Comparison of ANFIS Controller with ANN Controller for Power Quality Enhancement

R Lakshmi[1], N Ramesh Raju[2], S Ramesh[3], K Gunaprasad[4,] V Supriya[5]

[1]*Associate Professor, Department of EEE, Siddharth Institute of Engineering and Technology, Puttur, Andhra Pradesh, India.*
[2]*Professor & Head, Department of EEE, Siddharth Institute of Engineering and Technology, Puttur, Andhra Pradesh, India.*
[3]*Professor, Department of EEE, Siddharth Institute of Engineering and Technology, Puttur, Andhra Pradesh, India.*
[4]*Professor, Department of EEE, Siddharth Institute of Engineering and Technology, Puttur, Andhra Pradesh, India*
5Assistant Professor, Department of EEE, Siddharth Institute of Engineering and Technology, Puttur, Andhra Pradesh, India

ABSTRACT

This work presents an analysis of an adaptive Neuro-fuzzy inference system (ANFIS) based shunt hybrid active filter (SHAF) for power quality enhancement in electrical power systems. The proposed SHAF integrates a passive filter with a shunt active filter and utilizes ANFIS for real-time harmonic identification and suppression. The simulation results of the ANFIS-based control are discussed in detail, above controller mitigating harmonic distortion, improving power factor, and enhancing voltage regulation. The analysis of the proposed system is performed under various operating conditions, and its performance is compared with other conventional methods. The results indicate that the proposed ANFIS-based SHAF provides superior performance in terms of efficiency, accuracy, and robustness for power quality enhancement in electrical power systems. By using Matlab/Simulink software.

Keywords: Harmonic analysis, neural networks, power harmonic filters, power system analysis computing, total harmonic distortion.

1. General Overview

The performance of electrical devices has been steadily improving with advancements in power electronics. However, the use of nonlinear load tends to degrade the sinusoidal electric supply. Instead of conducting in a smooth manner, the nonlinear loads draw current in short pulses and introduce harmonics in the system. This issue of harmonics is not confined to industrial users; it affects the domestic users as well. The use of uninterrupted power supplies, computers, LED light bulbs, LCDs, fans, and refrigerators are common in commercial and residential sectors. Moreover, the use of distributed resources to fulfill the energy demands affects the power transmission similar to the nonlinear loads.

2. Problem Statement

To address this problem of harmonic contamination in the power system, researchers have presented different techniques to suppress harmonic distortion. For example, installation of capacitor banks has been suggested as a low cost and simple solution to eliminate harmonics in the power system.

The main contributions of the paper are as follows:

• To address the problem of harmonic distortion, neural networks based SHAPF are designed and compared for an unbalanced power system.

• To provide a thorough review from a broad perspective, a detailed comparison between the conventional and ANFIS controller based techniques with proposed neural network based SHAPF. The results present practical need of adopting neural networks for harmonic elimination in power systems.

3. Related work

The growing usage of nonlinear loads in industrial and residential sectors leads to the problem of harmonics in the power system, which results in huge energy losses The effectiveness and continuity of the instruments, such as relays and transformers are affected by the presence of harmonics [1-4]. To improve the distribution and transmission systems, it is necessary for harmonic elimination. Researchers have proposed different solutions, such as Active Power Filters (APF), Passive Power Filters (PPF) and Hybrid Active Power Filters (HAPF)[5-7].

PPF is a low-cost solution to eliminate harmonics. Therefore, use of passive power filter to reduce the energy losses and to achieve a pure sinusoidal source has always been an attractive solution for power systems in both domestic and industrial sectors[8-10]. The different structure-based topologies have been designed but the most simple and efficient is the Single Tuned PPF (STPPF).

The various optimization techniques developed by the researchers to improve the response of STPPF reducing its cost and complexity[11-12]. In implementation of different STPPFs considering the reconfiguration of the power distribution system is presented. The researchers achieved a significant reduction in THD; however, system response time and complexity increased compared to the traditional technique.

To reduce all harmonics from the system, researchers have designed SAPFs with various control techniques for the detection of harmonics present in a distorted power system. In, Artificial Neural Network based active filter is simulated and practically verified for up to eleventh order harmonics elimination.

4. Results Discussion

A Simulink model is developed to simulate the ANN and ANFIS controller based shunt active power filter in MATLAB/SIMULINK. The complete active power filter system is composed mainly of source, a nonlinear load, a converter, and a controller. All these components are modeled separately, integrated and then solved to simulate the system. Fig 1 shows the Simulink model of **ANN controller for power quality enhancement** with MATLAB Simulink.

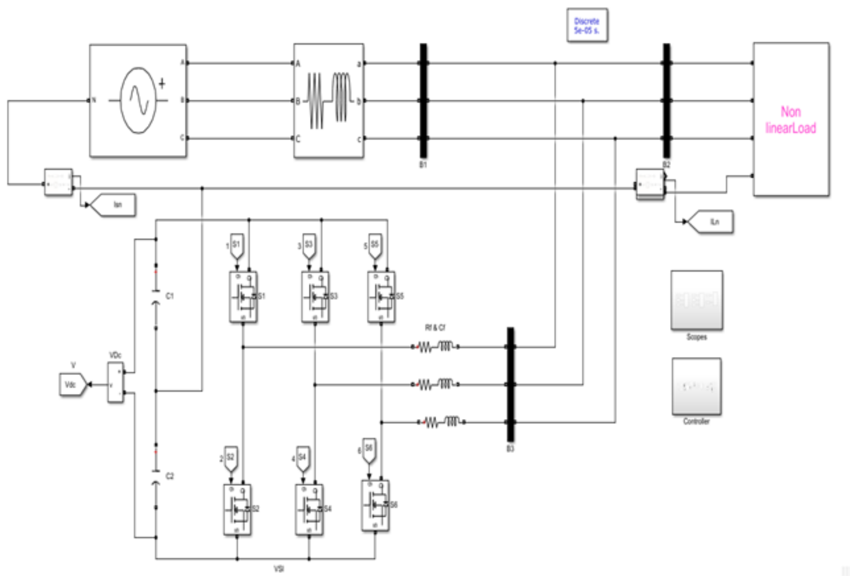

Fig 1 Simulink Model of Controlling System

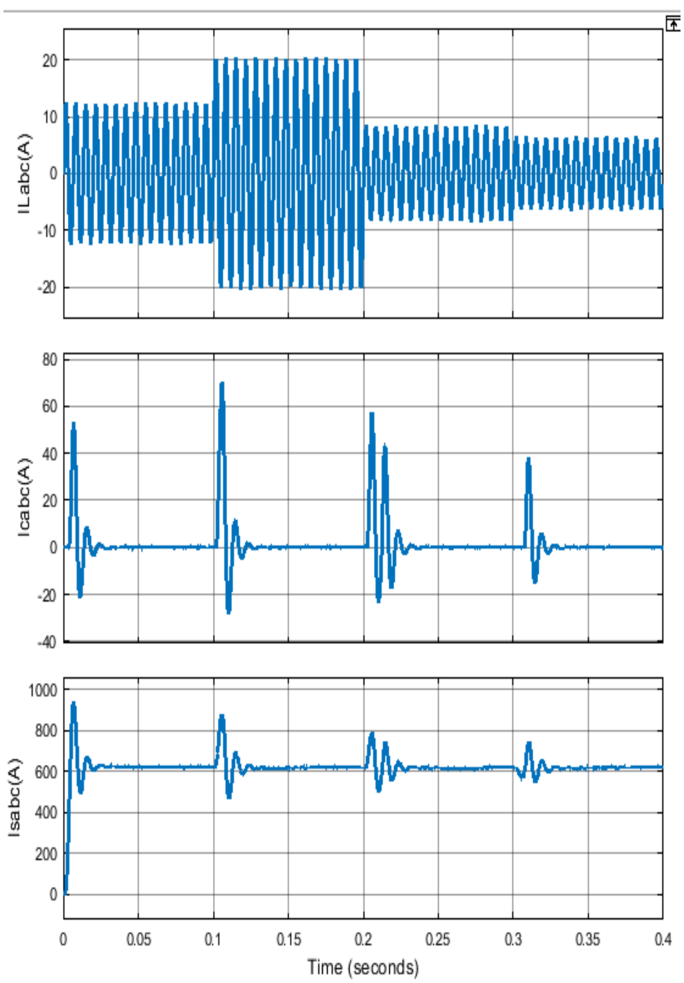

Fig 2 Graphical Representation of THD values using ANN Controller

Fig 2 shows the performance of ANN controller for power quality enhancement. ANN controller is the finest controller in all the controllers but it has some drawbacks like redundancy and iteration problems. Fig 3 and Fig 4 shows data training by ANFIS controller..

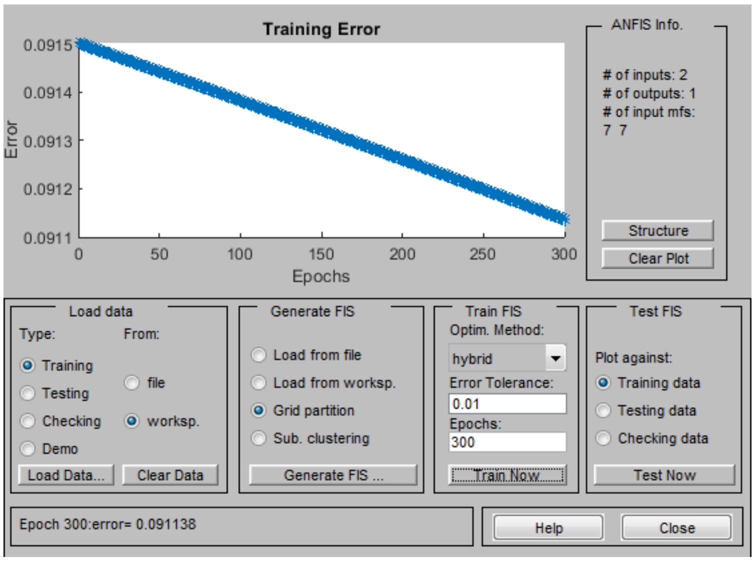

Fig 3 Calculating the error by ANFIS

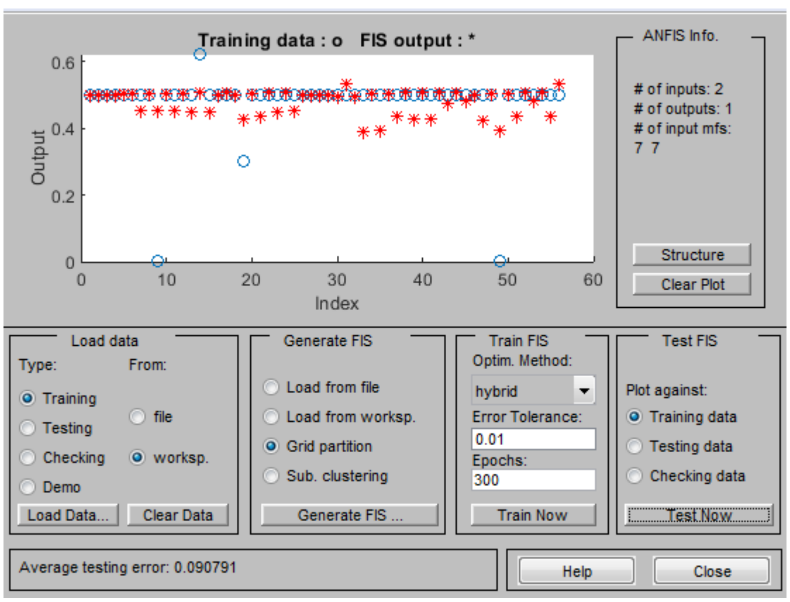

Fig 4 Training of data

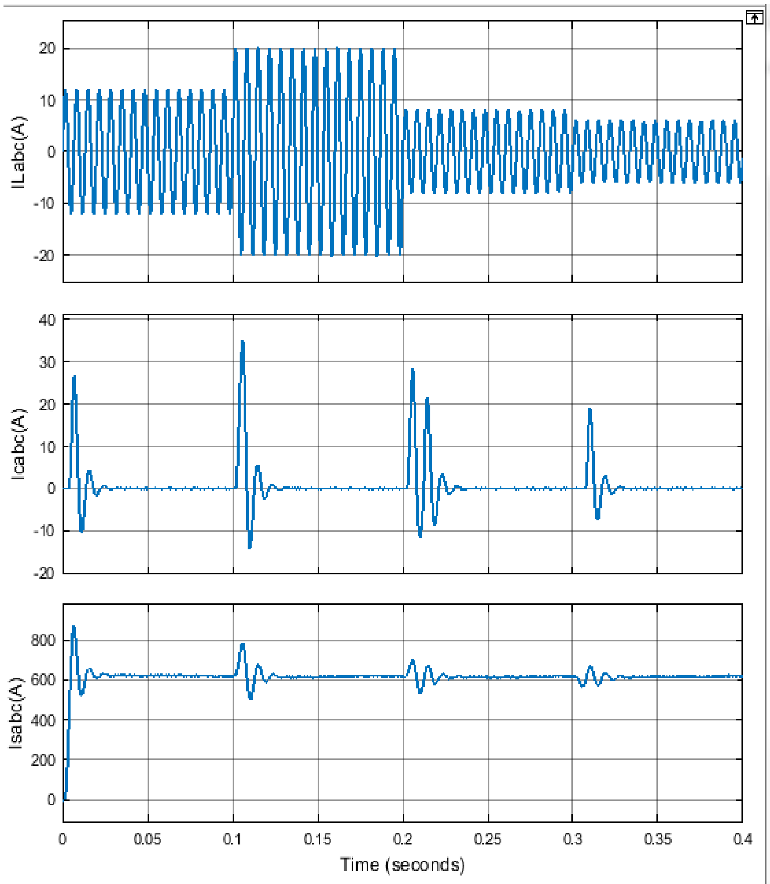

Fig 5 Graphical Representation of THD values using ANFIS Controller

From Fig 5, it is noted that ANFIS controller is accurate when compared to other controllers. Some of the advantages of the proposed controller are: It is independent of the source voltage distortion, fast and accurate tracing of fundamental component under nonlinear condition simple architecture and easy for implementation; and active filter controller compensates the whole neutral current of the load. The SAF with ANFIS controller adapt itself to compensate for variation in non-linear currents. Simulation results shown that system performs better with ANFIS controller than ANN controller.

CONCLUSION

In this paper, a comparative analysis with ANN controller and neural network-based control procedures for the SHAPF is presented to improve the power quality of the non-sinusoidal power system. The structure of the proposed three-phase Filter is designed to eliminate the harmonics and neutral wire current. The ANFIS based control strategy for the extraction of harmonics present in the system and the DC voltage regulation is encouraging approach due to robustness and more capability for Filtering. The ANFIS based control strategy have good dynamic and steady-state response and it can be a much better solution for power factor and current harmonics compensation than the conventional approach. Besides, the shunt active filter can also compensate for load current unbalances, eliminating the neutral wire current in the power lines.

REFERENCES

1. E. Gunther, Harmonic and inter harmonic measurement according to IEEE 519 and IEC 61000-4-7 in Proc. IEEE/PES Transmiss. Distrib. Conf. Exhib., Dallas, TX, USA, May 2006 pp. 223–225.
2. J. C. Das, Power System Harmonics and Passive Filter Designs. Piscataway, NJ, USA: Institute of Electrical and Electronics Engineers, Mar. 2015.
3. H. Kazem, Harmonic mitigation techniques applied to power distribution networks, Adv. Power Electron., vo1. 2013, Feb. 2013, Art. No. 591680.
4. M. R. Jannesar, A. Sedighi, M. Savaghebi, A. Anvari-Moghaddam, and J. M. Guerrero, Optimal probabilistic planning of passive harmonic filters in distribution networks with high penetration of photovoltaic generation,Int. J. Electr. Power Energy Syst., vol. 110, pp. 332– 348, Sep. 2019.
5. W. Yeetum and V. Kinnares, Parallel active power filter based on source current detection for antiparallel resonance with robustness to parameter variations in power systems,‘‘ IEEE Trans. Ind. Electron., vol. 66, no. 2, pp. 876–886, Feb. 2019.
6. M. Omran, I. Ibrahim, A. Ahmad, M. Salem, M. Almelian, A. Jusoh, and T. Sutikno, Comparisons of PI and ANN controllers for shunt HPF based on STF-PQ algorithm under distorted grid voltage, Int. J. Power Electron. Drive Syst., vol. 10, no. 3, pp. 1339–1346, 2019.
7. D. O. Abdeslam, P. Wira, J. Merckle, D. Flieller, and Y.-A. Chapuis, A unified artificial neural network architecture for active power filters, IEEE Trans. Ind. Electron., vol. 54, no. 1, pp. 61–76, Feb. 2007.
8. E. Kazemi-Robati and M. S. Sepasian, Passive harmonic filter planning considering daily load variations and distribution system reconfiguration, Electr. Power Syst. Res., vol. 166, pp. 125–135, Jan. 2019.
9. M. M. Elkholy, M. A. El-Hameed, and A. A. El-Fergany, Harmonic analysis of hybrid renewable microgrids comprising optimal design of passive filters and uncertainties, Electr. Power Syst. Res., vol. 163, pp. 491–501, Oct. 2018.
10. E. L. L. Fabricio, S. C. S. Junior, C. B. Jacobina, and M. B. de Rossiter Correa Analysis of main topologies of shunt active power filters applied to four-wiresystems,‘‘ IEEE Trans. Power Electron., vol. 33, no. 3, pp. 2100–2112, Mar. 2018.
11. P. Santiprapan, K. L. Areerak, and K. N. Areerak, Mathematical model and control strategy on DQ frame for shunt active power filters, Int. J. Electr., Comput., Energetic, Electron. Commun. Eng., vol. 5, no. 12, pp. 1–9, 2011.
12. H. C. Lin, Intelligent neural network-based fast power system harmonic detection, IEEE Trans. Ind. Electron., vol. 54, no. 1, pp. 43–52, Feb. 2007.