ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 4, 2021

Harmonic reduction in shunt active power filters with unusual energy sources

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Abstract: The article discusses shunt active filter switching device control methods based on artificial neural network (ANN) theory. The fundamental goal is to minimize disturbances perfectly in both steady and transient states. A four-legged converter with a voltage source that can correct for biased currents and harmonic components brought on by non-linear loads is discussed in the study. Harmonic currents are reduced by using an active filter with a shunt connection. In contrast, the new suggested ANN controller for the reduction of % total harmonic distortion (THD). The foundation of the entire power filter idea is an ANN controller modelled in MATLAB. The potential of the system is illustrated by studying and simulating the suggested circuit in this research under various operating conditions.

Keywords: Active power filter ANN controller, Harmonic current reduction Maximum power point, tracking Voltage source converter with four leg operation

1. INTRODUCTION

Many domestic and business electrical loads have recently been fused into facility grids. It causes problems with power quality [1]. Thyristor rectifiers, when connected to the facility grid, create many harmonics for the growing number of loads that do not respect ohm's law, such as diodes [2]. Harmonics create voltage distortions, grid losses, and poor load operation because of this. As a result, IEEE 519 standards [3] are recommended at the grid to manage harmonic currents caused by rapid load variations. The shunt power filter (SPF) is made up of specially tuned LC and high band pass filter settings[4]. These are simple to use and provide a cost-effective solution for harmonics [5]. Furthermore, the effectiveness of shunt filters is mostly determined by grid impedance, which might cause shunt resonance phenomena with the grid, which is not desirable. Harmonic reduction results in higher efficiency of power semiconductor devices [6]. The voltage source inverter is made up of the shunt active power filter (SAPF) voltage source inverter (VSI). Voltage disturbances in the power system are caused by irregular power generation [7]. The algorithmic control method using artificial neural network (ANN) and proportional integral (PI) controllers is explained in this work[8]. APFs, like PI

ISSN PRINT 2319 1775 Online 2320 7876

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(for linear analysis) or predictive (non-linear) controllers, are generally controlled and. In general, predictive controllers are close to the current power system [9]. The current methods demonstrate how to increase APF performance under dynamic settings[10]. It will be capable of precisely executing the reference signal for the current parameter while maintaining direct current (DC) voltage [11]. This control approach illustrates how to handle multivariate features in electric drive applications [12]. It provides a straightforward way to compensate for dead time and replace pulse width modulation (PWM) [13]. The advantage of this approach is that it is suitable for all APF applications because the output parameters are known[14].

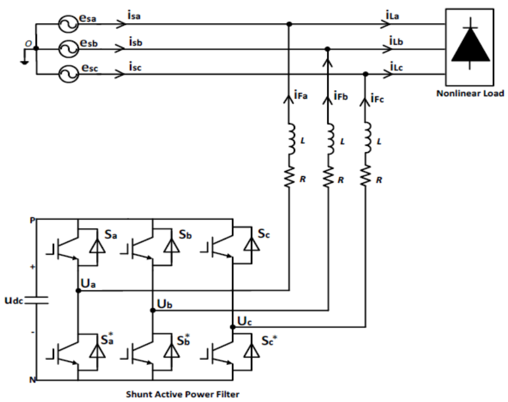

Figure 1. For two 3- SAPF, an analogous circuit has been proposed.

The study of the PWM converter [15] is shown in Figure 2. It's comparable to a three-phase converter with the fourth leg connected to a neutral bus[16]. By increasing the frequency at which switches are turned on and off, this architecture enhances the control litheness and voltage quality that is productive[17].

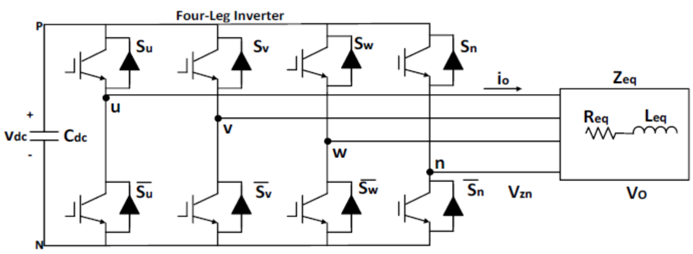

Figure 2. Pulse width modulation for a four-leg circuit with two levels

1.1 CURRENT CONTROL DEVELOPMENT WITH DIGITAL TECHNOLOGY

The proposed current control strategy[18] using digital technology is depicted in Figure 3. It outlines a control algorithm that is fed into a microprocessor as an input[19]. To illustrate time delay and its

ISSN PRINT 2319 1775 Online 2320 7876

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assumptions, discrete mathematics is used[20]. It uses the most switching structural information available to apply to the converter [21].

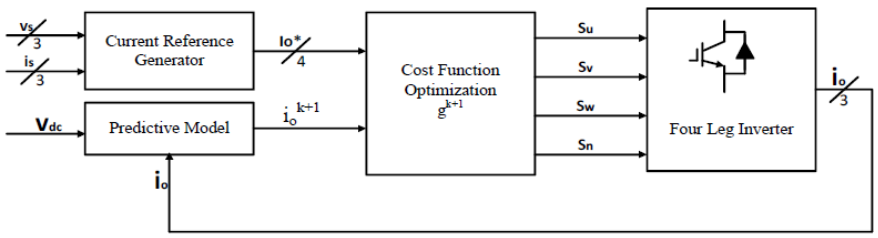

Figure 3. Digital technology was proposed for current control.

2. Training of ANN

When compared to fuzzy controllers, ANN is more useful because it is more efficient and fault tolerant. To improve control quality, data from hard controllers can be communicated with intelligent controllers utilizing ANN [22]. Feed forward neural networks perform the function of the compensation signal generator [23]. It has three layers, with seven neurons in the input layer and twenty-one neurons in the hidden layer (see Figure 4).

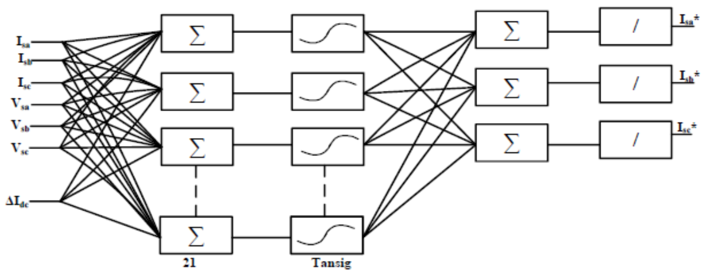

Figure 4. ANN network structure proposed

The output is influenced by the sort of input and how it evolves. As previously stated, the proposed concept consists of seven input neurons. The reference, load voltage, source current, and output for error (PI) controllers are among them. The output of the ANN is based on fundamental reference currents. The hysteresis load current controller consists of switching signals as output.

2.1 HARMONIC REDUCTION USING MPPT

MPPT techniques can also be used to solve the main harmonic problem. The MPPT system stands for maximum power point tracking [24]. MPPT approaches include perturbation and observation [P&O],

ISSN PRINT 2319 1775 Online 2320 7876

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hill climbing (HC), fractional v_{oc}, and fractional I_{sc}, as well as newer techniques like fuzzy logic, met heuristic algorithms, and ANN. These techniques aid in maintaining consistent precision, doubling tracking speed, and converting significant amounts of energy and power. The P&O approach is the most often utilised MPPT technique in solar systems, among all available methods. The P&O approach aids in maximum power tracking, as well as balancing voltage, current, and power among solar PV modules and assisting in power rise or decrease. Table 1 provides a detailed examination of several MPPT strategiesfor reducing THD.

3. SIMULATION RESULTS

The simulation results of proposed circuits are displayed in Figure 5. From the Figure 5(a) shows the terminal voltage, Figure 5(b) explain about load at the terminal of current profile, Figure 5(c) explain about Current profile at Active filter terminal, Figure 5(d) displays about Neutral current profile at load terminal, Figure 5(e) shows the Current at neutral terminal, Figure 5(f) displays Current in the system Figure 5(g) gives about Voltage profile at DC converter, and Figure 5(h) Current at the grid. The simulation THD values for the proposed circuit with PI and ANN controller for reduction of harmonic distortion are shown in Figure 6. Figure 6(a) will give the values of THD in case of PI controller and Figure 6(b) will gives the values of THD in case of ANN controller, same will displayed in the Table 1.

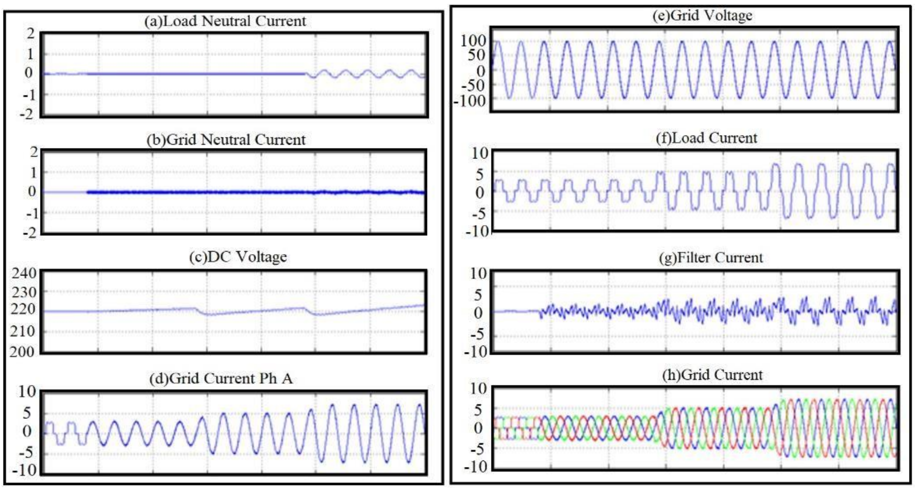

Figure 5. Circuit outputs that have been proposed; (a) voltage at the source terminal; (b) at the load terminal, the current profile; (c) at the active filter terminal, the current profile is displayed; (d) at the load terminal, the current profile is neutral; (e) current flowing via the neutral terminal; (f) currently available in the system; (g) DC converter voltage profile; (h) the current state of the grid

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 UGC CARE Listed (Group -I) Journal Volume 10, Iss 4, 2021

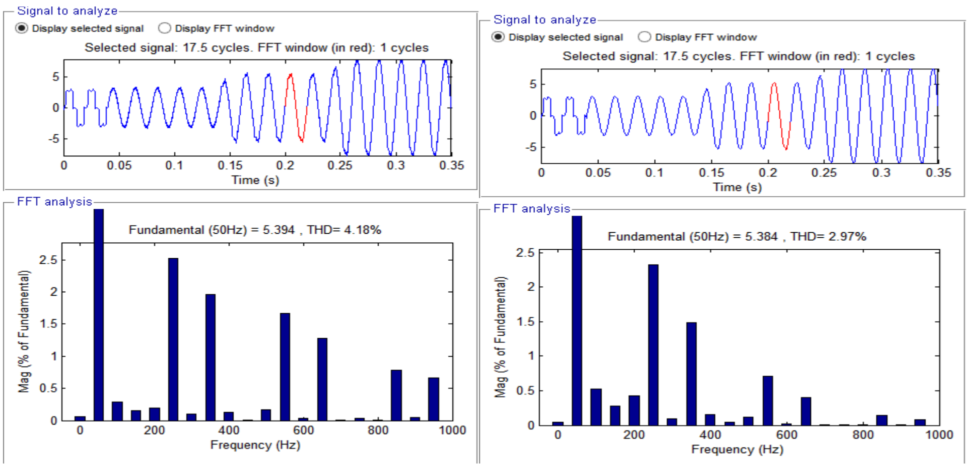

Figure 6. Values of THD, (a) with a PI controller 4.18 percent and (b) with ANN controller 2.97 percent

Controller	Nonlinear Load1	Nonlinear Load2	Unbalanced Load3
PI	2.53%	4.18%	2.75%
ANN	1.04%	2.97%	1.75%

4. CONCLUSION

The paper suggests implementing SAPF with ANN utilising SIMULINK. The SAPF uses a non-linear load to correct for harmonics. As a result, it was discovered that using PI, the current profile at source terminals' total harmonic distortion is 4.18 percent, but using an ANN controller, it is 2.97 percent. Additionally, it has been tested under several nonlinear load scenarios, with the outcomes reported. The findings lead to the conclusion that PI is less successful than ANN.

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