DSTATCOM BASED LOAD COMPENSATION OF A DIESEL GENERATOR USING FUZZY LOGIC

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Abstract: The main objective of this paper is to enhance the power quality for grid interfaced Diesel Generation system under some non-linear load conditions using DSTATCOM. This presents the control of distribution static synchronous compensator (DSTATCOM) for reactive power, harmonics and unbalanced load current compensation of a diesel generator set for an isolated system. For obtaining effective compensation characteristics DSTATCOM is designed based on model control theory. In this paper a Fuzzy based DSTATCOM controller is designed and the results are compared with the conventional controllers. This Diesel Generation system is simulated in Matlab/Simulink for both conventional PI and Fuzzy controllers. The control of DSTATCOM is achieved using least mean square-based adaptive linear element (Adaline). An Adaline is used to extract balanced positive-sequence real fundamental frequency component of the load current and a proportional–integral (PI) controller is used to maintain a constant voltage at the DC-bus of a voltage-source converter (VSC) working as a DSTATCOM. Switching of VSC is achieved by controlling source currents to follow reference currents using hysteresis based PWM control .The Fuzzy controller reduces the damping and improves the total harmonic distortions than the PI controller. From the simulation results we can conclude that the Fuzzy based controller can effectively improve the THD than the PI controller and enhances the power quality.

Index Terms - Diesel Generation System, Dstatcom, Fuzzy Controller, Harmonics

I. INTRODUCTION

Now a days the installation of the diesel engine-based electricity generation unit (DG set) is widely used to feed or supply the power to some crucial equipment in remote areas. Normally DG sets used for these purposes or areas are loaded with unbalanced, reactive and nonlinear loads. By using these loads some power quality problems like voltage sag, swell, flickers are occurred. At the point of common coupling the unbalanced and distorted three-phase voltages are occurred due to the unbalanced and distorted currents. Unbalanced currents and harmonics flowing through the generator results in torque ripples at the generator shaft. All of these factor lead to reducing the life of the DG sets, and the DG sets to be operated with derating, which results an increased cost of the system. Now a days in distribution system major power consumption has been reactive loads, such as fans, pumps, etc. These loads draw lagging power-factor currents and therefore give rise to reactive power burden in the distribution system. Excess reactive power demand increases the feeder losses and reduces the active power flow capability in the distribution system, due to unbalancing the operation of transformers and generators are affected. As we using nonlinear loads, these loads may create problems of high input current harmonics and excessive neutral current. The neutral current consists of mainly trip lent harmonics currents. The zero-sequence neutral current obtains a path through the neutral conductor. Moreover, the unbalanced single-phase loads also result in serious zero-sequence fundamental current. Therefore total neutral current consists of both the zero-sequence harmonic component and the zero-sequence fundamental component of the unbalanced load current, and this may lead to overload of the neutral conductor in the three-phase four-wire distribution system. Nowadays, small generator units are available with full conversion (inverter-converter) units to meet stringent power quality norms. Instead of using these, a DSTATCOM can be used with a three- phase DG set to feed unbalanced loads without derating the DG set and to have the same cost involved. Moreover, the DSTATCOM can provide compensation for harmonics which facilitates to load the DG set up to its full KVA rating.

II. CONFIGURATION OF DSTATCOM

Figure 1 shows the block diagram of Distributed Static Compensator. The main purpose of this DSTATCOM converter control technique is used to compensate the deviations in power system for improving power quality. In this paper grid interfaced wind turbine based DSTATCOM control scheme is proposed for improving the reliability of electrical power.

In general, in order to maintain voltage regulation, power factor correction, and harmonics compensation and load leveling the DSTATCOM can be utilized. DSTATCOM is a combination of voltage source converter which is used for controlling and compensating the error signal and the energy storage system is for discharging or delivering the energy required for compensation. And finally the control technique is for controlling the voltage source converters.

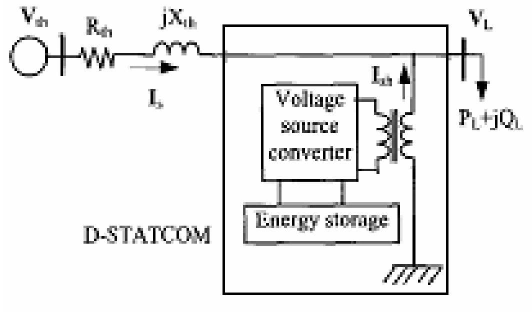


Figure: 1. Block diagram of D-STATCOM

III. Diesel Generator Set using DSTATCOM

For distributing the power to some crucial equipment in remote areas the electrical energy produced by diesel engine-based unit plays an effective role. This type of distribution energy storage systems are loaded with unbalanced loads and non-linear loads. Due to this load variation causes the variations in power system parameters. The source impedance of the DG set is quite high, and the unbalanced and distorted currents lead to the unbalanced and distorted three-phase voltages at point of common coupling (PCC). Harmonics and unbalanced currents flowing through the generator result into torque ripples at the generator shaft. All of these factors lead to the increased fuel consumption and reduced life of the DG sets. These forces the DG sets to be operated with derating, which results into an increased cost of the system. Nowadays, small generator units are available with full conversion (inverter-converter) units to meet stringent power quality norms. Instead of using these, a DSTATCOM can be used with a three-phase DG set to feed unbalanced loads without derating the DG set and to have the same cost involved.

The performance of DSTATCOM is very much dependent on the method of deriving reference compensating signals. Instantaneous reactive power theory, modified p-q theory, synchronous reference frame theory, instantaneous id− *i*q theory, and method for estimation of reference currents by maintaining the voltage of dc link are generally reported in the literature for an estimation of reference currents for the DSTATCOM through the extraction of positive-sequence real fundamental current component from the load current. These techniques are based on complex calculations and generally incorporate a set of low-pass filter which results in a delay in the computation of reference currents and therefore leads to slow dynamic response of the DSTATCOM. In this a fast and simple fuzzy based control scheme is used to estimate reference source currents for the control of the DSTATCOM. This technique presents a DSTATCOM for the load compensation of a diesel generator set to enhance its performance. The control of DSTATCOM with capabilities of reactive power, harmonics and unbalanced load compensation is achieved by Least Mean Square (LMS) algorithm based adaptive linear element (Adaline). The Adaline is used to extract positive-sequence fundamental frequency real component of the load current. The dc-bus voltage of voltage source converter (VSC) is supported by a proportional–integral (PI) controller which computes current component to compensate losses in DSTATCOM.

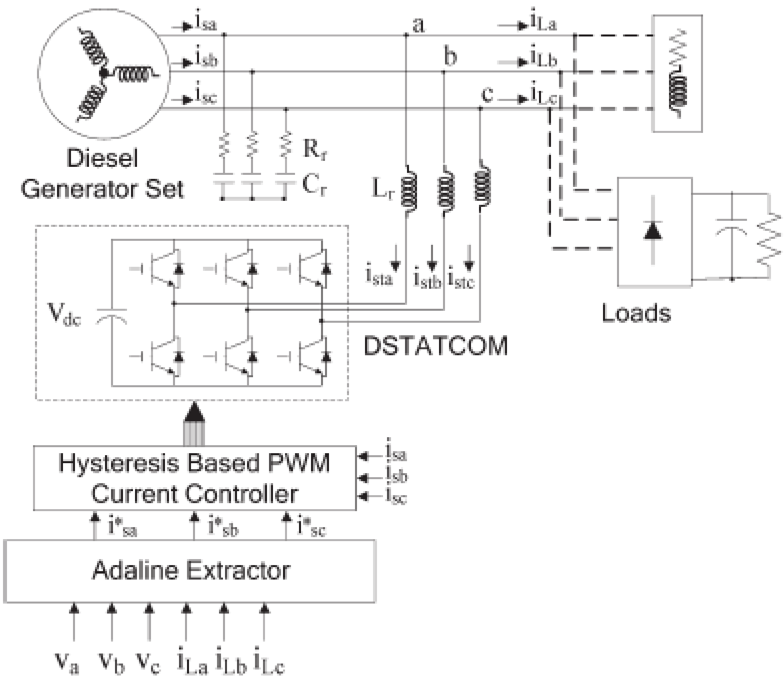


Figure: 2. Basic configuration of the DG set with DSTATCOM

Fuzzy Controller

The essence of fuzzy controller is to build a model of human expert who is capable of controlling the plant without thinking in terms of mathematical model.

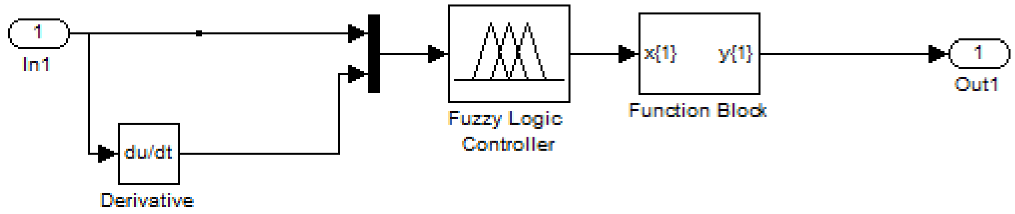


Figure 3.Fuzzy controller

IV. SIMULATION DIAGRAM AND WAVEFORMS

The simulation model for the diesel generation system along with statcom controller is shown in Figure 4. Power System Block set and Simulink are used to modeling of the control diagram for main power circuit .Three-phase AC source represents the grid source and connected at the load end. DSTATCOM is a combination of voltage source converter fed capacitive reactor or distributed energy source. The simulation diagram for the proposed diesel generation system with DSTATCOM controller is shown in Figure 5, 6 shows the simulation result for output current, source currents, voltages and compensated currents of the proposed system.

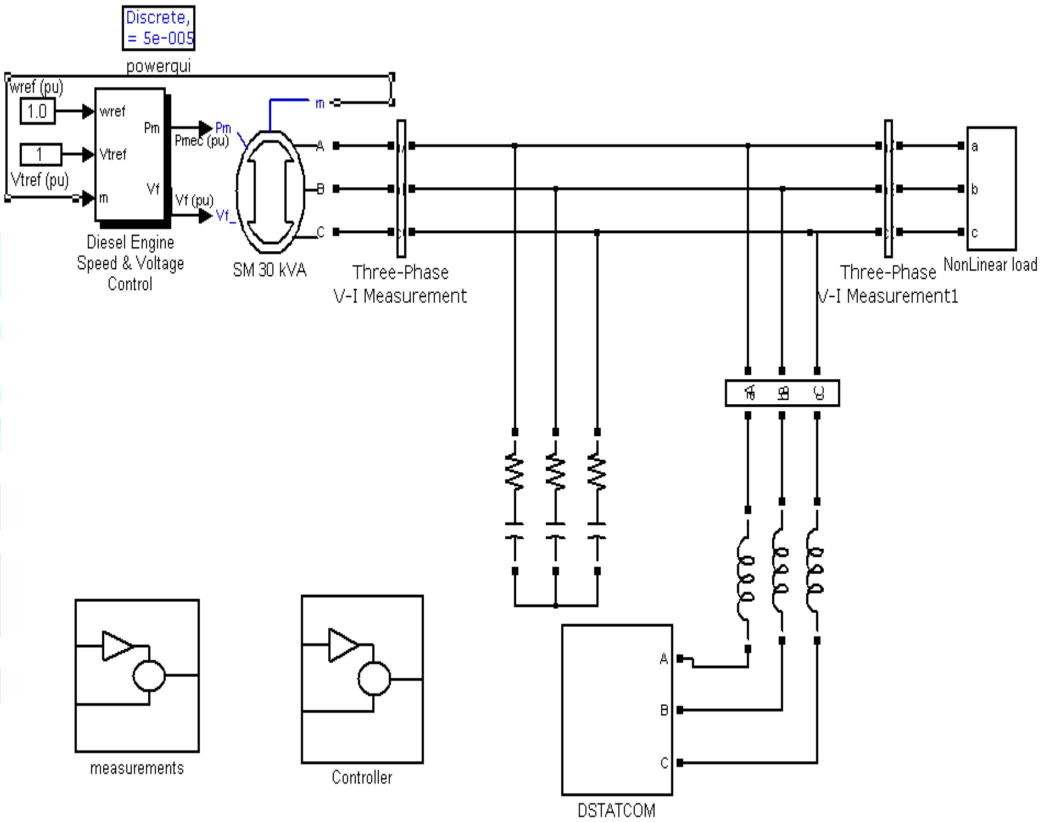


Figure 4: Simulation Circuit of DG with DSTATCOM feeding to nonlinear load using

Fuzzy controller

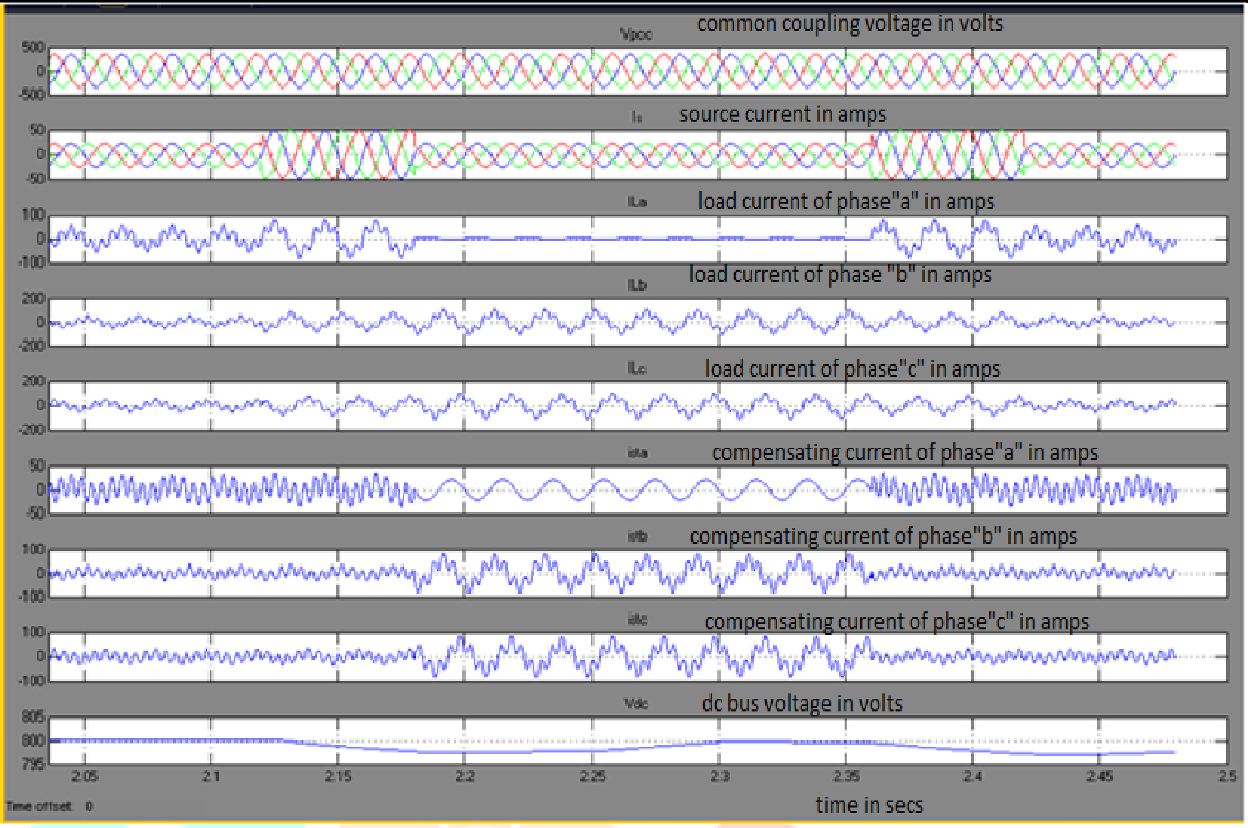


Figure5: Result for Nonlinear load using PI controller

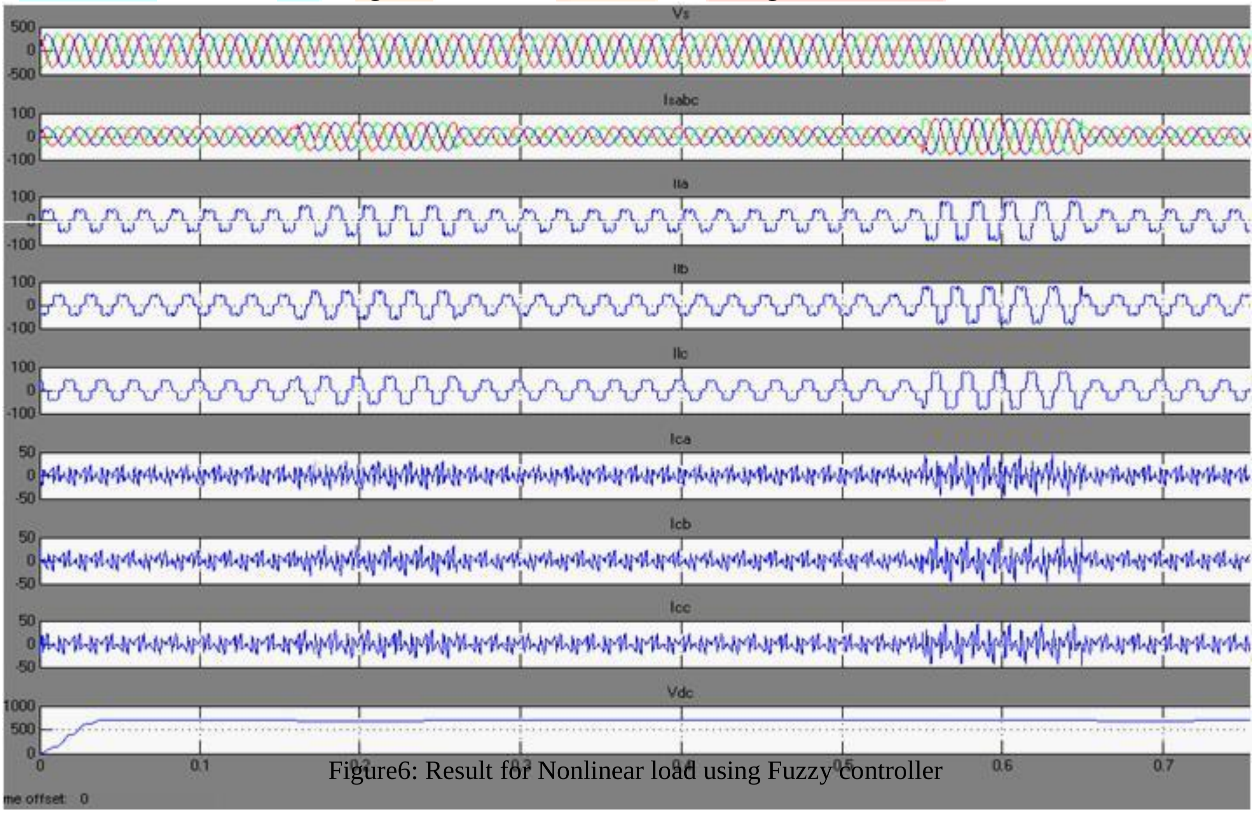
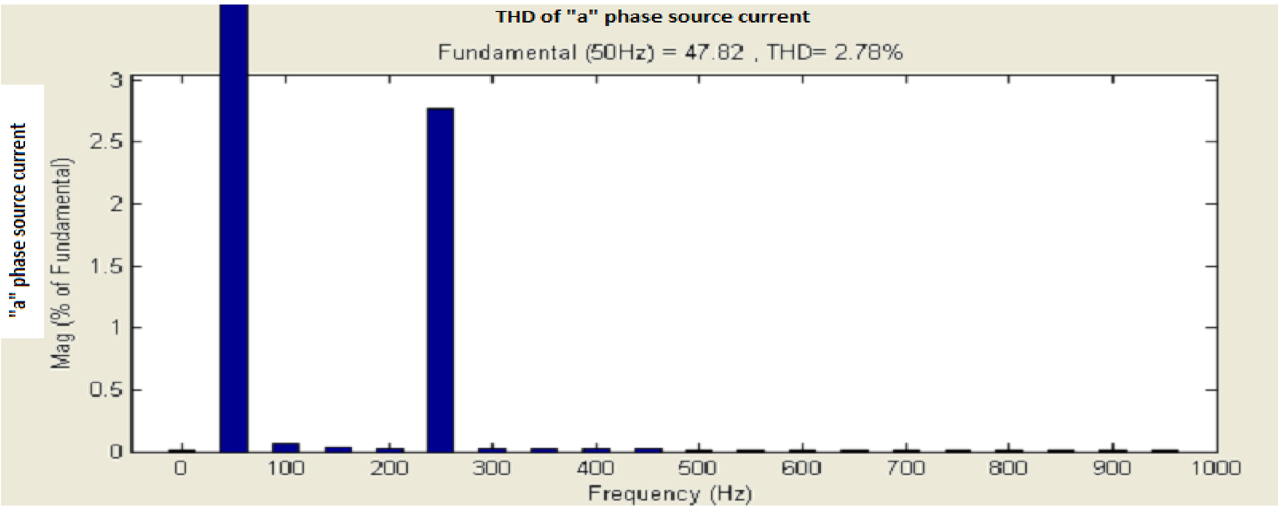
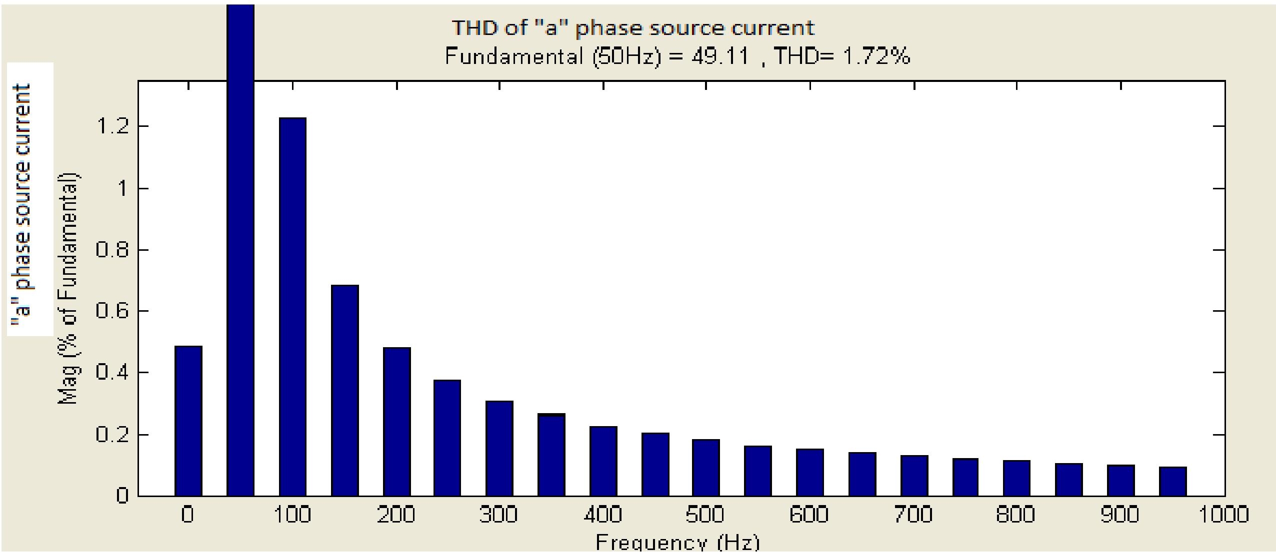


Figure6: Result for Nonlinear load using Fuzzy controller

V. Comparison of % THD Values



THD of "a" phase source current with PI controller



THD of "a" phase source current with fuzzy controller

currents	PI controller	Fuzzy controller
i_{sa}	2.78%	1.72%
i_{sb}	2.45%	1.71%
i_{sc}	2.62%	0.78%
i_{la}	41.21%	4.7%
i_{lb}	38.79%	6.53%
i_{lc}	38.88%	9.41%

Table I. THD Comparison in PI and fuzzy systems

This table shows the comparison of total harmonic distortions under both conventional PI and Fuzzy based Diesel Energy Systems. From this table we conclude that the proposed get better compensation with Fuzzy system as compared with the PI controller.

voltages	PI controller	Fuzzy controller
v_{sa}	4.24%	1.7%
v_{sb}	4.19%	1.71%
v_{sc}	4.35%	0.79%

Table II. THD Comparison in PI and fuzzy systems

VI. Conclusion

This paper proposed Fuzzy logic based distribution static synchronous compensator for compensating the power quality problems in the distribution systems. The distribution static synchronous compensator is one of the type in most flexible device which is operated under voltage or current controlled modes, the current control mode is used for compensating voltage variations, unbalances and the voltage control modes is for voltage stabilizers. It has the capability for controlling the unbalances and variations in input currents. It is observed that with the help of these compensator the factor of total harmonic distributor is reduced. This paper is extended with the help of fuzzy logic controller provides better control action. By using fuzzy controller total harmonic distortion is less as compared with the other conventional controllers.

VII. References

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