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Genetic Algorithm-Based Performance Optimization of Single-phase PWM Rectifier

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Abstract
The purpose of this study is to offer an effective approach for eliminating harmonics in single-phase PWM rectifiers that is based on a Genetic Algorithm. A control loop has been developed in order to achieve the desired DC voltage with the least amount of ripple, the input current with the fewest number of harmonics, and the highest possible input power factor. It has been demonstrated, via the use of theoretical research, that the approach that has been provided for the removal of harmonics is both successful and reliable. Simulations carried out with the MATLAB software programmed are used to check the correctness of theoretical findings.

Keywords: PWM Rectifier, Genetic algorithm (GA), power factor, MATLAB, Harmonics

1. Introduction

Because of its low cost, simple construction, and resilience, as well as their lack of control, diode rectifiers find widespread application in a variety of industrial industries as well as consumer goods. The use of these converters, however, may result in just one direction of power flow, a poor input power factor, a high level of harmonic input currents, the failure of delicate electronic equipment, higher losses, and wasted electricity. To maintain supply In order to maintain quality at levels that are considered acceptable, a number of regulations and recommendations set maximum levels of current harmonic content for specific kinds of applications. In recent times, a variety of potential methods for rectifier power factor adjustment have been presented.

In addition to the utilization of passive and active filters, the utilization of pulse width modulated (PWM) rectifiers is the most effective approach. Interest in three-phase PWM rectifiers' research has increased at a rapid rate over the past few years due to some of their significant advantages. These advantages include the capability of power regeneration and low harmonic distortion of input currents. All of these advantages have contributed to the rise in research interest in three-phase PWM rectifiers. Regulating the currents such that they are in phase with the voltages from the power source is all that is required to achieve unity power factor operating when using a converter that possesses the capabilities to regulate the sinusoidal waveforms of input currents.

Recent research on this kind of PWM rectifier has resulted in the development of a number of different control strategies [1-2].

In this article, a method that is based on the GA is proposed with the goal of optimizing output DC voltage ripple, total harmonic distortion of unity power factor and input current.

2. Circuit Topology

A proposed block diagram for a single phase PWM rectifier employing a genetic algorithm is shown in Fig. 1. Fig. 2 illustrates a single phase PWM rectifier circuit in which source V_s is supplying power to the PWM rectifier circuit.

Fig 1: Proposed Block diagram

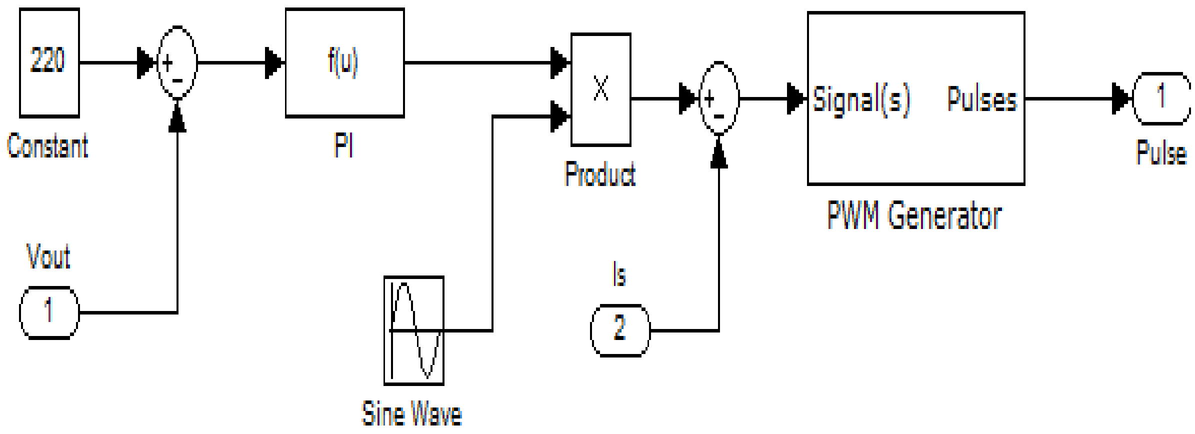
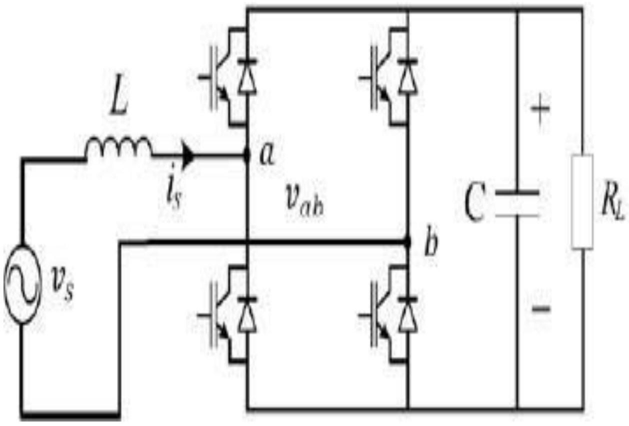


Fig2: Single phase PWM Rectifier circuit



The output voltage measured in this control system is compared to an output voltage V_{out} that will be selected at random, and the output of the PI controller is then multiplied by the outcome of that comparison. . The final product will next be subjected to a sinusoidal wave multiplication.

In order to activate the switches, the outcome of this comparison is provided into the PWM generator as an input [5–10]. This is accomplished through the utilization of a PWM generator. Other characteristics that have an influence on the generation of fires by a PWM generator include the switching frequency (fs), which was determined in the box containing the PWM generator.

3. Genetic Algorithm

A genetic algorithm is a method for solving issues that uses genetics as a model for problem solving. It is a technique for looking for roughly accurate solutions to optimization and search-related problems.

In essence, an optimization problem appears to be very straightforward. One is aware of the format of every potential response to a given problem. The search space is the collection of all solutions that satisfy this specification. Finding the solution that best fits the situation, or the one with the greatest potential rewards, is the challenge. The issue does not present many difficulties if all of the answers can be immediately listed. Enumeration, however, quickly becomes impractical as the search space grows larger since it would take too long. To identify the best solution in this, a special methodology must be used.

GA manages a population of potential answers. A chromosome, which is essentially an abstract representation, is used to represent each solution. The first step in a genetic algorithm, though not the easiest, is to code every potential answer into a chromosome. Additionally, a group of reproduction operators must be chosen. Reproduction operators are employed to carry out mutations and recombination over solutions to problems, and they are applied directly on the chromosomes. Given how heavily the GA's behavior depends on using the right reproduction and representation operators. They are actually something determinant. Finding a representation that abides by the search space's structure and reproduction operators that are coherent and pertinent given the characteristics of the problems can frequently be incredibly challenging.

Every member of the population should be able to be compared through selection. A fitness function is used for selection. Each chromosome has a value assigned to it that reflects how suitable the answer it represents is. An assessment of the prospective solution's quality should be made using the fitness. The answer that maximizes the fitness function is the best one. The challenges that optimize the fitness function are dealt with using genetic algorithms. However, if the issue at hand involves minimizing a objective or cost function, adaptation is rather simple. Either the objective or cost function can be changed to a fitness function, such as by inverting it, or the selection process can be changed so that people with low evaluation functions are prioritized over those with higher evaluation.

An accurate formulation of the reproduction and fitness functions is followed by the evolution of a genetic algorithm using the same underlying ideas. Chromosomes are created in an initial population to get things started. There must be a lot of genetic diversity in this starting population. The gene pool should be as lengthy as feasible to allow for the production of any search space solution. Usually, an initial population is generated at random. [11- 13] The population is then subjected to an iterative procedure that is repeated by the genetic algorithm in order to facilitate evolution. The following operations are performed with each iteration:

Selection: Before choosing two parent chromosomes from a population, determine their fitness (the higher the fitness, the greater the possibility of selection).

Reproduction: The second stage has the chosen individuals having more of their own children. In order to generate new chromosomes, the approach is able to take advantage of both recombination and mutation.

Evaluation: The new chromosomes fitness is next assessed.

Replacement: During the last stage of the process, members of the previous population are eliminated and their places are taken by members of the new population. When the population reached a point where it converged on the ideal solution, the algorithms terminated.
The simple genetic algorithms fundamental four steps for solving a problem are, in a nutshell, as follows:
The problem's first representation is:

- The fitness calculation.
- Different parameters and variables used to regulate the algorithm.
- The algorithm's display of results and method of termination.

4. Proposed Methodology

The Genetic Algorithm is one of the optimization techniques that may be utilised to get the best outcomes from the system. This paper considers the use of the Genetic algorithm to optimize four variables: power factor, settling time, harmonic of the input current, and ripple of the output voltage. The Simulink simulations were performed 30 times using the Genetic algorithm to find the values that produced the best results for the four parameters of switching frequency (Fs), Kp, time (T), and capacitor value (C). The load parameters for the rectifier are L=10mH and R=200, while the input voltage is 220 V, 50 Hz. Table I demonstrates the appropriate range for four variable parameters.

Table 1 Appropriate range

Variables	**Appropriate Range**	
Fs(kHz)	35	70
C(μF)	300	1000
Kp	1.8	5
T	0.03	0.07

5. Simulation Results

By using appropriate range, the best outcome obtained using this algorithm is given below in table 2.

Table 2 Best outcome with optimization

Optimization	**Fs(Hz)**	**C(F)**	**Kp**	**T(s)**	**THD**
Without optimization	60000	0.00039	2	0.035	7.2076%
With optimization	68500.8	0.00041578	2.8555	0.028026	3.7458%

On the basis of best result from GA, THD of input current and output voltage without and with GA is shown below in figure 3-6.

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Fig.3: THD without GA of input current

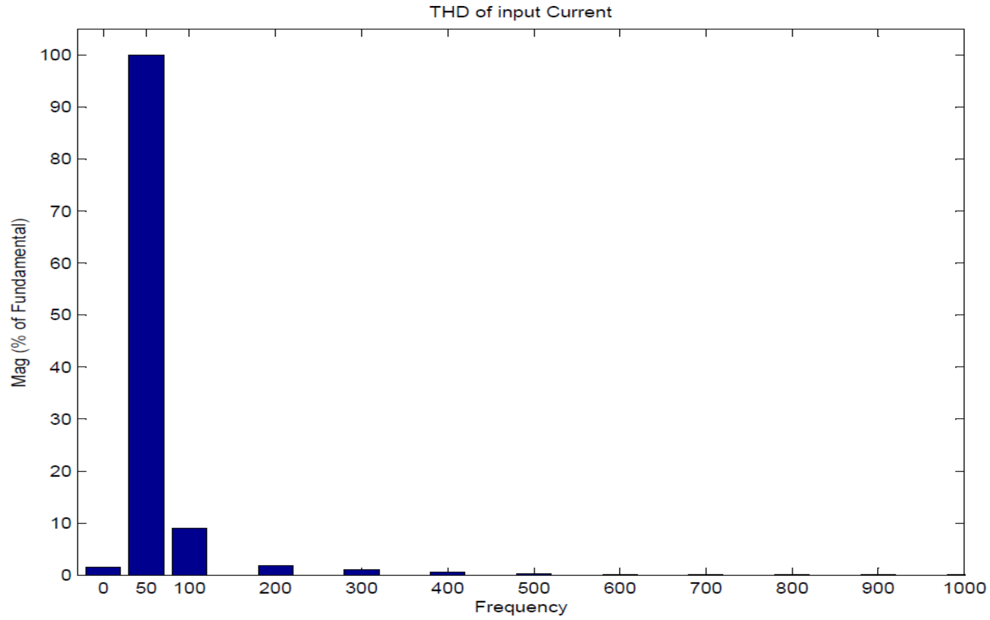


Fig. 4: Output Voltage

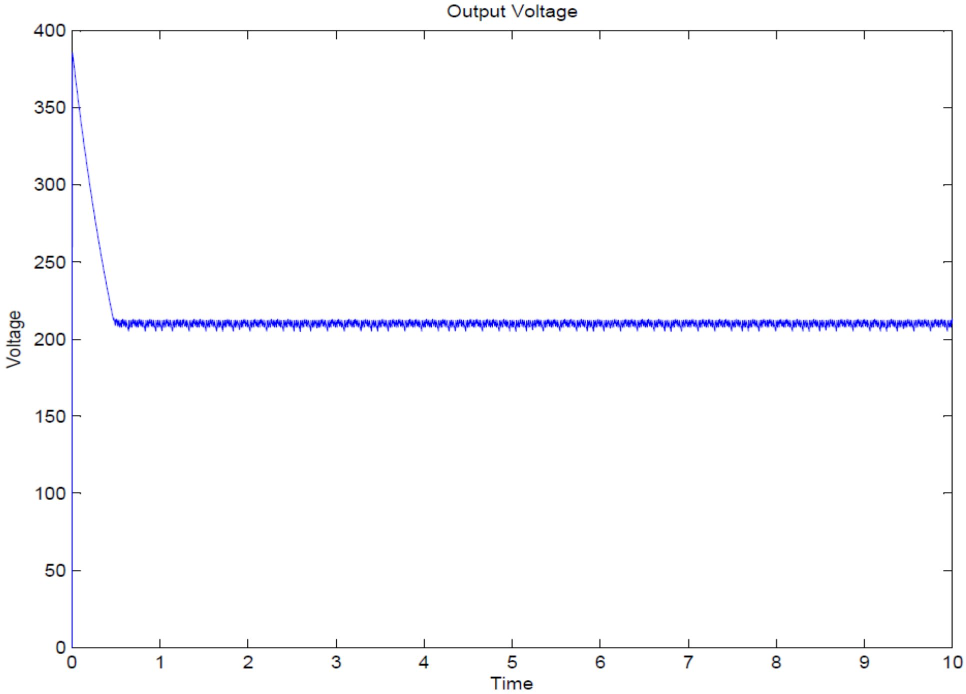


Fig. 5: THD with GA of input current

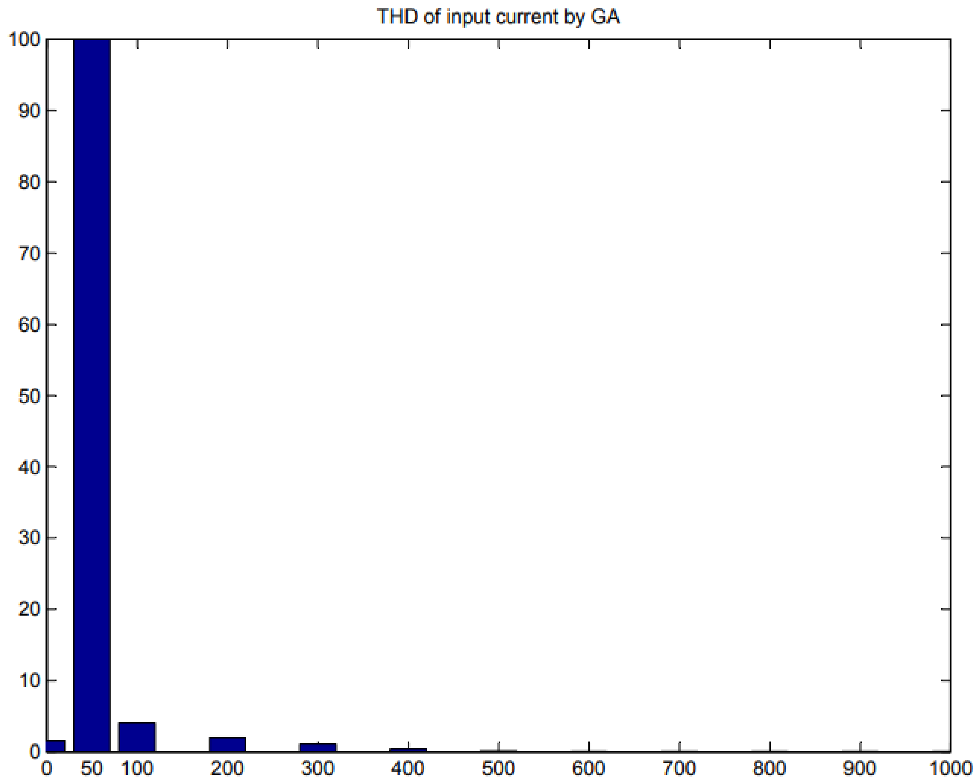
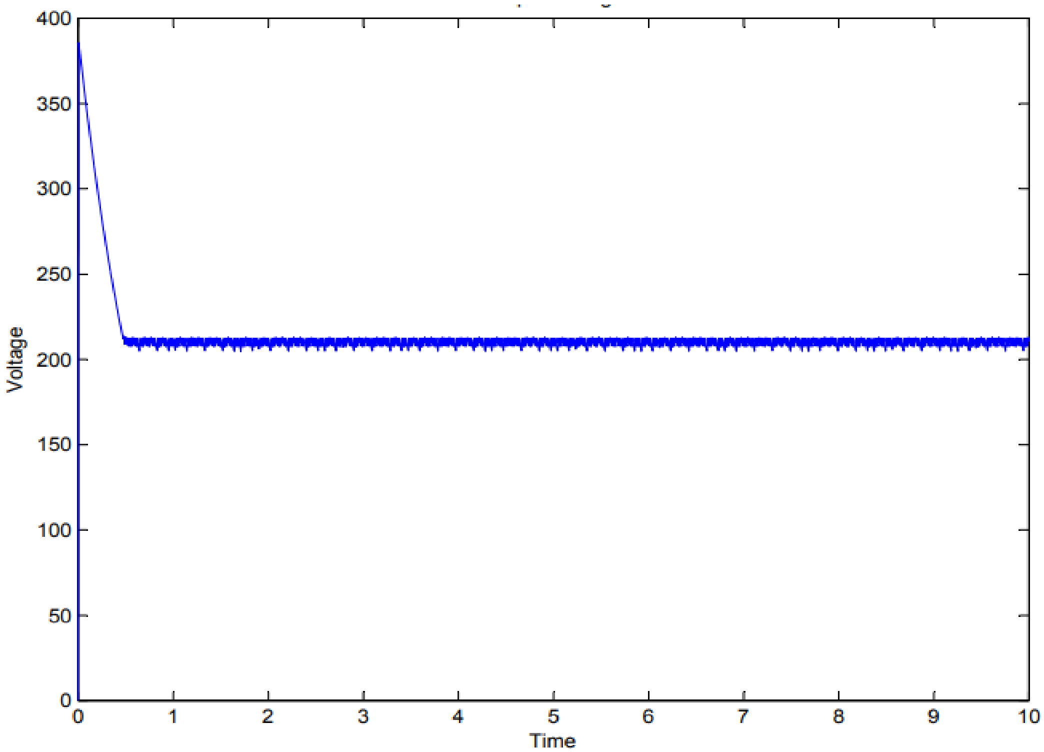


Fig. 6: Output Voltage



6. Conclusion

A standard system, which is employed MATLAB simulink, was provided in this research for the purpose of getting DC voltage with a low ripple, a minimum harmonic of input current, and a maximum power factor. Additionally, the Genetic Algorithm was used for the purpose of optimizing desired outputs. These simulation results suggest that the results acquired by the Genetic Algorithm are so suitable; thus by utilizing those parameters of genetic algorithm, an intelligent algorithm, were optimized in which they were indicated to be each suitable.

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