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The Improvement of Power Quality Using Parallel Active Filter Based on the Bee Reproduction Algorithm

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Abstract: So far many controllers are proposed to improve the performance of the filter that the most important differences between them are in the speed of response, ease of use, maximum capacity, insensitivity to line parameters and reduce the number of switches. If the proposed structure can obtain more than of the above mentioned, the design value would be doubled. In the present study, the objective is to introduce an active filter that with no complexity in the modulation method and so on, only with appropriate adjustments of the k_p and k_i coefficients of PI controller can improve the performance of the filter.

Key words: Filter, controller, evolutionary algorithms, sensitivity, performance, adjustments

INTRODUCTION

Today the use of electronic devices of power has gained popularity in different levels. The cause of this great popularity is high efficiency and controllability but these devices are the main source of harmonic generation. The harmonics in the power system have adverse effects and reduce power quality, power factor and increase the losses. These effects can be divided into two categories short-term effects: short-term effects include voltage distortion, sensitive loads slip, warming and saturating the iron cores in the power system (such as electric machines, transformers, etc.) is. Long-term effects Long-term effects include increased loses and voltage stress. Each of the above can lead to other problems, such as voltage stress can lead to malfunction of the relay, applying additional pressure to the dielectric capacitors and so on. One of the ways to reduce harmonic is the use of passive (inactive) filters (RLC circuit) (Mohan, 2001; Li and Haskew, 2007; Peng and Zhao, 2011; Brahim and Kurosawa, 1993; Restrepo *et al*., 2004). This method is mainly used in HVDC lines. These filters in addition to reduce harmonics, improve the power factor but they can only amend a special case of system power (state which they designed for) and they unable to adapt to changing system conditions. In addition, there is the possibility of resonance with the impedance of the system. Considering the posed problems, the necessity of propose a plan that remove the above disadvantages is felt (Restrepo *et al*., 2007; Bellman, 1957; Balakrishnan and Biega, 1996). Therefore, for this purpose, the active filter was proposed in 1971 (Venayagamoorthy *et al*., 2002). Active filters in the power system do tasks such as reactive power compensation, harmonic reduction, the compensation of negative sequence of voltage or current and voltage regulation. There are two types of series and parallel active filter (Li *et al*., 2012). Parallel active filters are used to compensate the current while series active filter are responsible for the voltage offset (compensation). The control system of current is an important part in the structure of the active filters and many methods have been proposed for controlling the inverter current. The main differences between current controllers are response rate, ease of use, maximum current capacity, insensitivity to the line parameters and reduction of the number of switches. In the structure of these filters as shown in Fig. 1, there are three important principles. The first is the identification method. In the mentioned part, the goal is the production method of the reference signal which must be produced by the compensation system to reduce line current harmonics. Another, significant part is the inverter that produces reference signal generated in the identification phase to power signal inverter and injects to line to reduce harmonic current. The way of inverter control is done in modulation phase.

Since, the generated signal in the detection phase is a current signal but the inverter generates voltage. Therefore, the current signal should be converted into

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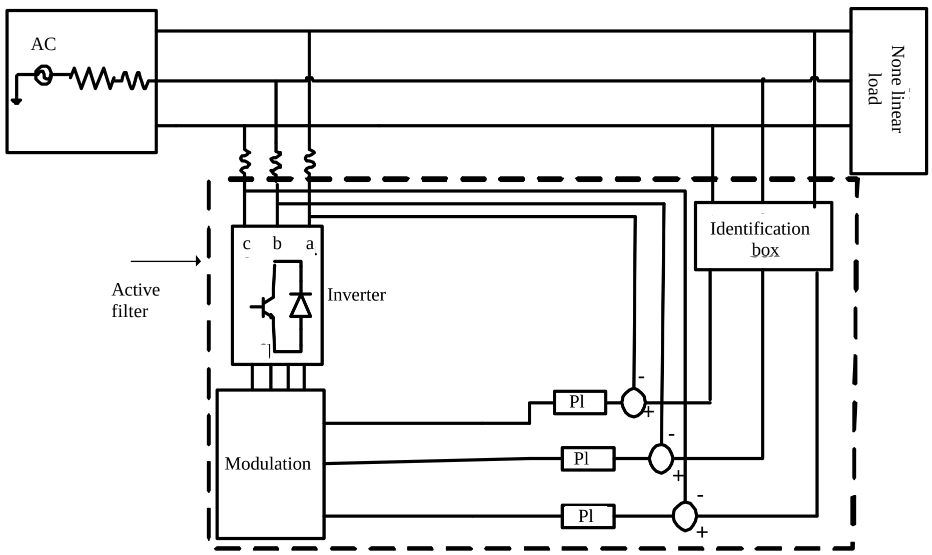

Fig. 1: The structure of the active filter

voltage signal because the exact relationship between voltage and current is unknown and on the other hand the inverter output is connected to with an inductor to line, so some capacitor property should be gave to filter capacitor to prevent its performance undermining. Given that the capacitor current is the integral of capacitor voltage, therefore, this conversion is done using a PI controller. The important point is to determine the k_p and k_i coefficients of this controller which has been less studied. In this study, the mentioned coefficients using bee reproduction algorithm aimed to reduce the current harmonic are determined. In the following, computer simulations required in order to demonstrate the capability of the proposed filter for nonlinear load with sinusoidal and non-sinusoidal sources are shown. In this study, the results were compared with its predecessors.

MATERIALS AND METHODS

The studied load: In the system under study, a nonlinear load is needed which as shown in Fig. 2 has been considered as rectifier diode bridge connected to RL. Another important point is in the supply system. The source sometimes is considered as pure sinusoidal and sometimes free of harmonics. In fact, one of the things that sometimes be ignored is the presence of harmonics at the source. Here, special attention is paid to the type of sinusoidal source and its impact on the proposed system will be shown.

Sinusoidal source: As mentioned before, two sources will be analyzed that in this part, the sinusoidal source with a range of 4160 V and a frequency of 60 Hz is used. If this

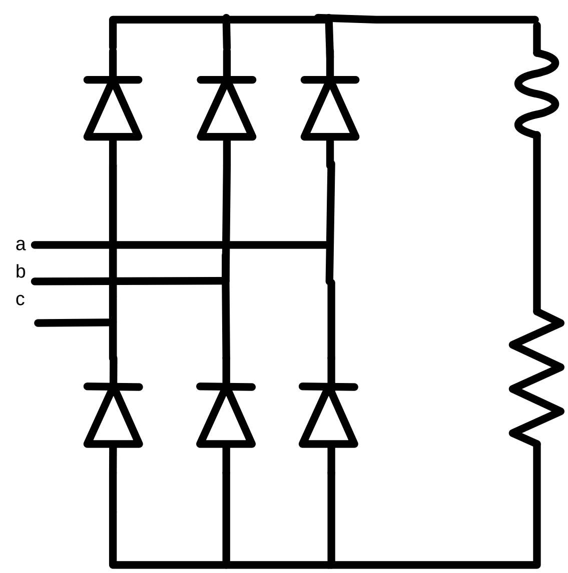

Fig. 2: Nonlinear load-a diode bridge rectifier

resource is applied to the given load of R = 10U and L = 1 mH, the passing current through each diode and its conduction time has been shown in Fig. 3. The plot of the load current changes has been shown in Fig. 4.

The mentioned nonlinear load removes the line current from a sinusoidal mode and makes it harmonic. This current for abc phases and its harmonic spectrum has been shown in Fig. 5a-d, respectively. The THD value in this figure is determined equal to 25.43%. This amount of current harmonic exceeded the boundaries of allowed range, thus to reduce it, the parallel active filter is used.

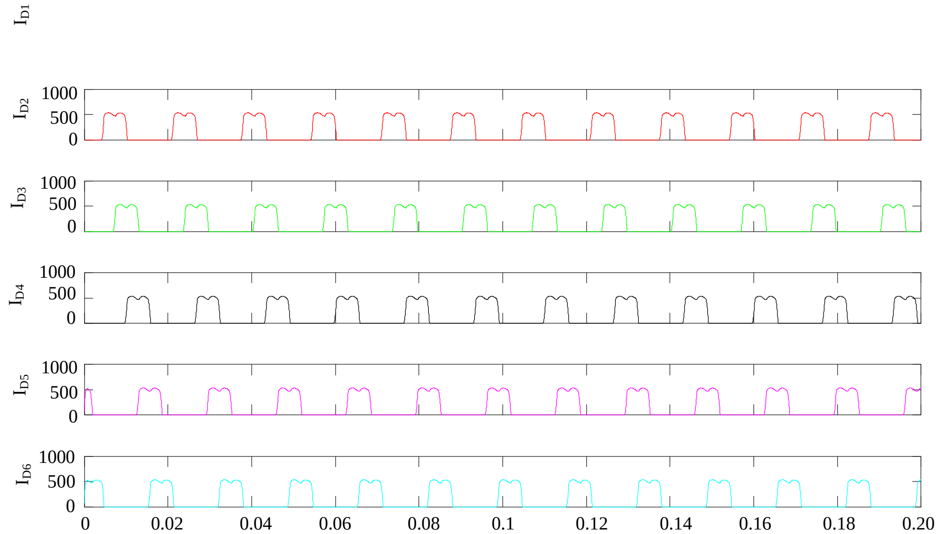

Fig. 3: The load diodes current

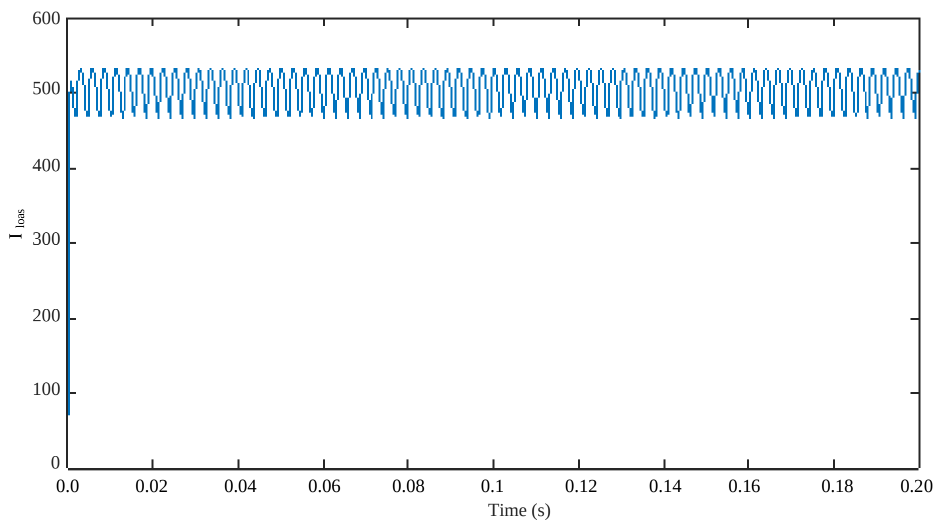

Fig. 4: The waveform of load current

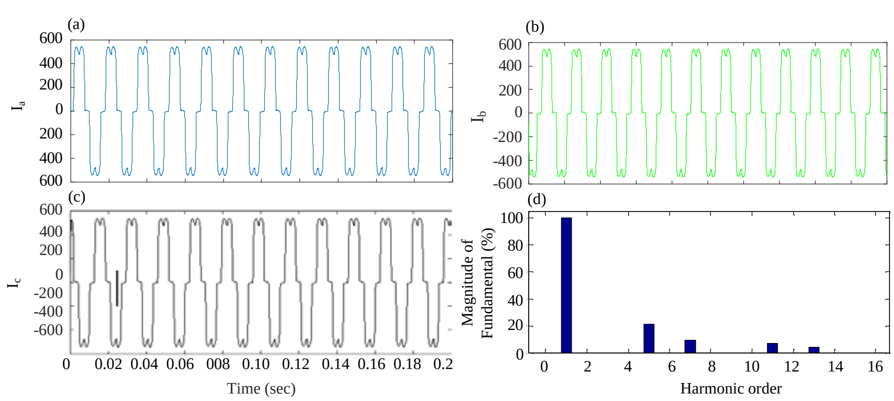

Fig. 5: The waveform of line current with sinusoidal source and without compensation. Phase a-d frequency spectrum; fundamental (60 Hz) = 568.8 , THD = 25.43%

RESULTS AND DISCUSSION

The compensation of sinusoidal source: As shown in Fig. 5, if parallel active filter is applied to this collection can reduce the amount of current harmonic. If the k_p and k_i coefficients are not determined properly, the system's ability to reduce harmonics is reduced. For example, if $k_p = 0.02$ and $k_i = 7.5$, the current waveform is as shown in Fig. 6 which has >15% distortion that this is not a satisfactory performance and with appropriate adjustments of coefficients controller PI the reduction of obtained harmonic should be attempted. As previously mentioned, for adjusting the controller coefficients a meta-heuristic method is used. Reproduction of bee algorithm can be an efficient method to adjust these coefficients. If the mentioned algorithm used to minimize line current harmonic as shown in Fig. 7 the harmonic is reduced to 6.86%. The resulting coefficient values for controller is k_p = 5.0707 and k_i = 6./0839. It should be noted that meta-heuristic methods at different times is not led to a same final answer and there are differences in the final answer.

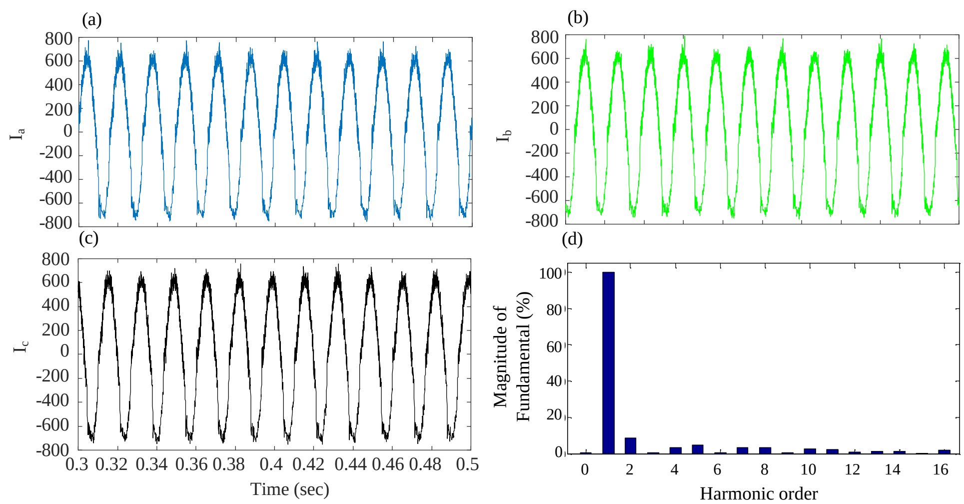

Fig. 6: The linear current without adjusting the coefficients. Phase: a-d frequency spectrum; fundamental (60Hz) = 679.6 , THD = 15.61%

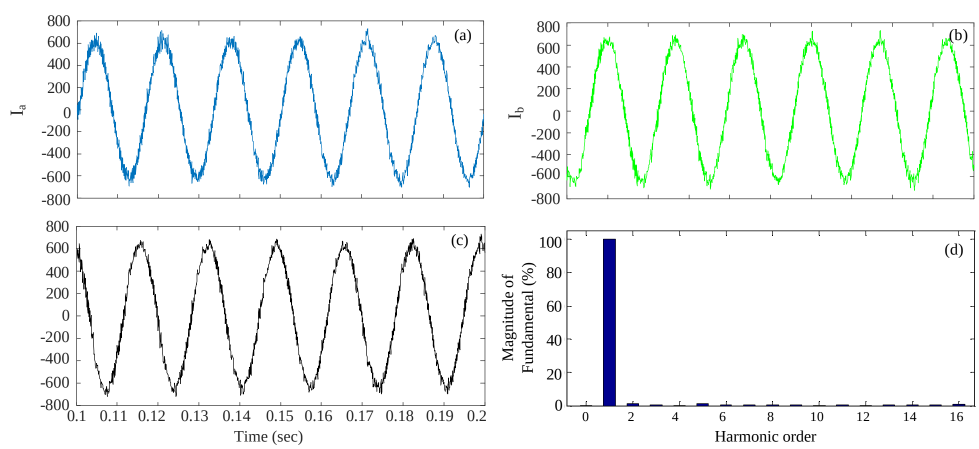

Fig. 7: The linear current with adjusting the coefficients. Phase a-d frequency spectrum; Fundamental (60Hz) = 568.8, THD = 25.43%

CONCLUSION

In this research an active filter presented that without complexity in modulation method and so, only with appropriate adjustment of k_p and k_i coefficients of controller PI improved the performance of the filter. In the system under study, a nonlinear load is needed which has been considered as rectifier diode bridge connected to RL. Another important point is in the supply system. The source sometimes is considered as pure sinusoidal and sometimes free of harmonic. We found that with the optimization of the controller coefficients using bee algorithm, filter performance was improved significantly.

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