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Research Paper

# ELIMINATION OF HARMONICS IN CASCADED MULTILEVEL INVERTER USING SOFT COMPUTING TECHNIQUE

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This paper presents the cuckoo optimization method for harmonic elimination in a cascaded multilevel inverter.The main objective is to eliminate 3rd, 5th, 7th, 13th harmonicsusing the Selective Harmonic Elimination Pulse Width Modulation strategy order by solving non linear equations, while the fundamental component is satisfied.In this paper,the cuckoo algorithm(CA) is applied to a 7level inverter for solving the equations.The algorithm based on parasitic behavior of the cuckoo bird and levyflights used for random walks(or)Brownian motions also the it is starts with an initial population.This method has high efficiency when compared to other metaheuristics algorithm.MATLAB software is used for optimization.It will reduced the Total Harmonics Distortion and eliminate the harmonics.

***Keywords:*** Metaheuristis algorithm cuckoo algorithm, Eliminate harmonics, Selective harmonic elimination(SHE-PWM), Parastics behavior, Total Harmonic Distortion

## INTRODUCTION

Using travelling salesman problem it is used to solving two evolutionary, conventional and bio-inspired algorithms. The performance are comparing basis on the tour length. It is important to save time and cost. Using TSP, Bio-inspired algorithms like cuckoo and firefly will provide feasible and can attain better performance than other methods. This Bio-inspired algorithm could be done by fine-tuning their self adaptive parameters and by using hybrid coding. There are several heuristic and metaheuristic algorithms have been used to solve a wide range of NP-hard problems. A large number of real-life optimization problems in science, engineering, economics, and business are complex and difficult to solve. They can't be solved in an exact manner within a reasonable amount of time. Real-life optimization problems have two main characteristics, which make them difficult: they are usually large, and they are not pure, i.e.; they involve a heterogeneous set of side constraints . Metaheuristic techniques are the basic alternative solution for this class of problems. Recently, many researchers have focused their attention on a metaheuristics. A metaheuristic is a set of algorithmic concepts that can be used to define heuristic methods applicable to a wide set of

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different problems. The use of metaheuristics has significantly increased the ability of finding solutions practically relevant combinatorial optimization problems in a reasonable time. Prominent examples of metaheuristics are Evolutionary Algorithms, Simulated Annealing, Tabu Search, Scatter Search, Variable Neighborhood Search, Memetic Algorithms, Ant Colony Optimization, Cuckoo Search, and others. Which successfully solved problems include scheduling, timetabling, network design, transportation and distribution problems, vehicle routing, the traveling salesman problem and others .

## LITERATURE SURVEY

To reduce the harmonics content is to minimize the THD for the output phase voltage of inverter up to 50 harmonics is considered to calculate the THD. Using Switching angles specific lower order dominant harmonics are suppressed. This method is known as selective harmonic elimination (SHE) or programmed PWM technique in technical literatures[1].THD of multilevel inverters with unequal dc sources is a first method and Integrating waveform is second method using this obtain the results are faster, simpler, and ideally accurate[2].SHE-PWM a five-level voltage source inverter with elimination of 11 low-order harmonics is investigated. The SHE-PWM equations that can eliminate harmonics from 5th to 35th with modulation index M varying from 0 to 1.15 are formulated [3].DFCM converter used to doubling the voltage levels and improve the output voltage frequency spectrum this will achieved by adding only two low-power switches and one dc voltage source [4]. The unbalanced degree of the compensation currents that the star-connected STATCOM can deal with is limited to the maximum attainable output voltage of the converter leg. Also the dc-link voltages of the star-connected cascade converter were effectively controlled during the unsymmetrical fault [1]. Reference rotation method rotates the modulation waveform through different bands of carrier waveforms by using line-line redundant voltage states. This makes use of all the levels in the inverter even at low modulation indexes. The carrier common-mode dc-offset method to increase the voltage levels and reduce harmonic-current distortion at low modulation indexes the series-connected IGBTs in the three-level unidirectional buck and boost choppers resulted in good voltage sharing. Also reducing the switching frequencies of the IGBT's[4].The nature of a low-voltage step in the inverter output makes a significant contribution to reducing motor current ripple and the resultant motor torque ripple, as well as to mitigating undesirable effects of common-mode voltage on ground leakage current and/or bearing current[3]. Based on different switching states, it is possible to achieve more voltage levels on output voltage by adding and subtracting dc link voltages compared with conventional multilevel inverters with the same number of components.Bydoing so, output voltage with superior quality can be obtained with less circuit and control complexity. Also, increasing the harmonic characteristic of the output voltage can decrease the size of the filter. The main advantage of this arrangement is the simplicity to cascade several H-bridge cells for improvement of the output voltage resolution with reduced number of components[6].SHE-PWM techniques offer several advantages over other modulation methods, including acceptable performance with low switching frequency to fundamental frequency ratios, direct control over

output waveform harmonics, and the ability to leave triple harmonics uncontrolled to take advantage of circuit topology in three phase systems, and therefore have drawn great attention in recent years. SPWM method and also reduces switching frequency with the similar waveform quality in the full range of modulation index. To eliminate higher order of harmonics by simply generating the opposite of the harmonics to cancel them[8].Comparison between three types of balance control strategy, namely, the active voltage vector superposition, modulation index regulation, and phase shift angle regulation has been reported in for delta-connected twelve level CHI topology controlled by CB-PWM. It was concluded that the former offers good control performance with strong regulation capability followed by the phase shift angle regulation method and modulation index regulation method. A nineteen-level CHI-based STATCOM to simultaneously balance the dc-link capacitor voltages, minimize the inverter switching losses, and provide good current reference tracking [10]. Elimination theory has been employed to determine the switching angles to eliminate specific harmonics, such as the fifth, seventh, 11th, and the 13th. The benefit of the fundamental frequency switching method is its low switching frequency compared to other control method [12]. Switching losses in these high-power high-voltage converters represent an issue and any switching transitions that can be eliminated without compromising the harmonic content of the final waveform is considered advantageous. The term multilevelstarts with the introduction of the three-level converter. By increasing the number of levels in a given topology, the output voltages have more steps generating a staircase waveform, which approaches closely the desired sinusoidal waveform and also offers reduced harmonic distortion.An optimization technique assisted with a hybrid genetic algorithm was successfully applied to find the switching transitions of the SHE-PWM ac/ac converter [15].The cascaded inverters is producing the total output active power and the other inverters are used as a support to improve the output voltage waveform The main features of this topology are the inherent galvanic isolation, bidirectional power flow, reduction of the transformer size and weight, and high efficiency[18].

## EXISTING SYSTEM DRAWBACKS

Elimination of low-order harmonics using SHEPWM strategy is investigated.BA is applied to solve the equations. Using the Newton -Rap son method does not suggest any optimum solution for Infeasible. Also the Gauss Newton method only used in evolutionary algorithms cannot find solutions only eliminate low order harmonics. In this also optimum solution is infeasible.BA codes have more complexity and greater running time.

## PROPOSED SYSTEM CONCEPT

Using Metaheuristics algorithm cuckoo algorithm to implement cascaded multilevel inverter reduce the harmonics. Giving various n input values to the Natural Algorithm like cuckoo algorithm in this only best optimized value will taken and given to the multilevel inverter. Optimization means finding out the firing angles for minimizing losses. In this harmonics will reduce. It was observed that the bio-inspired algorithms provide feasible methods for TSPs and can attain better performance than other methods. Firefly and cuckoo algorithm have

been used with success to compute optimal switching angles for multilevel inverters with many dc sources while minimizing several harmonics. In firefly algorithm, a firefly population is placed in random locations in the search space where the fireflies represent a candidate solution. In CS In firefly algorithm, a firefly population is placed in random locations in the search space where the fireflies represent a candidate solution. Using firefly algorithm optimized result is obtained and using the cuckoo algorithm it is efficient.

## METAHEURISTICS ALGORITHM

CUCKOO ALGORITHM

Start with $\zeta 0 \in S$, at t = 0

While (criterion)

Propose a new solution YT+1;

Generate a random number $0 \leq Pt \leq 1$;

Zt+1 =

end

YT+1

At

With probability Pt

With probability 1 – Pt

end

## DESIGN OF INVERTER

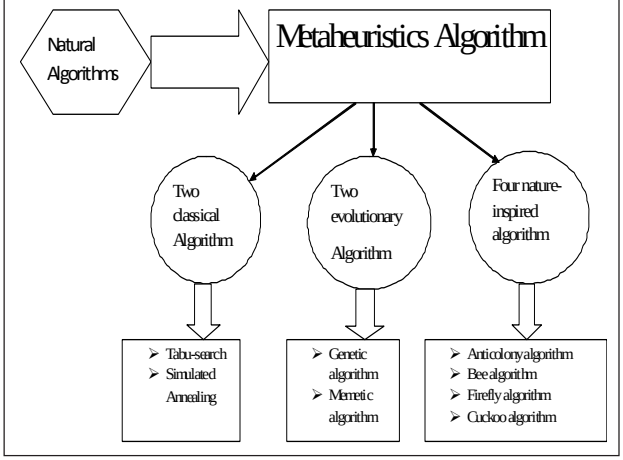
An inverter is a device that changes or inverts direct current (DC) input to alternating current (AC) output. It doesn't "create" or "make" electricity, just changes it from one form to another. DC in is changed to AC out. Output is usually 120 or 240 volts at 60-cycle alternating current to match line power. Inverters are often a good choice for applications that require the main engine to operate at a job site. Powering hydraulic systems or air compressors.Since, inverters are electronic devices, we don't have the noise from a separate engine.An inverter requires no fuel and virtually no maintenance. Inverter output is fully voltage and frequency regulated and functions independently from the speed of the engine. In this paper 17-level inverter is used to solving the equations using the two algorithms. Formula to calculate level 2S+1 Where S indicates the number of voltage sources.

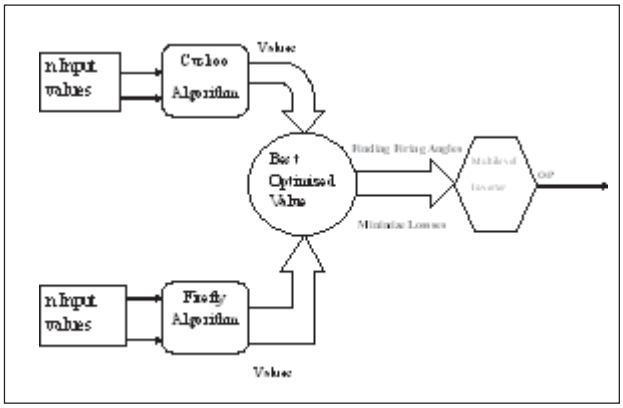
## CHARACTERISTICS OF GOOD INVERTER

Its output voltage waveform should be sinusoidal.Its gain should be high.Its output voltage and frequency should be controllable in the desired voltage.The power required by its controlling circuit should be minimum.Its overall cost must be minimum.Its working life must be long.The semi conductor device used in the inverter should be minimum switching and conduction losses.

## BLOCK FOR DIFFERENT TYPES OF ALGORITHMS

**Figure 1: Block Diagram**






## OPERATION

### Multilevel Inverter

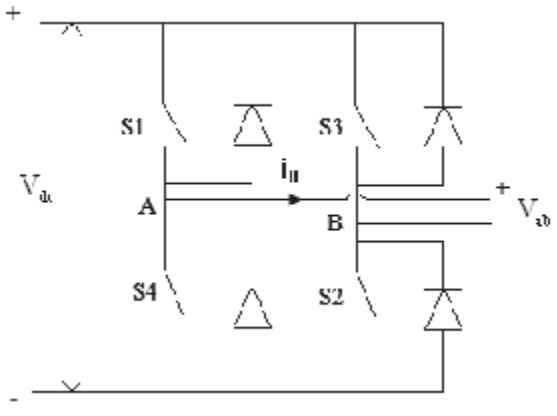
Multilevel inverter is used to extract power from solar cells. It synthesizes the desired ac output waveform from several dc sources. Multilevel converters are mainly utilized to synthesis a desired single- or three-phase voltage waveform. The desired multi-staircase output voltage is obtained by combining several dc voltage sources. Solar cells, fuel cells, batteries and ultra-capacitors are the most common independent sources used. One important application of multilevel converters is focused on medium and high-power conversion. Nowadays, there exist three commercial topologies of multilevel voltage-source inverters: neutral point clamped (NPC), cascaded H-bridge (CHB), and flying capacitors (FCs). Among these inverter topologies, cascaded multilevel inverter reaches the higher output voltage and power levels (13.8 kV, 30 MVA) and the higher reliability due to its modular topology. There are three main types of multilevelconverters: diode-clamped, capacitor-clamped, andcascaded H-bridges. The detailed advantages anddisadvantages of the three multilevel converters willbe discussed in this chapter. Modulation techniquesthat have been proposed include traditional PWMmethod, space vector PWM method, space vectorcontrol method, and selective harmonics elimination method. Applications that have been proposed includemultilevel rectifiers, DC/DC converters, large motor drives, distributed energy applications (such as staticvolt-ampere reactive (VAR) compensation), back-to-backhigh-voltage intertie, and adjustable speed drives.

## CASCADED H-BRIDGE MULTILEVEL INVERTER

The cascaded H-bridge inverter has drawn tremendous interest due to thegreater demand of medium-voltage high-power inverters. It iscomposed of multiple units of single-phase H-bridge power cells. The Bridgecells are normally connected in cascade on their ac side to achievemedium voltage operation and low harmonic distortion. The cascaded Bridgemultilevel inverter requires a number of isolated dc supplies, each ofwhich feeds an H-bridge power cell.More generally, a cascaded H-bridges multilevel inverter using s separate dc sources can produce a maximum of 2s + 1 distinct levels in the output phase voltage.

The advantages for cascaded multilevel H-bridgeConverter is the following:

**Figure 3: Single Phase H-Bridge Inverter**



(1) The series structure allows a scalable, modularized circuit layout and packaging. Due to the identical structure of each H Bridge.

(2) No extra clamping diodes or voltage balancing capacitors is necessary.

(3) Switching redundancy for inner voltage Levels are possible because the phase voltageis the sum of each bridge's output.

## LEVEL OF 3RD, 5TH, 7TH, 13TH HARMONIC ELIMINATION

Improving the efficiency of the multilevel inverter and quality of output voltage waveform. Seven level reduced switches topology has been implemented with only seven switches. Fundamental Switching scheme and Selective Harmonics Elimination were implemented to reduce the Total Harmonics Distortion (THD) value. Selective Harmonics Elimination Stepped Waveform (SHESW) method is implemented toeliminate the lower order harmonics. Fundamental switching scheme is used to control the power electronics switches in the inverter. The proposed topology is suitable for any number of levels. The harmonic reduction is achieved by selecting appropriate switching angles.It shows hope to reduce initial cost and complexity hence it is apt for industrial applications. In this third and fifth level harmonicshave been eliminated. In multilevel inverter using five equal dc sources, the five switching angles weredetermined such that the 5th, 7th, 11th, and 13th orderharmonics were eliminated while at the same time controlling the value ofthe fundamental. The idea of SymmetricPolynomials was used in conjunction with Resultant theory to solve the corresponding set of polynomial harmonic equations for all possible switching angles.

## HARMONIC ELIMINATION SWITCHING SCHEMES

This section presents switching schemes involving harmonic elimination besides various multilevel switching schemes which was discussed in previous chapter. More specifically, Bipolar Programmed PWM, Unipolar Programmed PWM, and Virtual Stage PWM are discussed. Bipolar Programmed PWM is one of the switching schemes involving harmonic elimination. In Bipolar Programmed PWM, the output voltage is either *Vic*or *Vic.* Figure 3.8 illustrates the Bipolar Programmed PWM switching scheme using three switching angles and an *Vdc*equal to 12 V.

### Bipolar Programmed PWM

Another advantage of Bipolar Programmed PWM is that control is not as complicated as some other switching schemes. Neglecting blanking time, switches *S*11 and *S*13 are switched "on" and "off" together. Similarly, switches *S*12 and *S*14 are switched "on" and "off" together.

### Bipolar Programmed PWM Using Three Switching Angles

That Bipolar Programmed PWM uses predetermined switching angles to cut notches into a square-wave output. These notches take the voltage either from *Vic*to *Vic*or from *Vic*to *Vic.* The number of notches cut per fundamental cycle is equal to twice the number of switching angles used, which was addressed in Mohan et al (1995). By using Fourier series theory, these switching angles can be used to eliminate certain harmonics. For example, three switching angles can be used to eliminate the fifth and seventh order harmonics while at the same time controlling the value of the fundamental. One of the main advantages of using Bipolar Programmed PWM

concerns its applicability when low modulation indices are used. When low modulation indices are used, the fundamental multilevel switching scheme is unable to perform the desired harmonic elimination process. The three switching angles are considered again, when the fundamental multilevel switching schemes are used, it is not able to eliminate both the fifth and seventh order harmonics and control the value of the fundamental. However, Bipolar Programmed PWM can be used with low modulation indices were discussed in Chanson et al (2004). When a multilevel inverter utilizes Bipolar Programmed PWM for a low modulation index, typically one H-bridge is used. Another advantage of Bipolar Programmed PWM is redundancy. If one H-bridge fails, another Hbridge can be used to compensate the necessary voltage. Also, the desired voltage can be achieved by using a sequence of switching's for each H-bridge inverter within short periods of time. Bipolar Programmed PWM can be used for higher modulation indices in addition to low modulation indices. If a multilevel inverter needs to use two or more H-bridges in order to produce a desired voltage, one can choose a lower modulation index and use Bipolar Programmed PWM on multiple H-bridges.

## TRAVELLING SALESMAN PROBLEM

The Travelling Salesman Problem (TSP) represents a large class of problems known as combinatorialoptimization problems. These are difficult to solve using traditional methods and ifsolvable, computations tend to be very time consuming.Hence we settle for approximated results which in less time, end up giving a resultthat isn't necessarily the best tour, but instead a tour that is close to the best tour .Aform of the TSP was introduced by Euler in 1759 and later in 1948 Rand Corporation formally named and introduced it . It defined the Classical Travelling Salesman Problem (CTSP) as a problem where starting from one city it is required by the salesman to visit every other city only once in a way that the total distance covered is minimized. As the number of cities increases, the complexity of the problem increases exponentially due to the number of possible solutions increased very heavily.CTSP and a variant of TSP named as Random Travelling Salesman Problem (RTSP) are solved using conventional, evolutionary and bio-inspired algorithms. The performances are compared on the basis of tour length. For CTSP, six available datasets on TSPLIB are used and for RTSP, four datasets are randomly generated having all the city coordinates generated in a pre-defined range from 0 to 100.

## CUCKOO-ALGORITHM (CS)

CS is a population based optimization algorithm influenced by the parasitic behavior of the cuckoo bird whose female lays their eggs in the nests of other birds.In CS algorithm, a set of nests with one egg each are placed in random locations in the search space where the eggs represent a candidate solution. A search pattern called Levy Flights is used which is considered more efficient than random walks or Brownian motions.

### Pseudo Code for CS-TSP

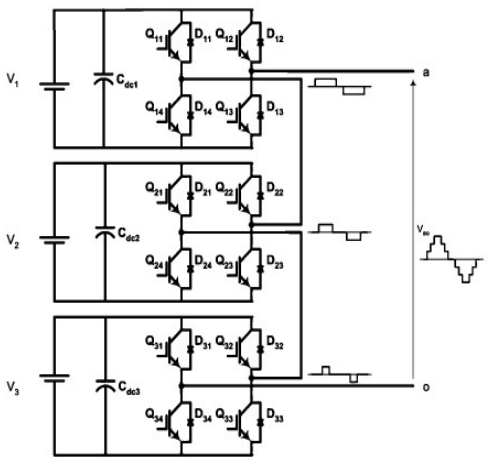
1. Generate a random dataset or add a standard dataset from TSPLIB (as a part of initializing population of cuckoo nests);
2. While (termination criteria is not met)
3. Get a cuckoo randomly (say, i) and replace its

solution by performing Levy flights;

4. Evaluate its quality/fitness;
5. Choose a nest among n (say, j) randomly;
6. Replace j by the new solution if fitness value of i is more than fitness of j;
7. Abandon worse nests build new ones;
8. Keep the best solutions/nests;
9. Select the best nests representing the solution;

## SEVENLEVEL MULTILEVEL IVERTER

**Figure 4: Sevenlevel Multilevel Inverter**



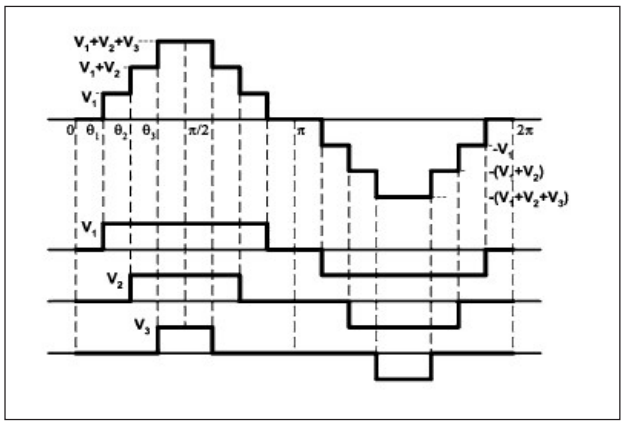
The phase output voltage is synthesized by the sum of three inverter outputs,

$$V_{an} = V_{a1}+V_{a2}+V_{a3} \quad ...(1)$$

Each inverter can be generate three different outputs, $+V_{dc}$, 0 and $–V_{dc}$, by connecting dc source to that ac output side by different output combinations of four switches S1,S2,S3 and S4. Using the top level as the example, turning on S1 and S4 yields $V_{a4} = +V_{dc}$. The turning on S2 and S3 yields $V_{a4} = -V_{dc}$. Turning off all switches yields $V_{a4} = 0$.

### Seven-level cascaded multilevel inverter waveform generation

Similarly, the ac output voltage level can be obtained in the same manner. If $N_S$ is the number of dc sources, the output phase level is $m=N_S+1$. Controlling the conducting angles at different inverter levels can minimize the harmonic distortion of the output voltage.



The output voltage of the inverter is almost sinusoidal, and it has less than 5% total harmonic distribution (THD) with each of the H-bridges switching only at fundamental frequency. If the phase current $i_a$, as shown in Figure 9.8b, is sinusoidal and leads or lags the phase voltage $V_{an}$ by 90°, the average charge to each dc capacitor is equal to zero over one cycle. Therefore, allSDCS capacitor voltages can be balanced.

## CONCLUSION

Using Metaheuristicsalgorithm of cuckoo algorithm to implement cascaded multilevel inverter reduce the harmonics. Giving various n input values to the Natural Algorithm of cuckoo algorithm in this only best optimized value will taken and given to the multilevel inverter. Using 7level multilevel inverter to reduce the switching angles and getting optimized value.Optimization means finding out the firing angles for minimizing

losses. In this harmonics will reduced. It was observed that the bio-inspired algorithms provide feasible methods for TSPs and can attain better performance than other methods. Cuckoo Algorithm, have been used with success to compute optimal switching angles for multilevel inverters with many dc sources while minimizing several harmonics.

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