Optimal Controlling of Harmonics in Distributed System using 11-Level MLI Based Hybrid Filter and Fuzzy Logic

Reena Devikar[1], Prof. Ashish Bhargav[2]

[1]*Mtech. Scholar,* [2]*Research guide*

Department of Electrical Engineering, Bhabha Engineering and Research Institute, Bhopal

Abstcact - ***The harmonics present in the system higly affects the power quality and reliability of the system, and it needs to be mitigated to deliver power at load side. The distributed system is designed with the help of active and passive power filters together has controlling mechanism based on the fuzzy set theory. The fuzzy logic controller is taking reference of changes in the harmincs and generate controlling pulses to apply on the system using 11 level MLI. The conservative power theory explained the presence of and existence of harmonics in the system, previously SAPF along with seven level MLI has been used to reduce the effects of harmonics and improve overall reliability of the system. But from the previous results it can be analysed that there is scope for further improvements in the system. For achieving this goal this work proposed a hybrid shunt active power filter along with fuzzy set theory to mitigate the harmonics and improve the power quality of the system.***

Keywords - Active filters, passive filters, fuzzy logic, multilevel inverter.

I. INTRODUCTION

Now a day's power electronic based equipment is used in industrial and domestic purpose. These equipments have significant impacts on the quality of supplied voltage and have increased the harmonic current pollution of distribution systems. They have many negative effects on power system equipment and customer, such as additional losses in overhead and underground cables, transformers and rotating electric machines, problem in the operation of the protection systems, over voltage and shunt capacitor, error of measuring instruments, and malfunction of low efficiency of customer sensitive loads.

Passive filter have been used traditionally for mitigating the distortion due to harmonic current in industrial power systems. But they have many drawbacks such as resonance problem, dependency of their performance on the system impedance, absorption of harmonic current of nonlinear load, which could lead to further harmonic propagation through the power system [2].

To overcome of such problem active power filters is introduced. It has no such drawbacks like passive filter. They inject harmonic voltage or current with appropriate magnitudes and phase angle into the system and cancel harmonics of nonlinear loads. But it has also some drawbacks like high initial cost and high power losses due to which it limits there wide application, especially with high power rating system. [3].

The rising interest in the use of electronic devices levies nonlinear loads to the source that draw active current, reactive current and harmonic current. Due to the reactive current and harmonic current electromagnetic interference with nearby equipment and heating of transformers occur. Power system can sop up harmonic currents with no problem. Resonant condition mainly affects the power problem. In fig.1.1 the source refers to the three phase source (generator) in power system and impedance represents the line impedance. Due to the nonlinear load the current becomes non sinusoidal. As a result we are getting a distorted voltage across the load..

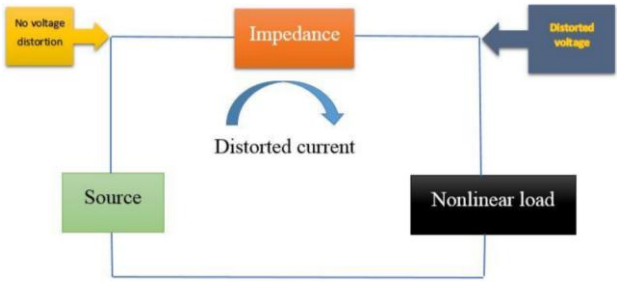

Figure 1.1 Flow of harmonic currents and generation of harmonic voltage.

Fig. 1.2 shows an active power filter connected in parallel with the main path invalidates all the harmonic current and reactive current from nonlinear loads.

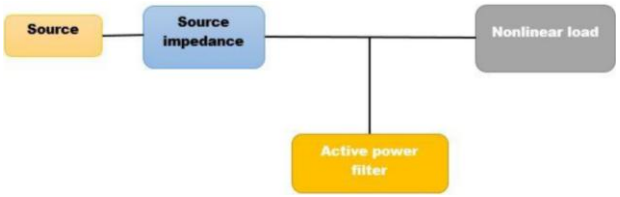

Figure 1.2 Schematics of a system with the shunt active power filter.

As the active power filter provide a fraction of total power for compensation of harmonic and reactive currents it can

have low rating which is economical. Among the various control strategies of active power filters pulse width modulation scheme is an efficient one. A hybrid power filter which is a combination of passive filter and active filter improves the resonance characteristics and reduces filter rating.

II. PROPOSED SYSTEM

The proposed work is based on the hybrid power filter based multi level inverter topology of eleven levels controlled by fuzzy logic control as demonstrated in figure. This work is an extension of the previous 9-level SAPF based distributed system. Here the system is having fuzzy logic controller togenerae the control pulses for the multi level inverter system.

Hybrid filters are based on the combination of active filters and passive filters. Such a combination with the passive filter makes it possible to significantly reduce the rating of the active filter. The task of the active filter is not to compensate for harmonic currents produced by the thyristor rectifier, but to achieve “harmonic isolation” between the supply and the load As a result, no harmonic resonance occurs, and no harmonic current flows in the supply.

And for the harmonic reduction and elimination fuzzy logic controller is utilized. In a fuzzy logic controller, the control action is determined from the evaluation of a set of simple linguistic rules. The development of the rules requires a thorough understanding of the process to be controlled, but it does not require a mathematical model of the system. The internal structure of the fuzzy controller is shown in Fig 2.1

A fuzzy inference system (or fuzzy system) basically consists of a formulation of the mapping from a given input set to an output set using fuzzy logic. This mapping process provides the basis from which the inference or conclusion can be made. A fuzzy inference process consists of the following steps:

Step 1:Fuzzification of input variables

• Step 2: Application of fuzzy operator (AND,OR,NOT) in the IF(antecedent) part of the rule

• Step 3: Implication from the antecedent to the consequent(THEN part of the rules)

• Step 4: Aggregation of the consequents across the rules

• Step 5: Defuzzification

The crisp inputs are converted to linguistic variables in fuzzification based on membership function (MF). An MF is a curve that defines how the values of a fuzzy variable in a certain domain are mapped to a membership value μ (or degree of membership) between 0 and 1. Figure 2.2 Demonstrated controlling of system using fuzzy logic controller

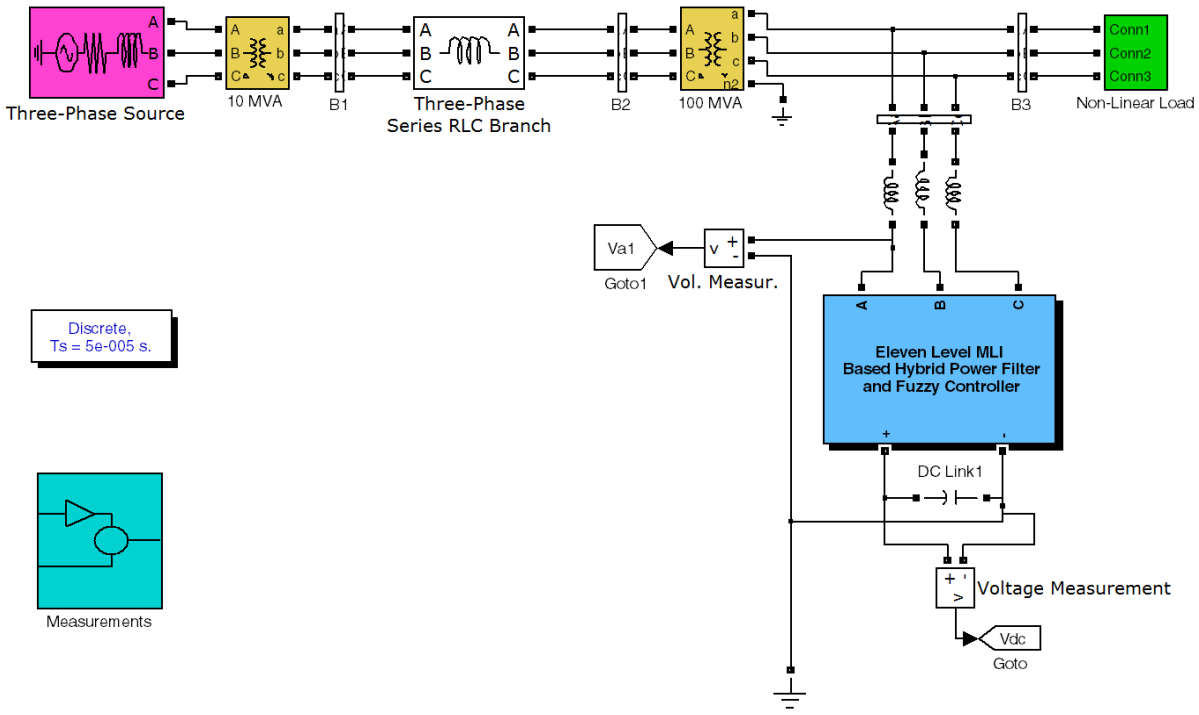

Figure 2.1 Proposed simplified model with hybrid power filter and Fuzzy Controller with eleven level MLI.

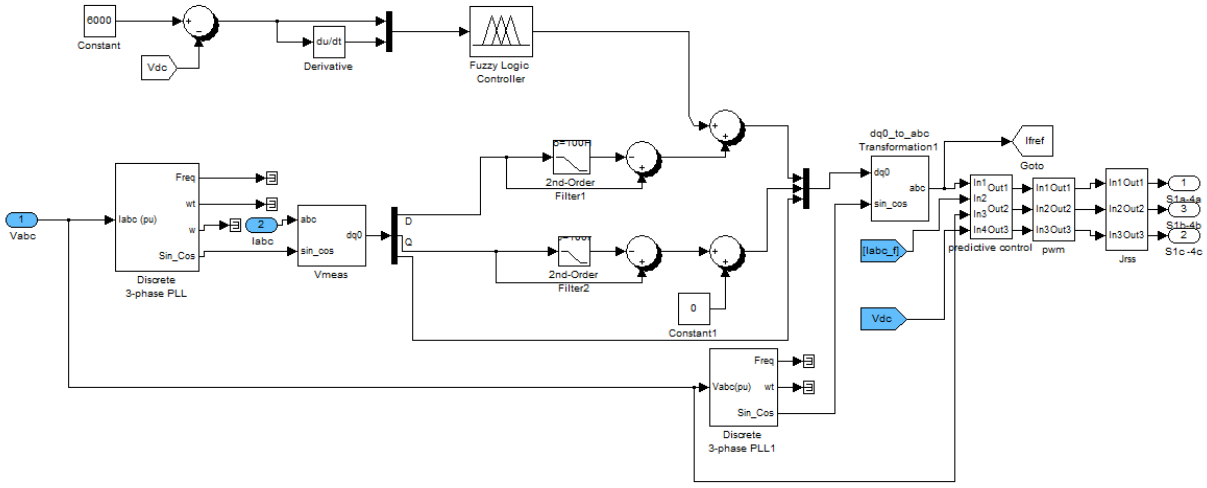

Figure 2.2 Fuzzy Logic Controlling in Proposed System

III. SIMULATION OUTCOME

Proposed system has been implemented and Simulated on MATLAB/Simulink ISE the outcome of proposed work has been given in the below figures.

Fig. 3.1 shows the waveforms of source current and has lower harmonic presence in the waveforms. Initially the fluctuation is obvious due to initialization of the system, after some mili seconds it has been start behaving smoothly with low distortion rate.

Fig. 3.2 shows the source voltage waveforms which has also low distortion rate and compared to previous system has smooth behaviour.

Fig. 3.3 show the controlling waveforms of the eleven level MLI hybrid filter controlled by the fuzzy logic waveforms. The increased number of levels has better controlling over due to increase in number of points per cycle than previous 9 level MLI.

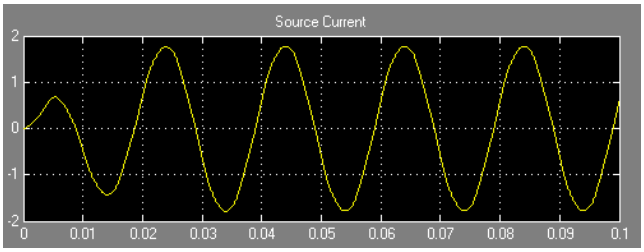

Figure 3.1 Source Current Waveform

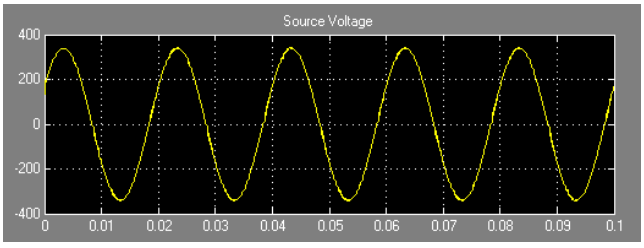

Figure 3.2 Source Voltage Waveform

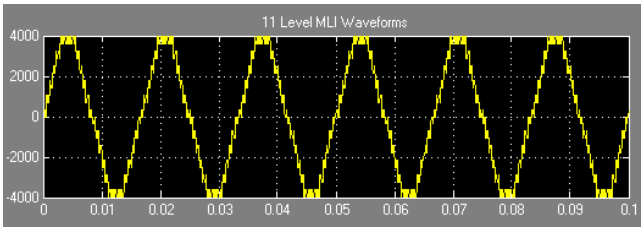

Figure 3.3 Eleven Level MLI Voltage Waveforms for Controlling

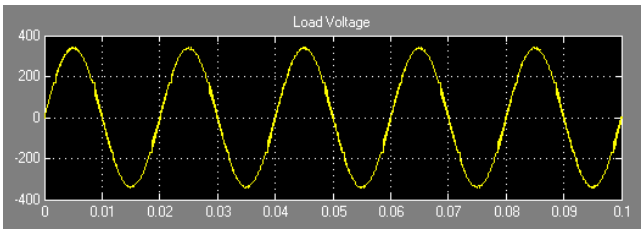

Figure 3.4 Load Voltage waveform

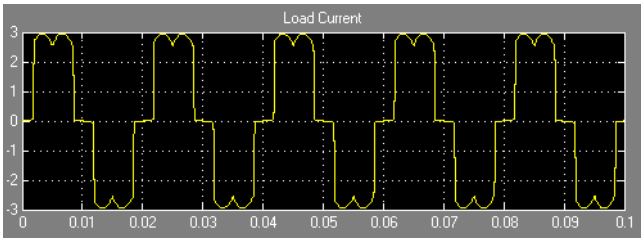

Figure 3.5 Load Current waveform

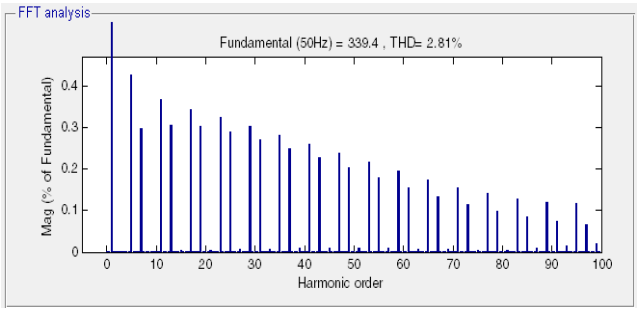

Figure 3.6 Total Harmonic Distortion (THD) 1.18%

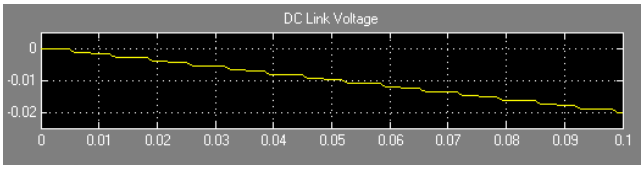

Fig. 3.7 DC Link Voltage

Table 3.1 Comparison of THD %

System	*Load Type*	*THD %*
9-Level SAPF	Non-Linear	18.06%
11-level Hybrid PF + Fuzzy	Non-Linear	1.18%

IV. CONCLUSION

A shunt active power filter along with 11 level MLI has been investigated for power quality improvement. Various simulations are carried out to analyze the performance of the system. Both Hybrid SAPF and eleven level MLI based and fuzzy logic controller are implemented for harmonic and reactive power compensation of the non-linear load. A model has been developed to simulate the fuzzy logic based hybrid power filter in MATLAB. It has been found from simulation results that hybrid shunt power filter along with MLI referenced by fuzzy controller improves power quality of the power system by eliminating harmonics and reactive current of the load current, which makes the load current sinusoidal and in phase with the source voltage. The performance of the controller has been studied and compared.

REFERENCES

[1] R. Arulmurugan and A. Chandramouli, "Design and Implementation of a Nine-Level Inverter with Shunt Active Filter for Distributed System," 2018 4th International Conference on Electrical Energy Systems (ICEES), Chennai, 2018, pp. 224-228.

[2] T. D. C. Busarello, J. A. Pomilio and M. G. Simões, "Passive Filter Aided by Shunt Compensators Based on the Conservative Power Theory," in IEEE Transactions on Industry Applications, vol. 52, no. 4, pp. 3340-3347, July-Aug. 2016.

[3] T. D. C. Busarello and M. G. Simões, "Power quality enhancement by means of shunt compensators based on the conservative power theory," 2015 Clemson University Power Systems Conference (PSC), Clemson, SC, 2015, pp. 1-5.

[4] J. C. Leite, I. P. Abril, W. F. Silva, A. de Oliveira Castro, R. de Mendonça Nogueira and M. S. S. Azevedo, "Planning passive filters using NSGA II for industry applications," 2014 11th IEEE/IAS International Conference on Industry Applications, Juiz de Fora, 2014, pp. 1-8.

[5] S. Rahmani, A. Hamadi, K. Al-Haddad and L. A. Dessaint, "A Combination of Shunt Hybrid Power Filter and Thyristor-Controlled Reactor for Power Quality," in IEEE Transactions on Industrial Electronics, vol. 61, no. 5, pp. 2152-2164, May 2014.

[6] M. Jafar and M. Molinas, "A Transformerless Series Reactive/Harmonic Compensator for Line-Commutated HVDC for Grid Integration of Offshore Wind Power," in IEEE Transactions on Industrial Electronics, vol. 60, no. 6, pp. 2410-2419, June 2013.

[7] E. S. Sreeraj, E. K. Prejith and K. Chatterjee, "One cycle controlled active harmonic filter," IECON 2012 - 38th Annual Conference on IEEE Industrial Electronics Society, Montreal, QC, 2012, pp. 621-626.

[8] F. C. de La Rosa, "Effects of harmonics in distribution systems," in Harmonic and Power Systems, 1st ed. Boca Raton, FL, USA: CRC Press, 2006, pp. 69-84.

[9] P. E. C. Stone, J. Wang, Y.-J. Shin, and R. A. Dougal, "Efficient harmonic filter allocation in an industrial distribution system," IEEE Trans. Ind. Electron., vol. 59, no. 2, pp. 740-751, Feb. 2012.

[10] A. Hamadi, S. Rahmani, and K. Al-Haddad, "A hybrid passive filter con¬figuration for VAR control and harmonic compensation," IEEE Trans. Ind. Electron., vol. 57, no. 7, pp. 2419-2434, Jul. 2010.

[11] S. H. E. Abdel Aleem, A. F. Zobaa, and M. Mamdouh Abdel Aziz, "Optimal C-type passive filter based on minimization of the voltage har¬monic distortion for nonlinear loads," IEEE Trans. Ind. Electron., vol. 59, no. 1, pp. 281-289, Jan. 2012.

[12] V. Dzhankhotov and J. Pyrhonen, "Passive LC filter design considera¬tions for motor applications," IEEE Trans. Ind. Electron., vol. 60, no. 10, pp. 4253-4259, Oct. 2013.

[13] B. Badrzadeh, K. S. Smith, and R. C. Wilson, "Designing passive har¬monic filters for an aluminum smelting plant," IEEE Trans. Ind. Appl., vol. 47, no. 2, pp. 973-983, Mar./Apr. 2011.

[14] M. M. Liu, Demystifying Switched Capacitor Circuits. Burlington, MA, USA: Newnes, 2006.

[15] W. Jian, H. Na, and X. Dianguo, "A 10KV shunt hybrid active filter for a power distribution system," in Proc. 23rd Annu. IEEE Appl Power Electron. Conf. Expo. (APEC'08), Feb. 24-28, 2008, pp. 927-932.

[16] G. Panda, S. K. Dash, and N. Sahoo, "Comparative performance analysis of shunt active power filter and hybrid active power filter using FPGA- based hysteresis current controller," in Proc. 5th IEEE India Int. Conf. PowerElectron. (IICPE'12), Dec. 6-8, 2012, pp. 1-6.