IDENTIFICATION OF HARMONIC CURRENTS BY NEURAL MVF METHOD USED IN SHUNT ACTIVE POWER FILTER CONTROLLED BY SVM

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Abstract **:** *This paper presents a new approach for the identification of harmonic currents that MVF method called the neural, architecture chosen and the type of network occurred, We exposed the Feedforward neural by the backpropagation algorithm and system based on the neural adaptation technique with non-linear loads of variable electrical networks ,neural MVF Used for generate and extract the reference currents which should be injected by three level inverter is presented after the identification using the three-level inverter controlled by space vector modulation (SVM) for minimizing the harmonics of source currents, The regulation of the current is accomplished by PI regulators all results achieved by digital simulation using MATLAB environment.*

key Words: *harmonic current, neural MVF, shunt Active power filter ,SVM, three level inverter.*

1. Introduction

To improve the quality of energy, the solution used so far is the crossover that supplies reactive energy and harmonic trap despite its simplicity and low cost, this solution has drawbacks, and through the recent development of Semiconductor fully controllable power. The GTO Thyristors and IGBTs in particular, led to the design of new structures called static converters, active filters for compensation of electrical disturbances such as harmonics from the load and including several topologies have been developed and studied. Their response is automatically adapted to the disturbance to be removed. It therefore appears that the use of an inverter three level NPC structure as an active filter meets the needs of high levels of power required and can lead to more effective solutions.

Most APFs use a standard two-level voltage-source inverter (VSI) [1, 2].However, for medium-voltage applications, three- level VSIs have been proven to be more advantageous [3, 4, 5]. A three-level neutral-point-clamped (NPC) inverter can be employed in three-phase three-wire systems. The advantages of three-level VSIs include lower harmonic distortion, lower switching frequency, and lower power loss. [6] APFs based on three-level inverters are generally more expensive but can be compensated by using smaller filter inductors, assuming the same switching frequency. However, the control of a three-level inverter is more complicated than a two-level inverter because of the large number of inverter switching states.

Therefore, there is greater difficulty in synthesizing the voltage reference vector [7,6].

K.Hartana and G.G.Richards were among the first who used back propagation ANN to track harmonics in large power systems, where it is difficult to locate the magnitude of the unknown sources [8]. In their method, an initial estimation of the harmonic source in a power system was made using neural network. P.K.Dash et.al utilized the ADALINE, a version of ANN, as a new harmonic estimation technique [9,10]

The work presented in this article relates particularly to the simulation study of an inverter three level NPC structure used as a parallel active filter is for filtering of harmonic currents. This converter controlled by SVPWM strategy and will present an effective solution to pollution networks produced by non-linear loads. The extraction reference currents achieved by this new method is the FVM Neural networks based on feedforward multilayer perceptron type with the type propagation algorithm and the learning base that is developed from the results provided by the FMV algorithm.

2. three-level inverter (NPC)

Multilevel inverters are currently being investigated. Recently, these are being used in various industrial applications. Three-level inverter is one of the most popular converters employed in medium and high power applications. Their advantages include the

capability to reduce the harmonic content and decrease the voltage or current ratings of the semiconductors As shown in Figure 1. the studied system is constituted of a DC supply, and a three-level voltage inverter bridge, we start by defining the Fij connection function of switch. It is “1” if the switch is closed and “0” otherwise.
In controllable mode, the connection functions are related to the relation (1).
F_{ij} in the following manner:

$$F_{ij} = \begin{cases} 1 \ if \ S_{ij} \ is \ closed \\ 0 \ if \ S_{ij} \ is \ open \end{cases} \quad (1)$$

The switches of each leg are complementary pairs:

$$F_{ij} = 1 - F_{(i\_2)j} \quad i = 3 \ j = 1,2,3$$

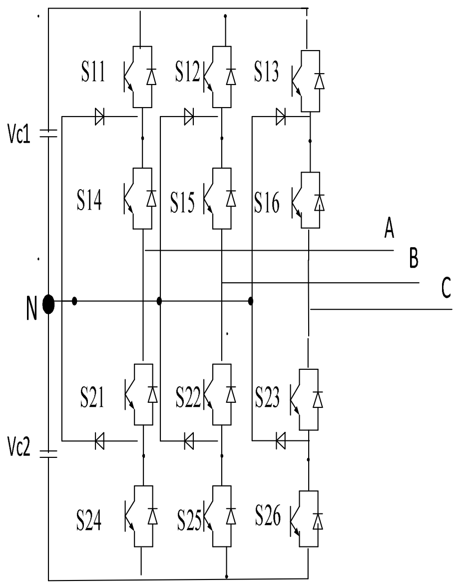

Fig. 1. Three level inverter

3 Space Vector PWM for Three Level Inverter

There are altogether 27 switching states They Table 1,correspond to 19 voltage vectors whose positions are fixed. These space voltage vectors can be classified into four groups, where the first group corresponds to 3 zero vectors or null vectors (V0, V7, V14), the second group consists of large voltage vectors (V15-V20), the third group consists of medium voltage vectors (V8-V13) and finally the fourth group consists of small voltage vectors (V1-V6). The last three groups can be distinguished into three hexagons illustrated in Figure 2.

TABLE I. THE SWITCHING STATES FOR A THREE-LEVEL INVERTER

SWITCHING STATES	S11	S12	S13	Vector
1	0	0	0	V0
2	1	1	1	V7
3	2	2	2	V14
4	1	0	0	V1
5	1	1	0	V2
6	0	1	0	V3
7	0	1	1	V4
8	0	0	1	V5
9	1	0	1	V6
10	2	1	1	V1
11	2	2	1	V2
12	1	2	1	V3
13	1	2	2	V4
14	1	1	2	V5
15	2	1	2	V6
16	2	1	0	V8
17	1	2	0	V9
18	0	2	1	V10
19	0	1	2	V11
20	1	0	2	V12
21	2	0	1	V13
22	2	0	0	V15
23	2	2	0	V16
24	0	2	0	V17
25	0	2	2	V18
26	0	0	2	V19
27	2	0	2	V20

The figure 2.shows the different switching state

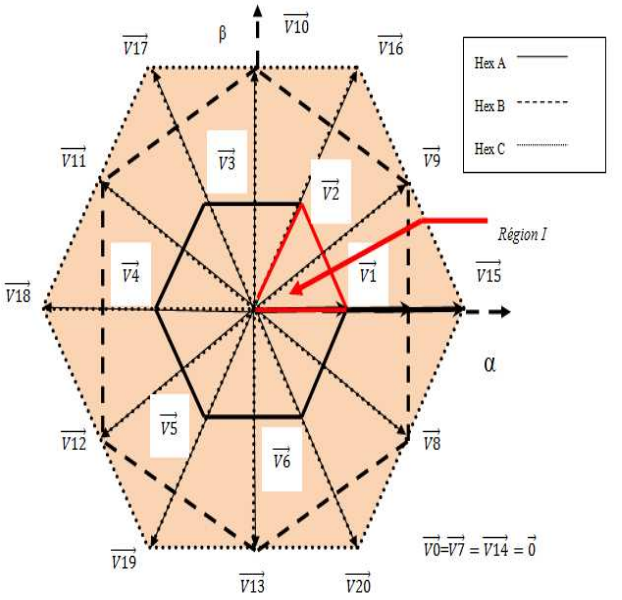

Fig. 2. Three-level voltage inverter vectors in the (α-β) frame

3.1 Hexagon Identification

The small hexagon, we now called Hex A, bounded by the vectors, identical amplitude equal to 0.408.Vdc, The average hexagon, be called Hex. B, defined by the vectors, identical amplitude equal to 0.612.Vdc, The large hexagon, be called Hex. C, delimited by the vectors,identical amplitude equal to 0.816.Vdc.[12]

Each hexagon contains six sectors.

3.2 Sectors Identification

$$sector = \begin{cases} 1 & \text{if } 0 \le \theta < \pi/3 \\ 2 & \text{if } \pi/3 \le \theta < 2.\pi/3 \\ 3 & \text{if } 2.\pi/3 \le \theta < \pi \\ 4 & \text{if } \pi \le \theta < 4.\pi/3 \\ 5 & \text{if } 4.\pi/3 \le \theta < 5.\pi/3 \\ 6 & \text{if } 5.\pi/3 \le \theta < 2.\pi \end{cases} \quad (2)$$

3.2 Calculating the Periods of Application of the Control Vectors

As said previously, we distinguish between 03 hexagons Figure 2. where each one is constituted of 06 regions. As aresult, we have 18 regions that wait the calculation of their respective switching times. To simplify this task, and for reason of similarities in the 06 regions of one hexagon on the one hand, and resemblance between hexagons ‘a’ and ‘c’ on the other hand (the largest magnitude in hexagon ‘a’ (E/√6) constitutes the half of the largest magnitude in hexagon ‘c’ (E.√2/√3)), for these all reasons, in the switching times calculation’s procedure presentation, only two regions of hexagon ‘a’ and hexagon ‘b’, corresponding to the positive components of Vref, will be considered . The other switching times will be then deduced from these four regions. Remind-we that the limiting vectors (V1 to V20) magnitudes will take the following values[12]

- Region I switching times calculation:

$$T_s = T_k + T_{k+1} + nT \quad (3)$$

Region I for k=0

$$\begin{cases} T_1 = T_s . \dfrac{\sqrt{6} V_\alpha^* - \sqrt{2} V_\beta^*}{Vdc} \\ T_2 = T_s .2\sqrt{2}\dfrac{V_\beta^*}{Vdc} \\ T_0 = (T_s - T_1 - T_2)/6 \end{cases} \quad (4)$$

The strategy of vector PWM consists of five steps diagrammed by the flowchart Figure 3.

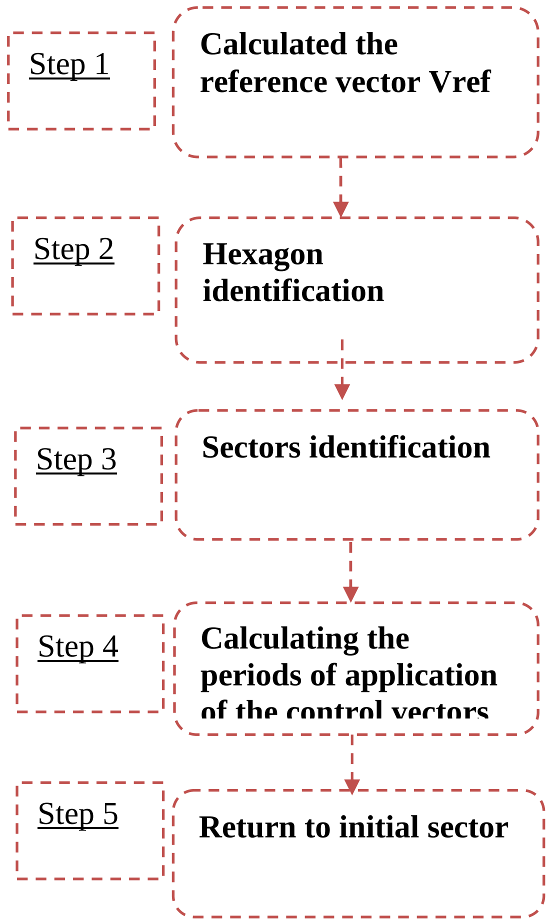

Fig. 3. Steps in SVPWM

4. Identifying harmonic current

A. Identifying Harmonic Current by the Method of MVF

This filter says MVF, was developed by M.Benhabibe [14]. It’s based on the work of Song

Hong-Scok and is based on the extraction of the fundamental signals, directly from the axes. However, it can be used very well to isolate the direct or inverse of a particular harmonics order [15,16].

The equivalent transfer function of the integration in the synchronous references frame «SRF» is expressed by the equation:

$$i_{\alpha\beta}(s) = e^{j\omega_c t}\int e^{-j\omega_c t}\, i_{\alpha\beta}(t)\,dt \quad (5)$$

After Laplace transformation, we get the following equation:

$$H(s) = \frac{\hat{i}_{\alpha\beta}(s)}{i_{\alpha\beta}(s)} = \frac{s + jw_c}{s^2 + w_c^2} \quad (6)$$

By developing this equation, we obtain the expressions:

$$\hat{i}_\alpha = \frac{k}{s}\left[i_\alpha(s) - \hat{i}_\alpha(s)\right] - \frac{\omega_c}{s}.\hat{i}_\beta(s)) \quad (7)$$

$$\hat{i}_\beta = \frac{k}{s}\left[i_\beta(s) - \hat{i}_\beta(s)\right] - \frac{\omega_c}{s}.\hat{i}_\alpha(s)) \quad (9)$$

Figure 4 illustrates the scheme of the multivariable filter.

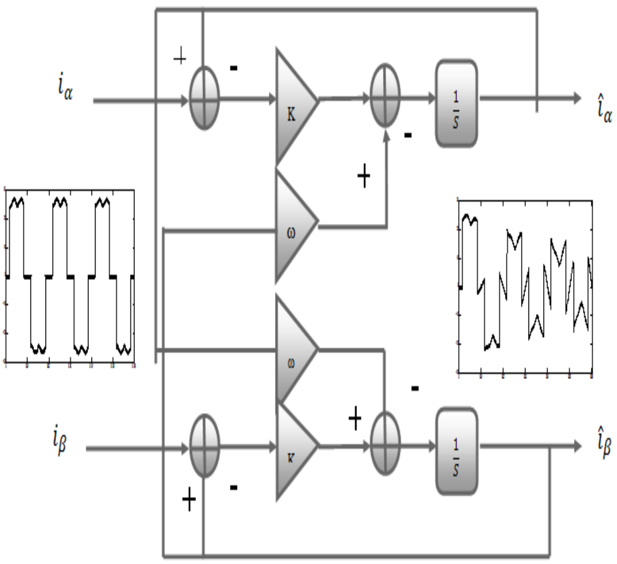

Fig. 4. Multi-Variable Filter

B. Identifying Harmonic Current by the Method of neoral MVF

Each neural network filled with a well defined functio n depending on the chosen architecture (the number of neurons in each layer). The problem is finding the function that gives a better result.

The layers of input and output are well known because they are imposed by the system, but it is not known properly size the number of hidden layer et the number of neurons in these layers. For that several tests were performed to determine the optimal network architecture [13].

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Figure 5 represent a schematic diagram of a neural network based on a MVF, the neural network comprises a layer of between two and hidden layer and an output layer.

- The activation function used for the first hidden layer is the hyperbolic tangent function (tansig) ;
- The activation function used for the second hidden layer is the hyperbolic tangent function (tansig).
- The activation function used for the output layer is the linear function (purelin).

5. Simulation Results for neural MVF

The best learning achieved by the proposed structure is presented in the following figures 6 (a and b)

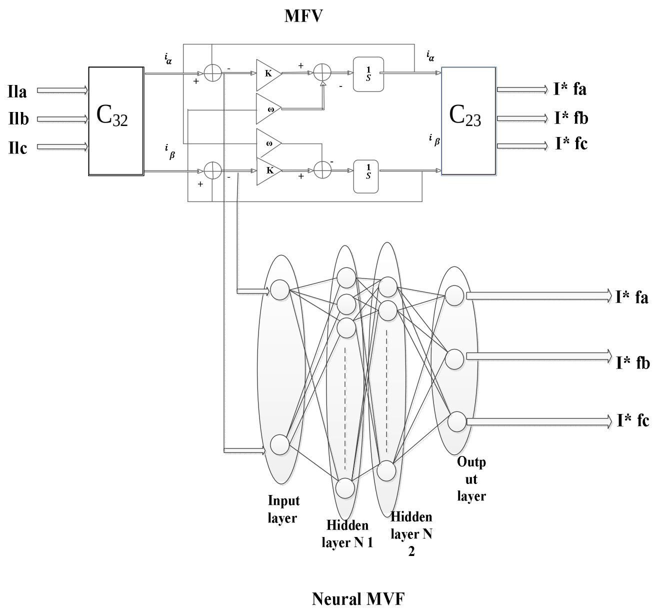
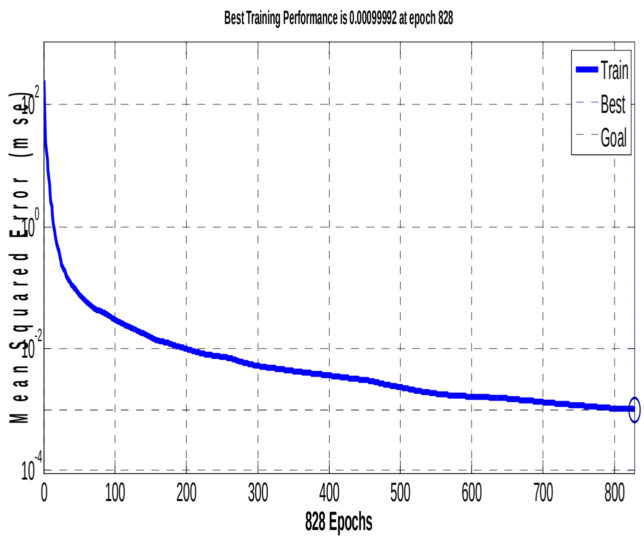
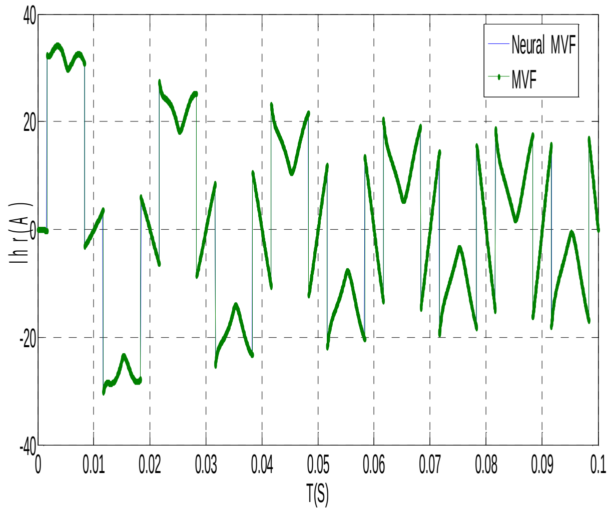


Fig. 5. The neuronal architecture proposed for neural MVF



a.Results for the recognition



b. harmonic current by identifying neural MVF & MVF

Fig. 6. (a)-Results for the recognition ,(b)- harmonic current by identifying neural MVF & MVF

We note that the current MVF identified by neuronal follow the current identification by MVF shows that the networks neurons give significant results

6. Shunt active filter

In power distribution network active power filters are widely used for the reduction of harmonics caused by nonlinear loads. This paper describes a shunt active power filter with a control system based on the multi-level inverter (PWM). Due to the wide spread of power electronics equipment in modern electrical systems and power convertor units causes the increase of the harmonics disturbance in the AC mains currents has become a major concern due to the adverse effects on all equipment and distribution network [11].

The circuit configuration of the studied active filter is shown in Figure 7. The configuration is controlled to cancel current harmonics on the AC side and make the source current in phase with the voltage source. The source current, after compensation, becomes sinusoidal and in phase with the voltage source.

A. Control Scheme

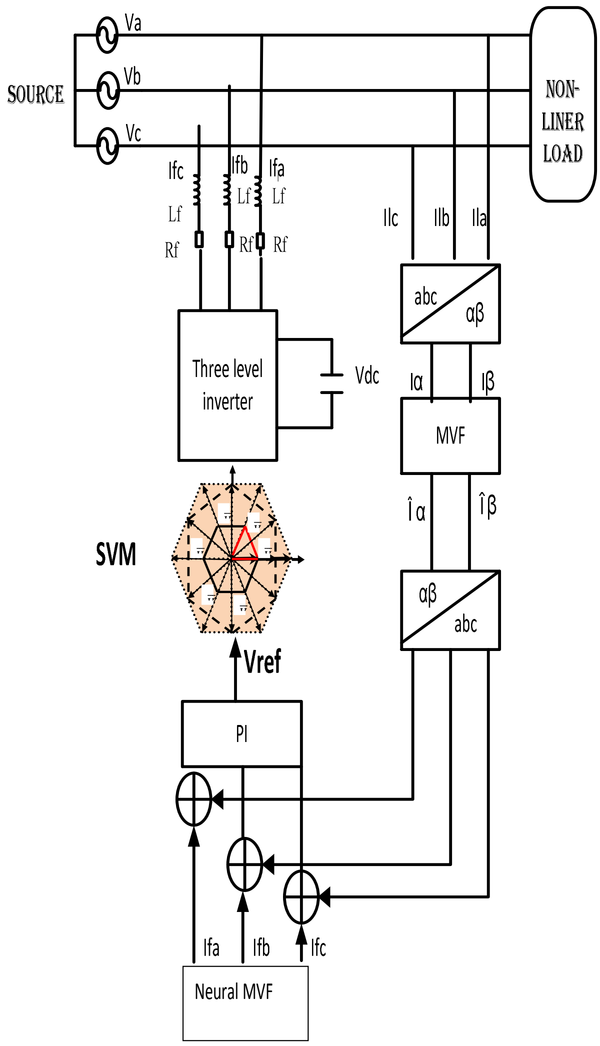


Fig. 7. The block diagram of a shunt active power filter control scheme

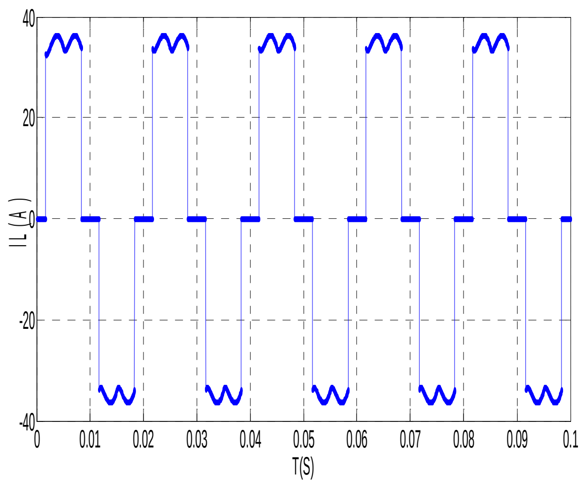


Fig. 8. The current to the terminal of the non-linear load

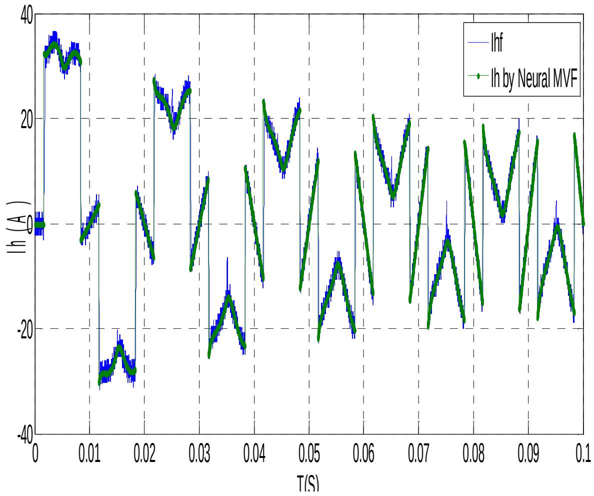


Fig. 9. The output current of the inverter and the harmonic current identified by Neural MVF

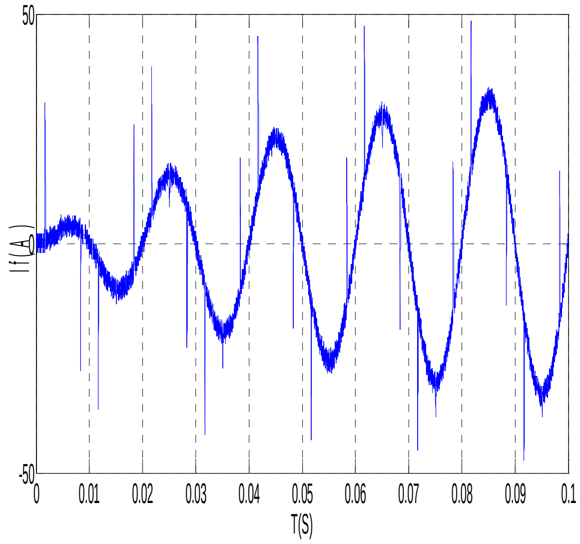


Fig. 10. The filter current

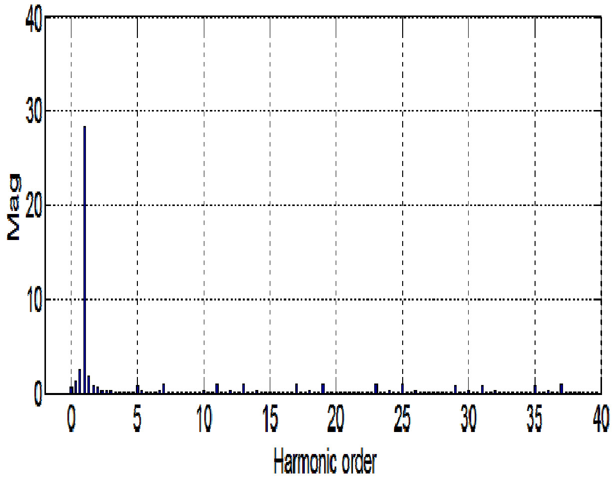


Fig. 11. harmonic current spectrum filtered

7. Conclusion

In this article we propose a neural network for the extraction of current harmonics apply to the method of MVF. Simulation results shows the convergence of networks neuron, then the uses three level inverter controlled by technical SVPWM for parallel active filter to minimize harmonic creates by a nonlinear load.

In another side they obtained results show that the current has almost a sinusoidal form and the inverter output current tracks the current identified by the neural MVF method.

References

1. L. Asiminoaei, P. Rodriguez, and F. Blaabjerg, “Application of discon- tinuous PWM modulation in active power filters,” *IEEE Trans. Power Electron.*, vol. 23, no. 4, pp. 1692–1706, Jul. 2008.
2. M. Asiminoaei, F. Blaabjerg, and S. Hansen, “Evaluation of harmonic detection methods for active power filter applications,” in *Proc. APEC 2005*, vol. 1, pp. 635–641.
3. J. Allmeling, “A control structure for fast harmonics compensation in active filters,” *IEEE Trans. Power Electron.*, vol. 19, no. 12, pp. 508–514, Mar. 2004.
4. O.Vodyakho, D. Hackstein,A. Steimel, and T.Kim, “Novel direct current- space-vector control for shunt active power filters based on three-level inverters,” in Proc. IEEE Power Electron. Conf. (APEC 2008), pp. 1868–1873.
5. O. Vodyakho, T. Kim, and S. Kwak, “Comparison of the space vector current controls for active power filters,” in *Proc. 2008 IEEE Ind. Electron. Soc. (IECON)*, Orlando, FL, Nov., pp. 612–617.
6. O.Vodyakho, C. C. Mi, “Three-level inverter-based shunt active power filter in three-phase three-wire and four-wire systems” *IEEE Trans. Power Electron.*, 2009 IEEE.
7. M. E. Ortuzar, R. E. Carmi, J. W. Dixon, and L. Moran, “Voltage-source active power filter based on multilevel converter and ultracapacitor DC link”, *IEEE Trans. Ind. Electron.*, vol. 53, no. 2, pp. 477–485, Apr. 2006.
8. Hartana.K, and Richards.G.G, “Harmonic source monitoring and identification using neural networks”, IEEE Trans. on Power Systems, Vol. 5, No. 4, NOV. 1990, pp. 1098-1 104.
9. Dash.P.K, Swain.O.P, Liew.A.C and Rahman.S , "Anadaptive linear combiner for on-line tracking of powersystem harmonics",IEEE Trans. on Power Systems, Vol. 11,No. 4, Nov. 1996, pp. 1730-1735.
10. E.Chandra Sekaran , P.Anbalagan, “Comparison of Neural Network and Fast Fourier Transform Based Selective Harmonic Extraction andTotal Harmonic Reduction for Power Electronic Converters” Asian Power Electronics Journal, Vol. 2, No. 1, Apr 2008.
11. Sandeep kumar, D.,Venu madhav, G, “power quality improvement with a shunt active power filters using matlab / simulink, international journal of innovative research in electrical, electronics, instrumentation and control engineering” ,(IJRITCC)vol. 3, issue 1, january 2015.
12. Djeghloud, H., Benalla ,H., “ Space Vector Pulse Width Modulation Applied to the Three-Level Voltage Inverter”,5th International Conference on Technology and automation, Thessaloniki,(ICTA’05) Greece, October 15-16, 2005.
13. O. Enaut Muxika , “Application Des Réseaux de neurones A L’Identification D’un Axe De Machine-outil”, Doctoral Thesis, The National Polytechnic Institute of Grenoble 2002.
14. Benhabib, M. C., Jacquot ,E., Saadate, S. , “An Advanced Control Approach for a Shunt Active Power Filter”, International Conference on Renewable Energy and power Quality, (2003) April 9-11, Vigo, Spain.
15. Laib, H. , Kouara ,H., Chaghi ,A. , “ A New Approach of Modular Active Power Filtering”, International Journal of Advanced Science and Technology Vol. 50, January, 2013
16. Chebabhi .A , Fellah, M-K. Kessal .A, Benkhoris ,M-F. “ the pq0 theory with multi variable filter and fuzzy logic control for a four leg shunt active power filter compensated by three dimensional space vector modulation under unbalanced loads”,journal of Electrical Engineering; vol.1(15), pp.32-39, 2015.