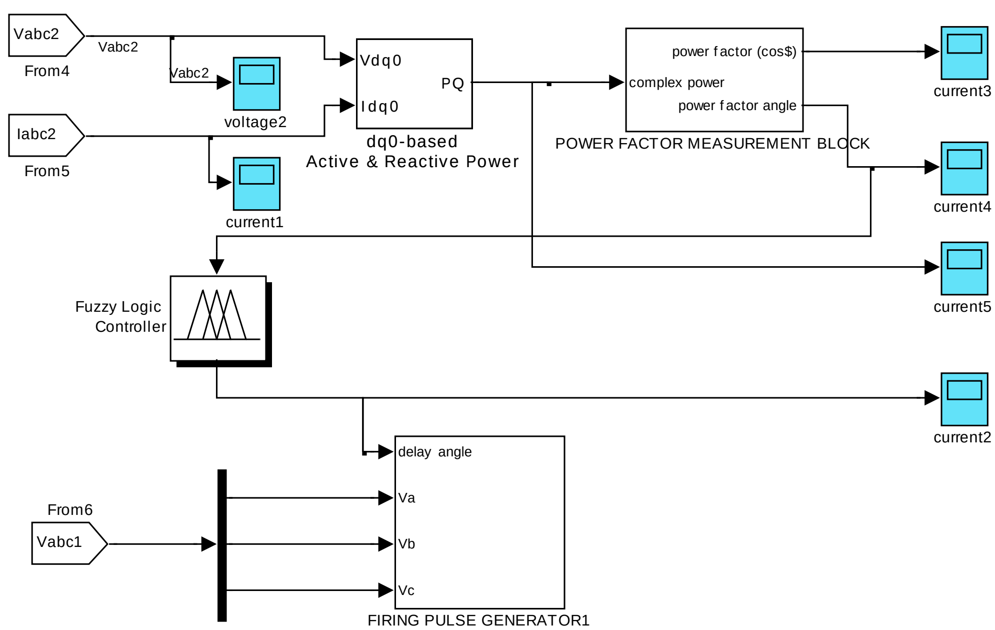

Fig. 3.2 Proposed Fuzzy Control Block

IV. SIMULATION RESULTS

The proposed DSTATCOM distribution network with the fuzzy logic is shown in the previous section and the simulation outcomes are shown here in the below Fig. 4.1.

The first waveform is showing 3-phase source voltage waveform of the proposed system. The second waveform is showing 3-phase source current which has distortions in the initial stage due to capacitor in the compensator block. Third waveform is showing load side current which changes after load applied at 0.2 time. Fourth waveform is compensator current which is sinusoidal as needed for better distribution performance. Fifth waveform is showing transformer neutral current which should be as lower as possible to load balancing and reduce distortions, the neutral current is lower than the existing work which is also proves the proposed system is better than the existing work.

Sixth waveform is source neutral current which is sinusoidal in nature and has lower harmonic distortion than previous work, and last waveform is DC voltage is quite straight than the existing work and is advantage factor of proposed system.

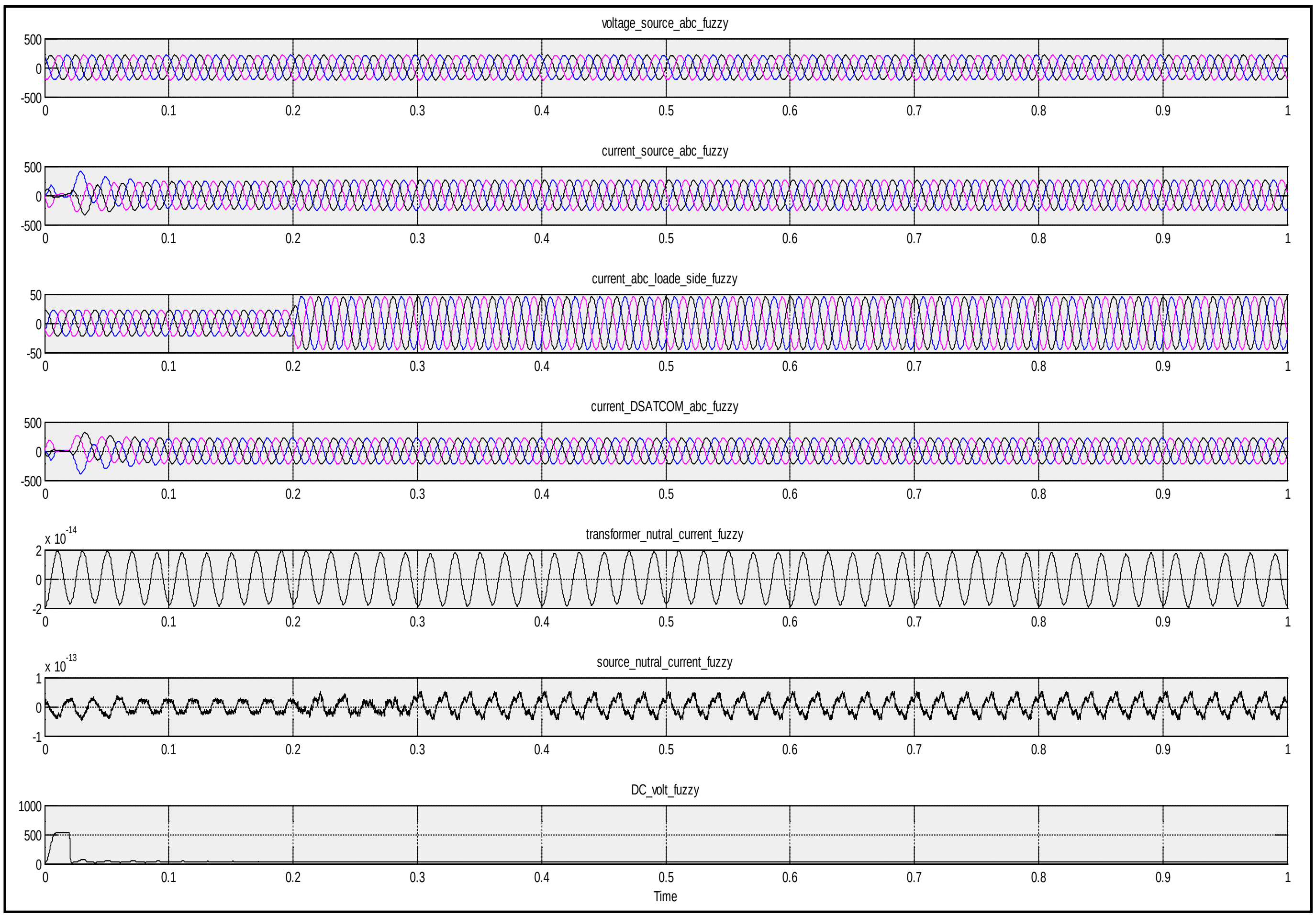

Fig. 4.1 Simulation Waveforms of the Proposed DSTATCOM Distribution Model with Fuzzy Logic. (a) Source Voltage, (b) Source Current, (c) Load Current, (d) Compensator Current, (e) Transformer Neutral Current, (f) Source Neutral Current and (g) DC Voltage.

V. CONCLUSION AND FUTURE SCOPE

The ability of the STATCOM device in compensating the power system and stabilize the bus voltage with no transient disturbances on the power system during the transition of increasing or decreasing the power compensation. We have proposed a design procedure of fuzzy-based DSTATCOM controller for providing neutral current elimination, power balancing, reducing harmonic distortion and voltage regulation during distribution. The demand for electric power is increasing at an exponential rate and at the same time the quality of power delivered became the most prominent issue in the power sector. Thus, to maintain the quality of power the problems affecting the power quality should be treated efficiently. Among the different power quality problems, neutral current is one of the major one affecting the distribution network. The future outcomes can be enhanced with the applications of passivity controllers with fuzzy logic.

REFERENCES

[1] Ahmed M. Massoud, Shehab Ahmed,Prasad N. Enjeti and Barry W. Williams “Evaluation of a Multilevel Cascaded-Type Dynamic Voltage Restorer Employing Discontinuous Space

Vector Modulation" IEEE Transactions on industrial electronics, vol. 57, no. 7, july 2010.

[2] Amit Kumar Jindal, Arindam Ghosh and Avinash Joshi,"Interline Unified Power Quality Conditioner", IEEE Transactions on power delivery, vol. 22, no. 1, january 2007.

[3] Amruta N. Jog, Narayan G. Apte, "An Adaptive Hysteresis Band Current Controlled Shunt Active Power Filter", 2007 IEEE.

[4] Anish Prasai and Deepak M. Divan, "Zero-Energy Sag Correctors—Optimizing Dynamic Voltage Restorers for Industrial Applications", IEEE Transactions on industry applications, vol. 44, no. 6, november/december 2008.

[5] Anshuman Shukla, Arindam Ghosh and Avinash Joshi, "State Feedback Control of Multilevel Inverters for DSTATCOM Applications", IEEE Transactions on power delivery, vol. 22, no. 4, october 2007.

[6] Anshuman Shukla, Arindam Ghosh and Avinash Joshi "Control Schemes for DC Capacitor Voltages Equalization in Diode-

[7] Clamped Multilevel Inverter-Based DSTATCOM", IEEE Transactions on power delivery, vol. 23, no. 2, april 2008.

[8] Arindam Ghosh and Avinash Joshi,"A New Approach to Load Balancing and Power Factor Correction in Power Distribution System", IEEE Transactions on power delivery, vol. 15, no. 1, january 2000.

[9] Arindam Ghosh and Gerard Ledwich "Compensation of Distribution System Voltage Using DVR" IEEE Transactions on power delivery, vol. 17, no. 4, october 2002.

[10] Arindam Ghosh and Gerard Ledwich, "Load Compensating DSTATCOM in Weak AC Systems", IEEE Transactions on power delivery, vol. 18, no. 4, october 2003.

[11] Arindam Ghosh,Amit Kumar Jindal and Avinash Joshi "Design of a Capacitor-Supported Dynamic Voltage Restorer (DVR) for Unbalanced and Distorted Loads" IEEE Transactions on power delivery, vol. 19, no. 1, january 2004.

[12] Arindam Ghosh and Avinash Joshi,"The Concept and Operating Principles of a Mini Custom Power Park", IEEE Transactions on power delivery, vol. 19, no. 4, october 2004.

[13] Bhim Singh, Jitendra Solanki and Vishal Verma,"Neural Network Based Control of Reduced Rating DSTATCOM", IEEE Indicon 2005 Conference, Chennai, India, 11-13 Dec. 2005.

[14] P. Kundur, "Power System Stability and Control", McGraw-Hill, 1994.

[15] Y.H. Song and A.T. Johns, "Flexible ac transmission systems (FACTS)", The Institute of Electrical Engineers, London, 1999.

[16] N.G. Hingorani and L. Gyugyi, "Understanding FACTS: concepts and technology of flexible ac transmission systems", IEEE Press, NY, 1999.

[17] M.H. Haque, "Damping improvement using facts devices". Electrical Power Syst. Res. Volume 76, Issues 9-10, June 2006.

[18] K. R. Padiyar and A. L. Devi, "Control and simulation of static condenser," in Proc. 9th Annu. Applied Power Electronics Conf. Expo., Feb. 13-17, 1994.

[19] P. Rao, M.L. Crow and Z. Yang, "STATCOM Control for Power System Voltage Control Applications", IEEE Transactions on Power Delivery, Vol. 16, pp. 18-23, 2000.

[20] K. R.P adiyar "FACTS Controllers in power transmission and distribution", New Age International Publishers, 2007.

[21] H. Saadat, "Power System Analysis", McGraw-Hill, 2002.

[22] S.H. Hosseini, A. Ajami, ; , "Transient stability enhancement of AC transmission system using STATCOM," TENCON '02. Proceedings. 2002 IEEE Region 10 Conference on Computers, Communications, Control and Power Engineering , vol.3, no., pp. 1809- 1812 vol.3, 28-31 Oct. 2002.

[23] S.Vishwakarma, R.K Tripathi; , "Transient energy dissipation and damping improvement using STATCOM & SSSC," Power, Control and Embedded Systems (ICPCES), 2010 International Conference on , vol., no., pp.1-4, Nov. 29 2010-Dec. 1 2010.

[24] P. Kumkratug;, "The Effect of STATCOM on Inter-Area Power System Stability Improvement," Computer Modeling and Simulation, 2008. EMS '08. Second UKSIM European Symposium on , vol., no., pp.359-363, 8-10 Sept. 2008.

[25] A. Ghosh, D.Chatterjee; , "Transient Stability Assessment of Power Systems Containing Series and Shunt Compensators," Power Systems, IEEE Transactions on , vol.22, no.3, pp.1210-1220, Aug. 2007.