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Performance Analysis of Different Soft Techniques Applied in Multilevel Inverter for Harmonic Elimination

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Abstract *- Now a day's Microcontroller is found to be very advantageous in developing electronics circuit. It has shorter design cycle, lesser complexity, lower cost and higher density. This project presents a Microcontroller based gate signal generator for Cascaded Multilevel inverter employing a selective Harmonic Elimination Pulse width modulation (SHEPWM) switching strategy to regulate its output voltage. There are totally different Soft switching optimization techniques, here during this project some special improvement techniques like Genetic algorithmic program (GA), Particle Swarm improvement (PSO) are applied MLI to determine the switching angles. The switching angles are calculated such that the constraints of SHEPWM are met which controls the switching of the CMLI thereby eliminating the lower order harmonics and minimizing the Total Harmonic Distortion (THD) while maintaining the required fundamental voltage. Simulation results are observed in SIMULINK .The switching angles obtained from the MATLAB are used in PIC to generate the pulses. The structure is then implemented in PIC. The PIC kit is interfaced with the 9 level hardw are CMLI and the results are observed in oscilloscope.*

Key Words: ***PWM, GA, PSO, SHEPWM.***

1. Introduction

Electrical energy is particularly valuable goods and plenty of market studies demonstrate that the demand for electricity is regularly increasing exponentially [2]. Currently a day's electricity has become a really basic necessity of human race. It's needed nearly for each and every work in our day to day life. India although could be a developing country nearly 30-40% [5]of the people doesn't have the luxurious of electricity in their life and plenty of market surveys have shown that the demand for electricity is growing exponentially[5]. As a result of the restricted accessibility of electricity and ever increasing oil costs, however, a replacement technical age has begun associate age during which the goal is to scale back electricity consumption and promote analysis into different sources of energy.

As a result, continuous enhancements are desperately required on the potency front altogether industrial and client applications. Inverters play an important role in conversion of DC current obtained from these renewable sources of energy into AC current. once this process is done there'll be some loss in power due to the presence of harmonics and total harmonic distortion .So so as to achieve maximum power conversion and to prevent the device from getting damaged it is desirable to remove these harmonics and to attenuate the THD[7].

Many researches square measure being carried enter this field to achieve output voltage with minimum THD. As a result of increasing demand of high power inverter unit, multilevel inverters square measure gaining more attention in industries [6]. In Multilevel electrical converter the output is obtained by adding many electrical converter units which ends with a step wave form which is nearer to a wave therefore reducing the THD. Multilevel electrical converter are used in low and high voltage applied in versatile AC transmission systems (FACTS), laminators, compressors, UPS systems, plasma, STATCOM applications etc,.

In this paper Genetic algorithm (GA) and Particle swarm optimization technique (PSO) which is a computational heuristic search algorithm is used to find the switching angles from the non-linear transcendental equation of SHEPWM. GA and PSO provides optimization by finding the solution for the whole range of modulation index (M.I) unlike the conventional Newton-Rapson method[7] which fails to provide the solution for the whole range of M.I and reduces the harmonics instead of eliminating them.

The main aim of this paper is to eliminate harmonics of three phase 9-level CMLI Using SHEPWM [5] based on GA and PSO while maintaining the required fundamental frequency. The simulation result shows that the SHEPWM efficiently eliminate the harmonics and minimizes the Total Harmonic Distortion (THD).Here results of both PSO and GA are compared and results are analyzed both in matlab and microcontroller.

2. Proposed Work

2.1. GA Method

Genetic algorithm is applied to solve problems iteration by iteration. It is used to solve constrained and unconstrained problems. It is based on concept of natural selection. The complete process is divided as selection, mutation and crossover [6]. The below diagram shows the flowchart of genetic algorithm: Different steps followed in the implementation of the GA are as follows:

Step 1: Initialization of tournament number and population number

Step 2: Random generation of bits.

Step 3: Calculation of string values.

Step 4: Define upper and lower bounds.

Step 5: Fitness value calculation.

Step 6: Tournament selection.

Step 7: Parent and children selection for crossover and mutation.

Step 8: Fitness function evaluation.

Step 9: Converged output (Switching angles)

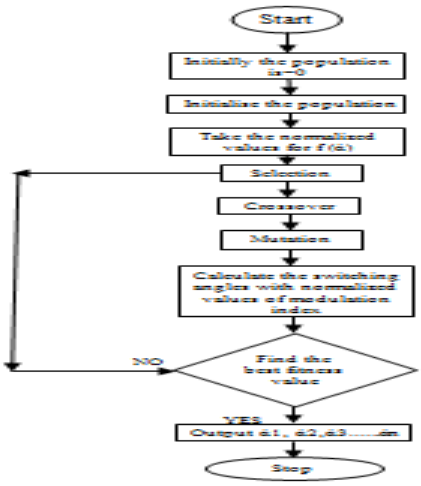

Fig 1: Flowchart of GA algorithm [5]

2.2 PSO Method

The PSO algorithm consists of just three steps, which are repeated until some stopping conditions:

- Evaluate the fitness of each particle.
- Update individual and global best fitness's and positions
- Update velocity and position of each particle

PSO is used as a search space for a given problem. It is used to find the settings required to enlarge a particular problem [7].PSO is derived with two different concepts first swarm intelligence is observed by habits of different kinds of animals. Examples are birds and fish. Next it is derived with different computation.

PSO was invented by Kennedy & Eberhart. It came into existence in 1995.Influenced by social manner and movement economics of insects, birds and fish. Worldwide upgrade-less suited search method Suited to variation in problems. Here the output is comparable to Genetic algorithms. It is applied for different types of problems.

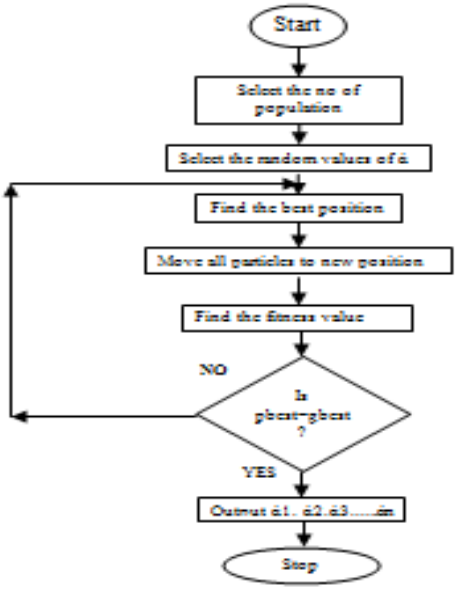

Fig 2: Flowchart of PSO algorithm [7]

3. Methodology

- 9-level cascaded multilevel inverters are developed in Simulink.
- MATLAB/SIMULINK software is used for simulation and verification of proposed PWM strategy for multilevel inverters.
- The pulses required for CMLI are obtained using SHEPWM technique and optimization is achieved by comparing with different soft techniques such as GA, PSO algorithms.
- Pulses are generated using Microcontroller. The processor is designed using C coding method, simulated using MP Lab simulator and implemented using PICKIT2 synthesis tool.
- PICKIT2 synthesis tool is used to interface with the hardware CMLI and the results are observed in oscilloscope.
- Discuss the results obtained from both MATLAB/SIMULINK and Microcontroller.

4. Implementation

4.1. Calculation of switching angle

Harmonic distortion of waveform is mainly observed switching angles for each voltage is calculated. In project switching angles are calculated for both PSO and GA are calculated. When the angels are good, the corresponding THD will also be good. Here PSO gives the good performance and THD value is very less. For calculating the switching angle, the output waveform should be considered. The output is represented by the term r (t),

$$r(t) = \sum_{n=1}^{\infty} (p_n \sin_n \propto_n)(q_n \cos_n \propto_n) \ldots\ldots\ldots (1)$$

Using the above equation corresponding angles can be calculated. The below table represents the angles calculated for GA algorithm.

M.I	a1	a2	a3
0.1	5	40	60
0.2	10	35	65
0.3	25	45	82
0.4	15	30	72
0.5	20	40	70
0.6	25	35	65
0.7	5	30	60
0.8	15	40	70
0.9	30	45	82
1	20	30	80

Table 1: switching angles for different modulation index obtained from GA

M.I	a1	a2	a3
0.1	6	42	63
0.2	10	34	62
0.3	15	44	85
0.4	15	33	70
0.5	24	44	72
0.6	28	32	63
0.7	23	32	55
0.8	20	44	50
0.9	10	41	70
1	5	32	80

Table 2: switching angles for different modulation index obtained from PSO

4.2. Calculation of total harmonic distortion

The total harmonic distortion, or THD, of a symptom could be a measuring of the harmonic distortion and is outlined because the quantitative relation of the total of the facility's of all harmonic elements to the power of the elemental frequency.

It is employed to characterize the one-dimensionality of audio systems and therefore the power quality of electrical power systems. Distortion issue could be a closely connected term, generally used as a word. In audio system, lower distortion suggests that the elements during a speaker unit, instrumentation or mike or different equipment turn out a additional correct replica of Associate in Nursing sound recording.

$$\%THD = [(1/\propto^2_1)\sum_{n=5}^{\infty}(a_n)^{1/2}] \times 100$$

..... (2)

By using the above equation the value of THD can be calculated. The below table represents the THD obtained by using the below equation.

	5th order harmonics	7th order harmonics	9th order harmonics	THD in %
FIVE LEVEL CMLI	12.1%	14.9%	9.8%	33.3%
SEVEN LEVEL CMLI	1.4%	1.8%	2.0%	28.0%
NINE LEVEL CMLI	0.7%	0.01%	0.07%	13.6%

Table 3: Comparison between 5, 7 and 9 level CMLI

4.3. Hardware Implementation

The above figure shows the block diagram of hardware implementation. Here FPGA controller is used to generate the pulses. The coding for FPGA is done in HDL coding. Buffer is used to amplify the circuit. It acts as a non inverting amplifier. When controller is directly connected to hardware due to the reverse current a high voltage flows to the hardware. Therefore there will be damage to the circuit.

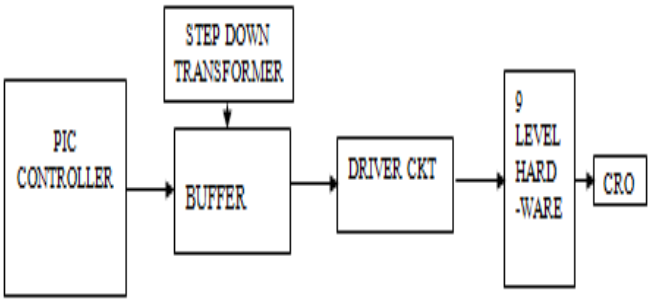

Fig 3: Hardware Implementation [4]

In order to avoid the damage driver circuit is used. The hardware consist of 2 H Bridges with 8 IGBT switches. It consists of 8 driver circuit with 2 buffers and a diode.3 step down transformers are used, 1 for controller and other 2 for 2 H bridges. Pulses are sent from controller, the corresponding waveform is seen in CRO or digital oscilloscope.

5. Results and discussion

5.1. Matlab Results

Figure 4 shows the plotting of modulation index versus THD. The normalized value of modulation index is from 0 to 1.The graph shows the reduction of THD with modulation index. Here genetic algorithm is implemented and THD is reduced to 2.9.switching angles are calculated and then THD is calculated by putting those angles.

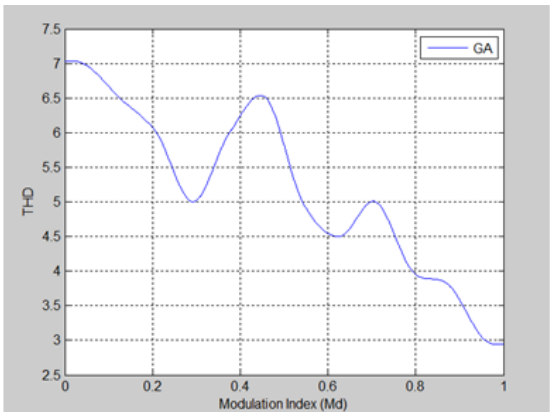

Fig 4: Modulation Index versus THD of GA

Figure 5 shows the plotting of switching angles versus Modulation index and from the graph it can be seen that for modulation index 0.8 the best solutions are obtained. The main advantage of using GA is that the solutions for the whole range of M.I can be obtained and the best solutions can be used to achieve optimization.

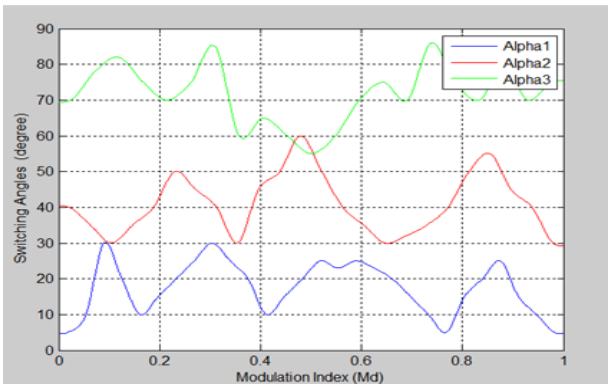

Fig 5: Modulation Index versus Switching Angles of GA

Figure 6 shows graph between the switching angles and the modulation index. In calculation of switching angle the firing angles as assumed as normalized values. Switching angles are then calculated by using the equation. Modulation index ranges from 0 to 1.PSO angle range is from 0 to 90.obtained angles are known as alpha 1, alpha 2, alpha 3 etc.When the obtained switching angles are good, there will be more THD reduction. Here in the project PSO is found to be having good switching angles.

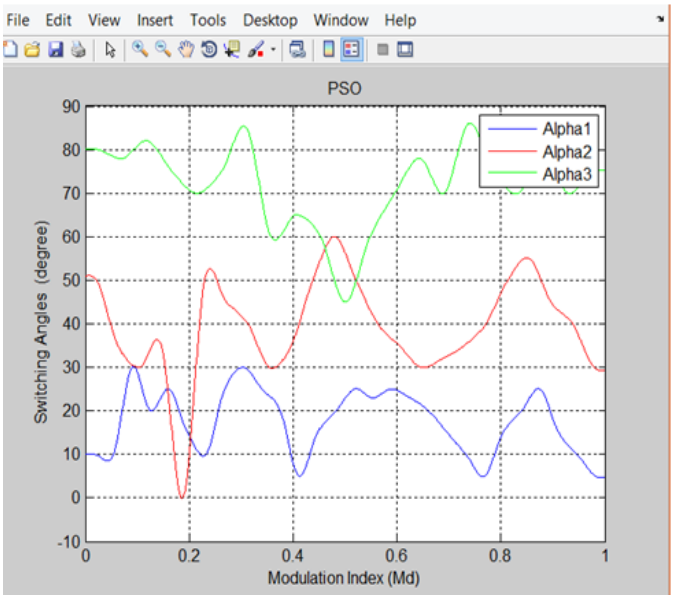

Fig 6: modulation versus switching angles of PSO

5.2. Comparison Result

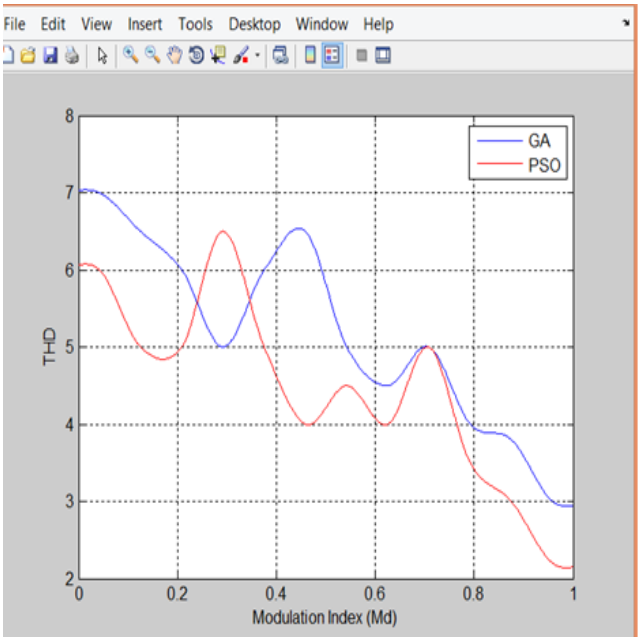

Fig 7: comparison of THD reduction of GA and PSO

Parameter	GA method	PSO method
THD Reduction	2.9%	2.1%

TABLE 4: Comparision result of GA and PSO

5.3 Hardware Result

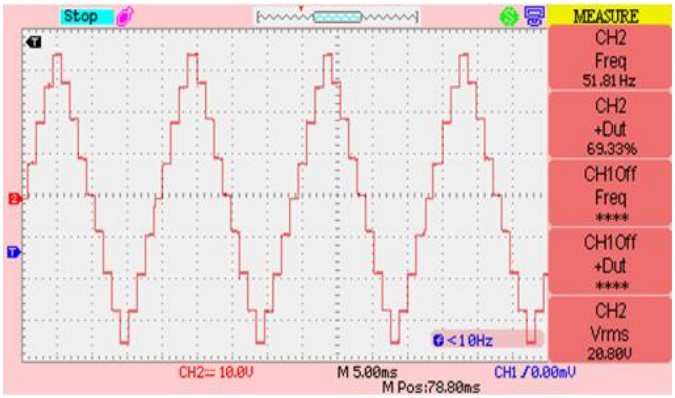

Fig 8: Output staircase wave form of 9 levels CMLI

6. CONCLUSIONS

The 5 level, 7 level and 9 level cascaded structure inverters area unit designed and enforced in MATLAB/SIMULINK. The pulses needed to drive the CMLI area unit generated by Selective Harmonic Elimination Pulse dimension Modulation technique. The shift angles for SHEPWM area unit calculated by Genetic rule and PSO rule. From the simulation results obtained that is listed within the table 1 it may be seen that because the range of levels will increase the entire Harmonic Distortion reduces. THD is 12.29%, the DC element is 0.036v. 5^{th} order harmonics is reduced to 0.7%, 7^{th} order harmonics is reduced to 0.01% and 9^{th} order harmonics is reduced to 0.07%.The hardware nine level CMLI is enforced in PIC platform and PIC KIT synthesis tool and also the simulation results area unit discovered in CRO.

6.1. Future Work

In the proposed project Genetic Algorithm, PSO algorithm, is compared and THD is calculated.THD reduction in PSO algorithm is more when compared to the Genetic algorithm. Pulses are generated and applied to the 9 level CMLI hardware and the result is seen in CRO.As a future work one could try to develop algorithmic hardware in PIC platform and generate the signals by comparing the algorithms. And also higher level CMLI hardware can be implemented in the PIC platform. One could try to develop FPGA based 9 level hardware and generate the signals.

6.2.References

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