THREE PHASE FIVE LEVEL INVERTER BASED DSTATCOM USING FLC CONTROL

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Abstract-

STATCOM can provide fast and efficient reactive power support to maintain power system voltage stability. In the literature, various STATCOM control methods have been discussed including many applications of PI controllers. However, these previous works obtain via a trial-and-error approach or extensive studies with a tradeoff of performance and applicability. Hence, control parameters for the optimal performance at a given operating point may not be effective at a different operating point. This project proposes a new control model based on fuzzy logic control, which can self-adjust the control gains during a disturbance such that the performance always matches a desired response, regardless of the change of operating condition. Since the adjustment is autonomous, this gives the plug-and-play capability for STATCOM operation. In the simulation test, the fuzzy logic control shows consistent excellence under various operating conditions, such as different initial control gains, different load levels, and change of transmission network, consecutive disturbances, and a severe disturbance. Here in STATCOM three phase five levels cascaded multilevel inverter is used as a voltage source converter. A threshold value of existing and proposed methods has been compared and the proposed threshold value is less than the existing system. Hence by using the fuzzy logic controller in proposed system reduced the threshold current and voltage values. So that improves the performance of operation in proposed system. The proposed method is simulated in 2013a MATLAB/SIMULINK.

Index terms **–Cascaded multilevel converter, distribution, STATCOM (DSTATCOM), distribution transformer, winding taps, passivity-based control.**

I. INTRODUCTION

In recent years, distribution static synchronous compensators (DSTATCOMs) become more and more attractive in distribution network due to their fast response and small size [1], [2]. They are connected to the utility grid either directly or via a step-up transformer to provide isolation and voltage matching. Three common connection types of DSTATCOM system are summarized in Fig. 1 [3], [4].The attainable capacity of type-I and type-II may reach mega volt-ampere. Therefore, they are suitable for centralized reactive power compensation in medium voltage (MV) or high voltage (HV) systems. However, the coupling transformer in type-I accounts for nearly forty percent of the total weight and its losses can be nearly half of the total losses [5], which make it less favorable than transformer-less structure of type-II. Type-III is popular in customer-side and its typical connection voltage is low, which limits its compensation capacity (kilo volt-ampere).

Hence, it is only suitable for decentralized compensation. With the development of power switches technology, the transformer-less DSTATCOM of type-II seems to be more and more popular. A variety of cascaded multilevel converter (CMC)-based transformer-less DSTATCOM topologies have been proposed in the literatures [5]-[8]. However, a compromise between the cascaded count and the sizing of a CMC module must be made due to the high AC line voltage. If the HV insulated gate bipolar transistors (IGBTs, 3300V, 4500V, 6500V) are chosen, the cascaded count will be decreased and the attainable capacity can be improved. In practice, the HV IGBTs are not so cost-effective. They are not always available on the markets. On the contrary, if we choose the most cost-effective LV IGBTs, the cascaded count, system complexity and unreliability will increase. One way to reduce the number of H-bridges is to decrease the connection point voltage of voltage source converter (VSC) indirectly. The idea is that VSC is connected in series with the passive power filter (PPF) instead of the points of common connection (PCC). A small-rating VSC in series with a tuned *LC* passive filter is proposed in [9] and [10]. A hybrid structure that consists of a thyristor-controlled *LC* (TCLC) in series with VSC is proposed in [11] and [12]. In [13], an improved hybrid DSTATCOM topology where the *LCL* filter followed by the series capacitor is applied.

These kinds of topologies proposed in [6]-[10] are called hybrid-STATCOMs. The voltage rating of the active part (APF/STATCOM) is significantly reduced, because most of the voltage drops on the passive part (*C* or *LC*). However, the coordination control of the active parts and reactive parts is difficult and the dynamic compensation range becomes smaller than the conventional CMC-based DSTATCOM. In [14] and [15] a Y-D multifunction balance transformer-based power quality control system is presented. The VSC is connected to the taps on the windings to eliminate the auxiliary transformer. The approach is interesting and cost-effective, but it is not suitable for three phase power system. Motivated by the structure of autotransformer, a novel integrated DSTATCOM topology was firstly presented in our previous work [16], [17]. DSTATCOM is connected to the taps on the primary windings of the transformer. Three kinds of integrated structures were presented in that paper, but only the multi-group taps structure was discussed in detail.

The compensation mechanism was not clearly described. The winding-taps-injection DSTATCOM (WTI-DSTATCOM) is further developed in this paper. The power transformer is used as the coupling transformer at the same time. The rated voltage of DSTATCOM is reduced, which is helpful to reduce the cascaded count and obtain a lower dc-link voltage. The capacity utilization of the transformer is also improved. Unlike previous work, the major contribution of this paper can be summarized as follows:

1) The compensation mechanism is first elaborated and Validated by both simulation and experimental results. The compensation mechanism consists of two important parts: transformer core saturation problem and winding currents distribution after compensation.

2) The nonlinear passivity based control (PBC) is first introduced to control WTI-DSTATCOM in this paper. Compared with PI controller applied in [17], the robustness are enhanced and the design and tuning process are simplified.

3) A new test bench is developed in this paper. A 7-level CMC-based DSTATCOM with *LCL* filter is designed for current injection.

II.EXISTING SYSTEM

Fig. 1 shows the circuit configuration of the proposed WTI-DSTATCOM. There are three winding taps (labeled as A*i*, B*i* and C*i*) on the primary windings of the Dyn11 connection distribution transformer. *u*SA,B,C and *i*SA,B,C are the three-phase voltage and current of the system. *ula*,*b*,*c* and *ila*,*b*,*c* are the three-phase voltage and current of the load. *u*TA, *u*TB, and *u*TC are the three-phase voltage of the winding taps (connection point voltage). *u*A, *u*B and *u*C are the three-phase voltage of DSTATCOM. *i*TA, *i*TB, and *i*TC are the three-phase injection current. *L*1 is the inductor at the converter side, and *L*2 is the inductor at the grid side. *Cf* is the filter capacitor. *Rd* is the damping resistance, which is used in series with *Cf* to provide passive damping. In Fig.2, the power distribution transformer is also used as the coupling transformer at the same time. Note that there are various connection alternatives for DSTATCOM. Three groups of winding taps labelled as A1-B1-C1, A2-B2-C2, and Am-Bm-Cm (central taps) are shown in Fig. 1. To guarantee the system working normally, the positions of the taps must be symmetrical, i.e. that must satisfy |AA*i*|=|BB*i*|=|CC*i*| (*i*=1, 2, 3…).

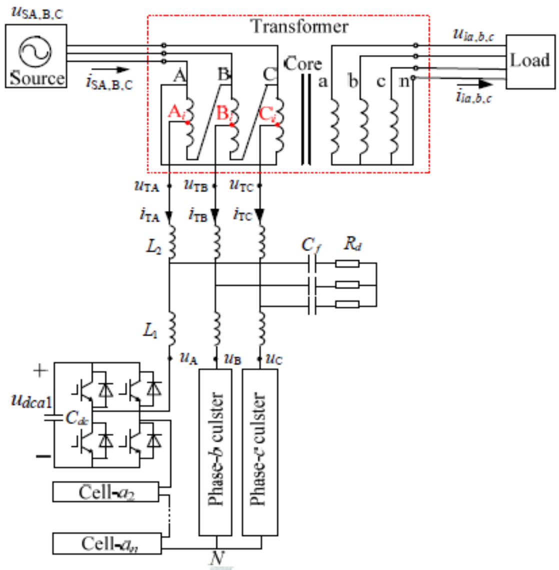


Figure.1 Existing system circuit of WTI-DSTATCOM

A.CONTROL STRATEGY

In this section, a modified nonlinear passivity-based control (PBC) strategy with dc-link voltage balancing control is proposed to control the CMC-based DSTATCOM. Fig. 4 shows the whole control diagram of the system. The control algorithm can be divided into four parts, namely

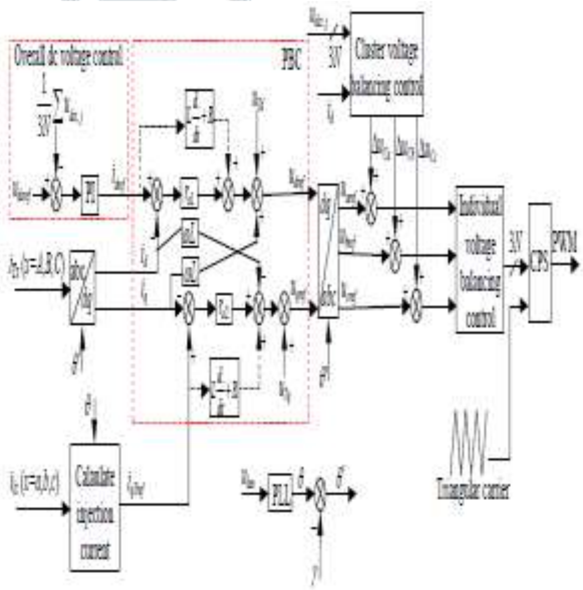


Figure 2. Control Block diagram of the prototype system.

III.PROPOSED METHOD

A. Block Diagram

This project proposes a new control model based on fuzzy logic control, which can self-adjust the control gains during a disturbance such that the performance always matches a desired response, regardless of the change of operating condition. Since the adjustment is autonomous, this gives the plug-and-play capability for STATCOM operation. In the simulation test, the fuzzy logic control shows consistent excellence under various operating conditions, such as different initial control gains, different load levels, and change of transmission network, consecutive disturbances, and a severe disturbance. Here in STATCOM three phase five levels cascaded multilevel inverter is used as a voltage source converter.

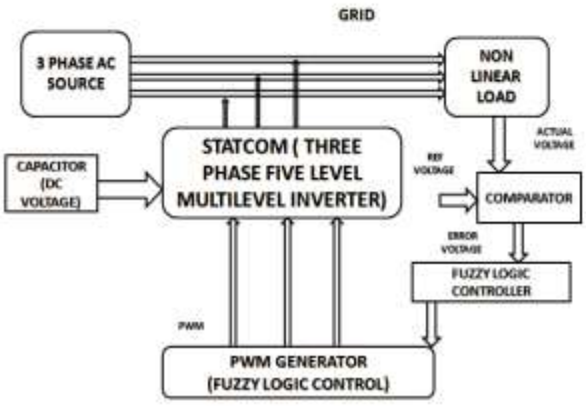


Figure 3.Prposed block diagram

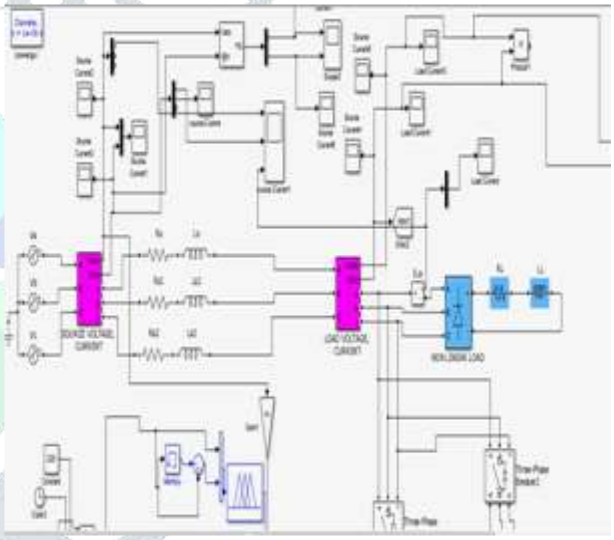
Fuzzy Logic is a particular area of concentration in the study of Artificial Intelligence and is based on the value of that information which is neither definitely true nor false. The information which humans use in their everyday lives to base intuitive decisions and apply general rules of thumb can and should be applied to those control situations which demand them. Acquired knowledge can be a powerful weapon to combat the undesired effects of the system response.

In most applications there are some points which lie in the common area. Information which lies within the common area has to be studied, stored, and used to quantify and to classify the data. This allows for smart manipulation of the data structure in order to make inference to a solution. Information which falls in that common area can be ranked, aged, and "best guess" made after evaluation of this "gray" information. Another advantage of Fuzzy Logic controllers is to quantify the input signal in a sometimes "noisy" environment. This noise, which tends to corrupt the integrity of the actual signal, is dealt with through the common sense of the competent operator. Mathematically, the information must be judged and prepared for use in decision making. If an operator took the time to plot the process information on an X-Y coordinate system, the operator could visually apply a curve fit to the data and come up with a fairly accurate generic representation

Mathematically, fitting a curve of lower order would produce a fairly inaccurate representation. Therefore, a higher order curve fit would be appropriate to accommodate the noisy signal. Fuzzy Logic attempts to emulate what the human response would be and apply the most intelligent fit to the data. Conventional computing is based on Boolean logic, meaning everything is represented as either zero or one. In some situations this leads to oversimplification and inadequate results. Fuzzy logic controllers, and by extension, fuzzy control, seeks to deal with complexity by creating heuristics that align more closely with human perception of problems.

Fuzzy logic provides a way of dealing with imprecision and nonlinearity in complex control situations. Inputs are passed to an "inference engine" where human or experienced-based rules are applied to produce an output.

B. Proposed simulink model

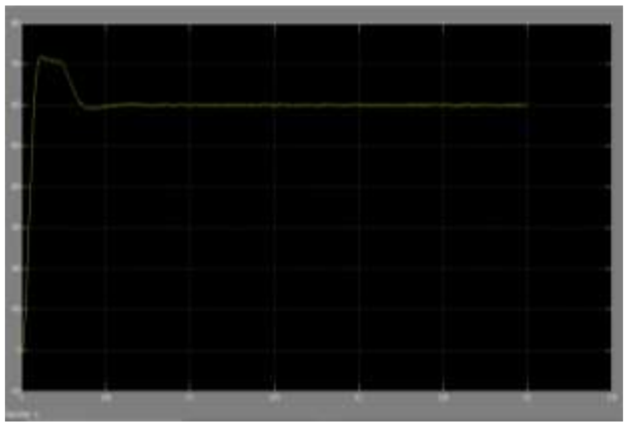


IV SIMULATION RESULTS

4.1 EXISTING SYSTEM

Bridge voltage

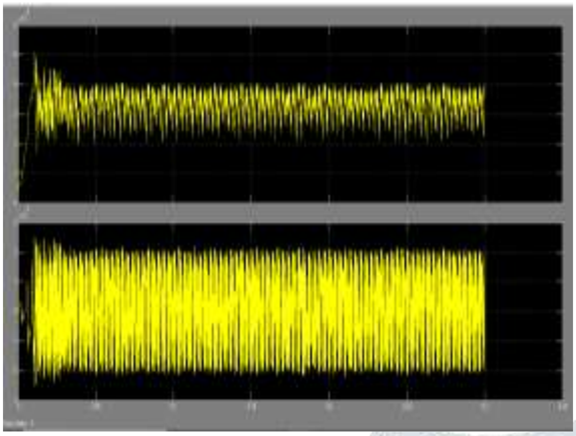
Voltage(V)



Time in Sec

The above figure represents the bridge voltage of the system.

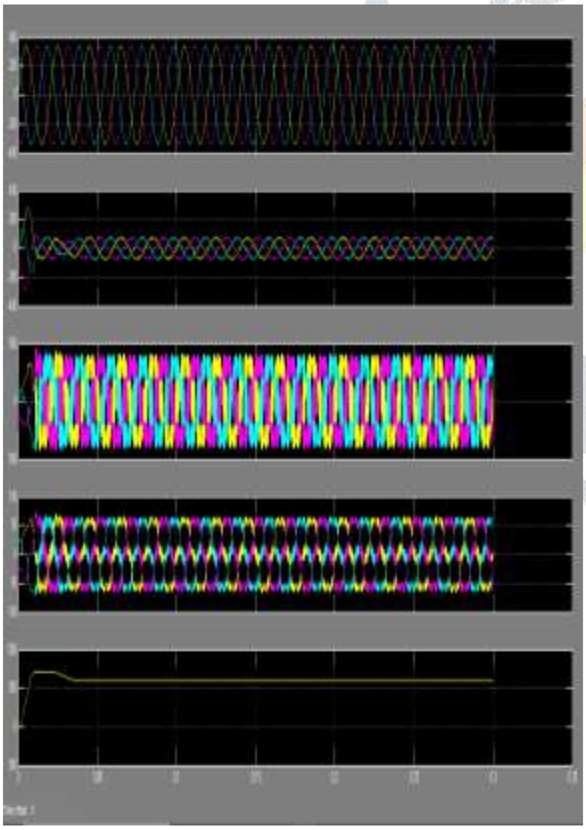
Three phase instantaneous power



Time in Sec

The above figure represents the 3 phase instantaneous power of the system .

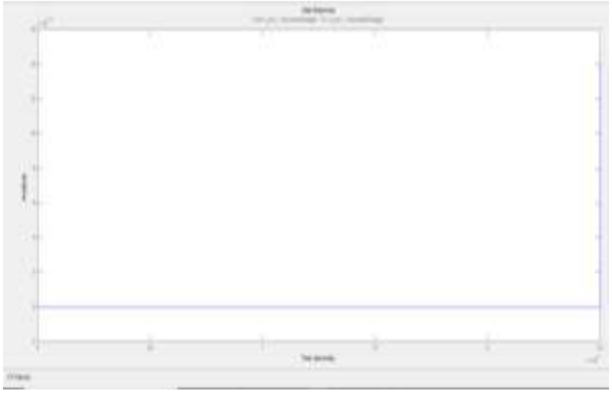
Voltage and current



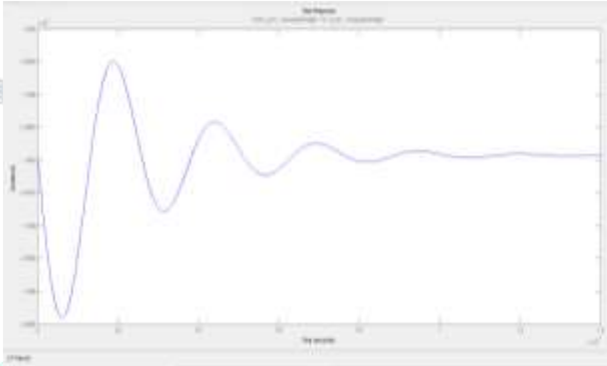
Time in Sec

The above figure represents the voltage and current of the system.

LTI viewer steady state Response



Current (A)



Real Power (W)

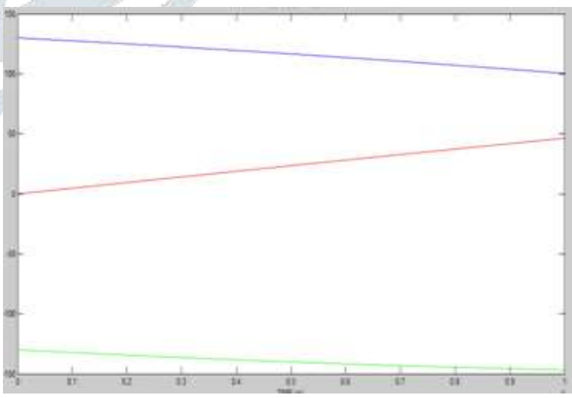
The above figure represents the LTI viewer steady sta response of the system

4.2 PROPOSED SYSTEM

The propsoed results simulated based on sourse code. The corresponding results at diffent points from the proposed simulink model shown below.

Input voltage waveform

Voltage(V)

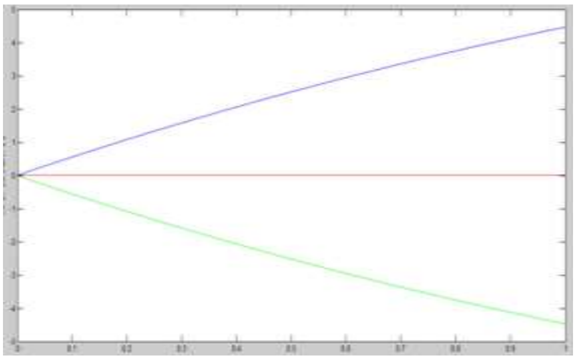


Reactive Power (VAR)

Time in Sec

The above figure represents the input voltage waveform.

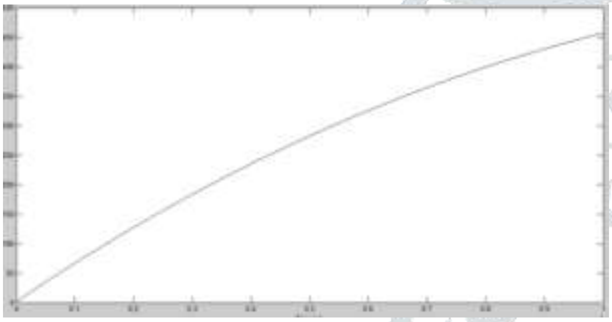
Input current waveform



Time in Sec

The above figure represents the input current waveform.

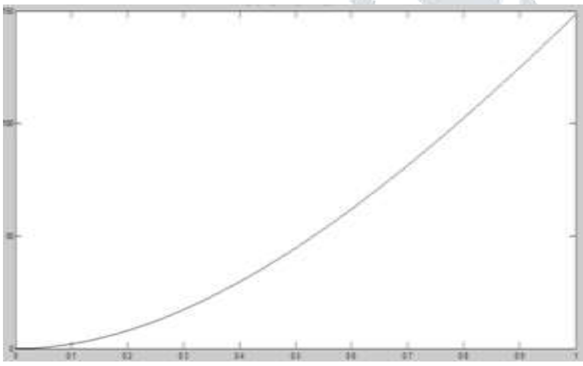
Real power waveform



Time in Sec

The above figure represents the real power waveform.

Reactive power waveform



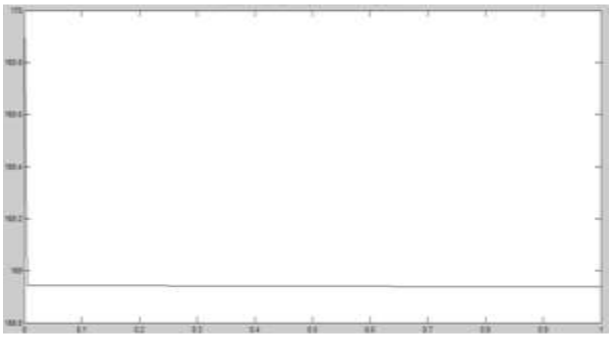
Time in Sec

The above figure represents the reactive power waveform.

DC Voltage at the capacitor

Voltage(V)

Voltage(V)

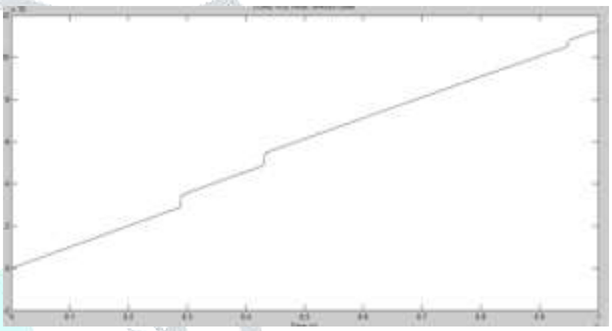


Time in Sec

The above figure represents the DC link voltage in the capacitor waveform.

Voltage at the load

Voltage(V)



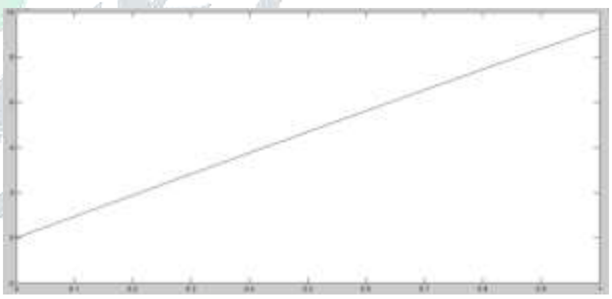
Voltage(V)

Time in Sec

The above figure represents the load voltage waveform.

Current at the load

Current(A)

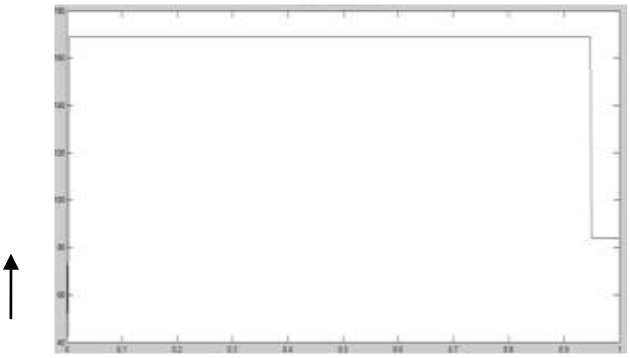


Real Power (W)

Time in Sec

The above figure represents the load current waveform.

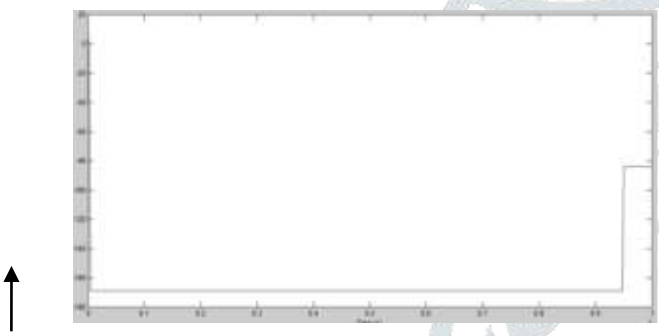
Voltage at the inverter



Time in Sec

The above figure represents the inverter voltage waveform.

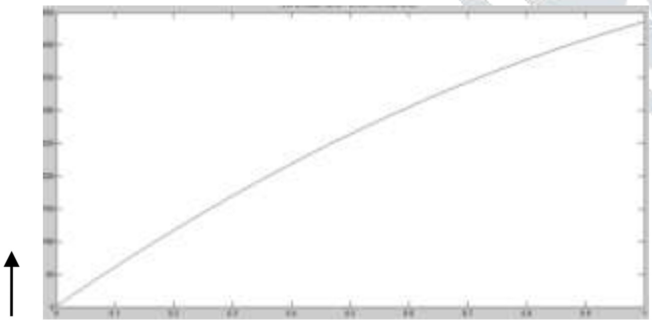
PCC Voltage waveform



Time in Sec

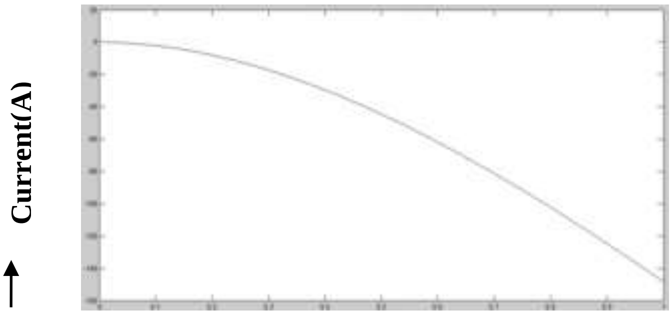
The above figure represents the PCC voltage waveform.

Real power at the load side



Time in Sec

The above figure represents the load side real power waveform.



Time in Sec

The above figure represents the load side reactive power waveform.

4.3 COMPARISON TABLE

S.NO	Type of model	Existing method	Proposed method
1	THD(Current)	8.7	4.3
2	T HD(Voltage)	2.8	1.6
3	Input Voltage, Current	100V, 15A	100V, 15A
4	Power Factor	0.8	0.93
5	Reactive Power	800VA	210 VA
6	Voltage Source Inverter Level	Two Level	Five Level
7	Current Control Technique	Hysteresis Current Control	SRF Theory Based Control Technique
8	Voltage Control Technique	PI Controller	Fuzzy Logic Control

The above table shows the threshold values of existing and proposed methods. It shows the proposed threshold value is less than the existing system. Hence by using the fuzzy logic controller in proposed system reduced the threshold current and voltage values. So that improves the performance of operation in proposed system.

VI CONCLUSION

Hence we conclude that the proposes a new control model based on fuzzy logic control, which can self-adjust the control gains during a disturbance such that the performance always matches a desired response, regardless of the change of operating condition. Since the adjustment is autonomous, this gives the plug-and-play capability for STATCOM operation. In the simulation test, the fuzzy logic control shows consistent excellence under various operating conditions, such as different initial control gains, different load levels, and change of transmission network, consecutive disturbances, and a severe disturbance. And the proposed method improved the performance level compared to the existing level.

REFERENCESS

[1] O. P. Mahela and A. G. Shaik, "A review of distribution static compensator," *Renewable and Sustainable Energy Reviews*, vol. 50, pp. 531-546, 2015.

[2] S. R. A. G. Farhad Shahnia. Static compensators (STATCOMS) in power systems, Springer, 2015.

[3] B. Gultekin and M. Ermis. "Cascaded multilevel converter-based transmission STATCOM: system design methodology and development of a 12 kV ±12 MVAr power stage," *IEEE Transactions on Power Electronics*, vol. 28, no.11, pp. 4930-4950, Nov. 2013.

[4] C. O. Gercek and M. Ermis. "Elimination of coupling transformer core saturation in cascaded multilevel converter-based T-STATCOM systems," *IEEE Transactions on Power Electronics*, vol. 29, no.12, pp. 6796-6809, Dec. 2014.

[5] K. Sano and M. Takasaki. "A transformerless D-STATCOM based on a multivoltage cascade converter requiring no dc sources," *IEEE Transactions on Power Electronics*, vol. 27, no.6, pp. 2783-2795, Jun. 2012.

[6] L. Maharjan , S. Inoue and H. Akagi. "A transformerless energy storage system based on a cascade multilevel PWM converter with star configuration," *IEEE Transactions on Industry Applications*, vol. 44, no.5, pp. 1621-1630, Sep.-Oct. 2008.

[7] H. P. Mohammadi and M. T. Bina. "A transformer less medium-voltage STATCOM topology based on extended modular multilevel converters," *IEEE Transactions on Power Electronics*, vol. 26, no.5, pp. 1534-1545, May 2011.

[8] H. Akagi , S. Inoue and T. Yoshii. "Control and performance of a transformerless cascade PWM STATCOM with star configuration," *IEEE Transactions on Industry Applications*, vol. 43, no.4, pp. 1041-1049, July-Aug. 2007.