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Optimization of Multilevel Inverter Using ACO

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Abstract:
This paper presents the optimization technique of multilevel inverter using Ant Colony Algorithm. Switching angles for which minimum THD can be attained is calculated using the above search techniques. A new reduced switch topology has been implemented for a 21 level inverter using Matlab. Obtained results are proven as best results through comparison.

Key words: *Optimization, search technique*

1. Introduction

Before optimization techniques came into existence, the signals are well analyzed. The sine and cosine signals can be represented with the help of infinite series of cosine and sine terms. From this, transcendental harmonic equations are derived using fundamental switching scheme. These are transformed in terms of switching angles of Multi Level Inverter. Then n number of harmonic equations can be derived with the help of Resultant theory approach. These are very difficult to solve and hence we use Newton Raphson method, an iterative technique that gives only one solution. But when number of number of level and switching angle increases and power quality is of concern with maximum number of iterations, optimization techniques can be well adopted. The value of the variables for which best THD can be obtained is calculated using these search techniques in a very simple method. Ant Colony Algorithm is adopted as the population based search technique.

2. Ant Colony Algorithm

ALife (Artificial Life) studies how the social behavior of living organisms can contribute computational problem solving and how computational techniques can assist studying biological phenomenon. Ants take different path in search of food from its source. Other ants follow its predecessor with the impact of pheromone deposition. The pheromone has evaporation factor which can vary for each and every ant. The ant with higher pheromone deposition will have more followers. This means that the distance is greatly lesser when compared to the other cases. By this way, we get optimized cost function. In Multi Level Inverters, switching angles are the variables that are used to calculate optimized THD value.

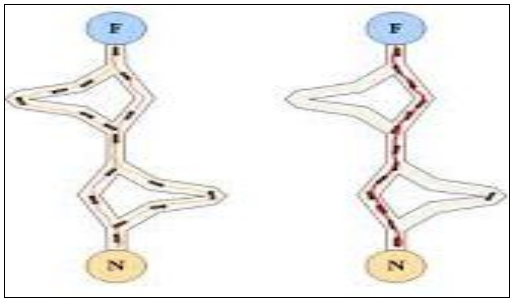

Figure 1: Trial path of ants in search of food. Ants following shortest path based on pheromone deposition

The above figure, first case shows ants taking different path in search of food (F) from nest (N). In second path, pheromone deposition is higher and the ants prefer this path as it is the shortest. Hence we understand that by properly choosing the vital variables, we obtain minimized cost function. From this, the inference is, with suitably calculated theta function we obtain optimized THD.

3. Cascaded H-Bridge Topology versus Proposed Topology

Out of the three conventionally available topologies, it is a well known fact that Cascaded H-Bridge Multi Level Inverter is more preferred because of reduced number of components, simple construction and reduced cost. For a 5 level inverter, Cascaded H-Bridge requires 2 cells, 2 DC sources and 8 switches. Whereas, in the proposed topology, for a 5 level inverter, only 6 switches and 2 DC sources are used. The sample circuit and waveform for both the topologies is shown below.

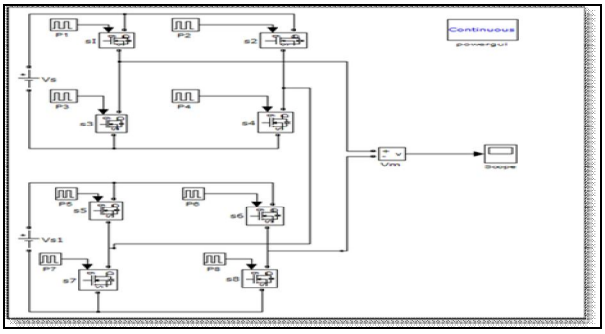

Figure 2: Cascaded H-Bridge Inverter for a 5 level inverter

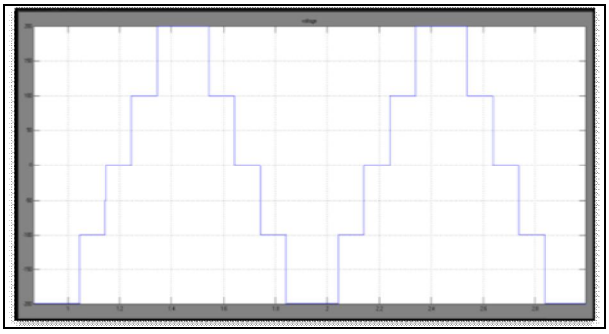

Figure 3: Waveform of a 5 level inverter

For the above shown circuit, fundamental frequency switching is only adopted and the corresponding waveform is shown in Fig.3. The obtained THD is 29.65 [3]. The DC Voltage used in the circuit is 10V. Similarly the result obtained for a 7 level inverter using proposed topology is shown below.

The proposed topology has cells connected in series with DC source interconnected with each leg. The DC sources are of equal voltage level. This circuit has also used fundamental frequency switching scheme and the obtained THD is 8.234

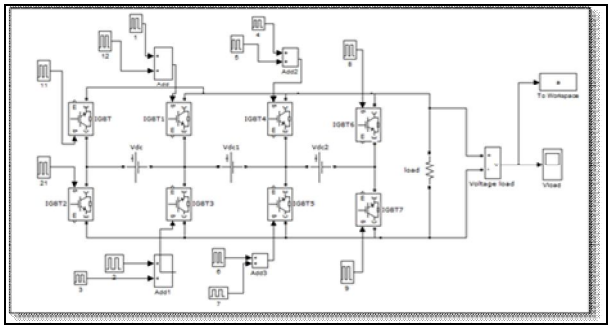

Figure 4: Proposed topology of a 7 Level inverter

4. Optimization Methodology

The optimization begins with initialization of number of nodes, population size, number of iterations, evaporation factor and theta values. Distance is assigned to the Fitness function. Minimum trip distance is formulated based on number of decision paths with a condition that there always exists at least one path. Ants choose random path depending on the number of nodes. The probability on each path is calculated and corresponding G_{best} , P_{best} and pheromone matrix are updated for each trial. Until maximum number of iteration as initialized is reached, the process continues. The conditions to be noted are the range of firing angle is in ascending order and required harmonics are eliminated so that we obtain quality output. Quality in output is observed with the value of THD.

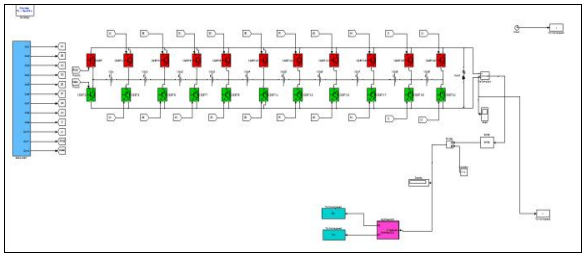

Figure 5: Simulink model of 21 level inverter

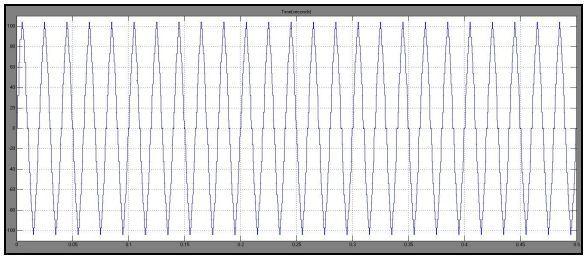

Figure 6: Output waveform of 21 level inverter

Fig.5., Fig.6. show the simulated circuit and waveform of 21 level inverter. Circuit is designed with proposed topology and result is obtained as above with a THD of 0.594. Also this optimization technique stands reliable for iterations of about 2000 and even more. When the number of iteration is increased, result show gradual improvement.
Simulation is done using MatLab 7.12(R2011a) and a THD and topology comparison is tabled with reference to previous work by professionals as cited. The table is shown below.

Level	Topology, Technique	THD	Ref
5	Neutral point clamped	31.57	4
5	Cascaded, PWM	29.65	4
9	Cascaded, GA	7.22	5
11	Cascaded, Resultant theory approach	7.42	6
15	New topology(4n+3)levels	3.5	7
21	Proposed topology, ACO	0.594	-

Table 1: THD Comparison with different topologies and techniques

The above table shows that ACO gives best result when compared to other techniques. THD is highly reduced and the number of components required is also good in the proposed topology. In the proposed topology, for *n* level inverter, it requires only (n-1) switches.

5. Conclusion

Thus quality of output can be assured with the help of optimization techniques when complexities in solving transcendental equations involve. For large number of iterations, ACO implementation can be highly efficient. Future work shall focus further reduced switches and limited voltage stress on switches.

6. References

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