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Experimental investigation and comparative harmonic optimization of AMLI incorporate modified genetic algorithm using for power quality improvement

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Abstract. A super-lift mechanism has made tremendous progress in DC/DC conversion technology. In comparison to the asymmetrical form of MLI, the novel Asymmetric Multilevel Inverter (AMLI) technology proposes a minimized number of components. The Fuzzy-PI (Proportional integral) and Modified Genetic Algorithm (MGA) utilizes to minimize the harmonic content considerably using a variety of modulation index and firing angle values in open-loop and closed-loop control. This architecture for designing single-phase 7-level AMLI with an intelligent algorithm proposed for Renewable Energy (RE) applications. This circuit uses a single MOSFET switch with less switching stress and a single DC source. The effectiveness of the proposed MGA optimization eliminates the lower-order harmonics. MGA and Fuzzy-PI based Distributed Power Flow Intelligent Control (DPFIC) algorithms are applied with multilevel structures while maintaining the fundamental frequency for both MATLAB platform and hardware implementation. During this analysis, the losses is also find to investigate the influence of modulation index and output power factor on inverter efficiency. Simulations and experimental findings confirm the proposed inverter capacity to create high-quality multilayer output voltage. However, the proposed closed loop simulation circuit gives 0.47% minimum THD level, and 10.4% in experimental results.

Keywords: Asymmetric multilevel inverter, modified genetic algorithm, proportional integral, fuzzy logical control, distributed power flow intelligent control

1. Introduction

The absence of fossil fuels and the greenhouse effect, the need for sustainable energy has increased dramatically over time. The solar photovoltaic has the advantage of direct conversion of sunlight to electricity and also well suitable for most of the regions, therefore it is highly preferred when compared to other renewable energy sources [1, 2]. Pulse width modulation (PWM) and multilevel modulation (MLM) are the two forms of DC/AC conversion techniques. Various inverter topologies are offered for DC/AC conversion in solar PV systems, with the

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multilayer inverting technique horizontally collecting levels to attain the waveform [3, 4]. Many levels are generated from numerous clamping diode, clamping capacitor, and DC sources, which is a disadvantage of this converter design. The requirements of Power Quality (P-Q) depends on the voltage or current for either input or output side within certain boundaries. The P-Q is still a major universal issue that outcome is enriched by power converters. The electrical power is enhanced by energy resources that have rapidly simulated the change of energy resources every year which has been estimated by Spence dale BP statistical review of world energy council. In renewable power which continued to grow up rapidly in the preceding year, i.e., solar power installation represents at 585 GW a net increase of 98 GW, and that is 20% points higher than 2019. The electrical power is delivered to the load or temperature variation in electrical apparatus such as resistor, inductor, and motor drives. That includes excessive sudden changes like voltage/current unbalance, voltage drop, and harmonic distortion. Power factor plays a key role in improving the efficiency of the DPFIC systems as projected by [5]. The P-Q issues are formed in N-LL or distribution side, due to some energy losses and poor Reactive Power Compensation (RPC). These are the problems that appeared nowadays in all Electrical Load (EL) [6]. As a result, the general usage of EL such as resistance, inductance loads is attained major problems in harmonic content and change of impedance values across the load. If reducing the discharging negative sequence of voltage or current supply across the load terminals are enhanced to improve P-Q with the help of DC-link capacitors [7].

The alternating electrical unit charges are generated in the form of a sinusoidal waveform. It can be measured the parameters such as voltage, current, power factor, and efficiency. At any time, the current is proportional to the voltage is known as linear load. The linear load power factor is always near to one, i.e., incandescent light, heaters-Resistive (R) load [8]. The nature of non-linear load generates lower or higher-order harmonics in the current waveform. Due to the distortion of the current leads in to the distortion of voltage. Under these conditions, the voltage waveform is no longer proportional to the current, i.e., change of impedance value and temperature across the loads like Alternating Current (AC) motor, Resistive-Inductive (RL) load (heater, laser printer, electronic ballast, and refrigerator). The quality power in RE systems is a very significant feature in the recent scenario for all non-linear load connected system, due to unbalanced real and reactive power disruption in electric power networks [9].

Therefore, these loads generate disturbances in the output waveform, particularly in non-linear load. It has changed into an effectively predicted part of the interest in recent years because of the electrical load affects. The consumer electrical appliances draw the supply in electrical networks. The electric supply flow through the semiconductor switches, which control the output (load) system. But, the recent scenario increase fluctuation, and harmonics appear in a distribution load. It leads to the consequences of consumer appliances [10]. Hence, to solve these issues should be minimized electrical components such as semiconductor devices, transformer, DC sources, and DC link capacitors, etc. Renewable and sustainable energy is growing up day by day, and the need for power demand is also increasing regularly. Nowadays in all countries, due to constantly increment in the quantity of environmental pollution and greenhouse gases, the availability of RE power is generated in many countries by more emphasis on using power resources such as solar, wind, and hydro-electric. The energy storage devices are estimated to achieve maximum energy from S-PV panels in the day time, and the batteries are the most widely used off-grid RE storage devices all over the world [11]. Therefore, the need for reactive power enhancement by using energy storage devices, and it has been furthermore more energy developed by power converters with implementing some optimization control strategy.

There are many advantages are in S-PV model, (1) Grid connected system such as micro-grid or mini-grid is possible to associate with S-PV power plant, (2) S-PV panel is fed with linear or non-linear motor load conditions interface with power inverters, (3) low consumption charges compared to the other RE and pollution-free, and (4) DC power is generated frequently in a peak S-PV irradiation conditions. A feature development of the metaheuristics algorithm, it has been the establishment of a nature-inspired approach based on the three categories [12], (1) Single metaheuristics solution, (2) Based on the population, and (3) Hybrid metaheuristics. The swarm and memory based emerging intelligent optimizations are performed based on intermediate, direction, and population approaches. Due to the nature-inspired algorithm, the current velocity point is to move into a new velocity search point.

To minimize the objective function of lower values that is helpful for minimize the harmonics level. Therefore, there are no issues to associate with both

Table 1
Comparison of classical MLI versus proposed AMLI

Different types of Multilevel Inverter (MLI)	Total Number of Stage	Number of Main diodes	Number of Switches	Number of clamping Diodes	Number of DC bus Capacitor	Number of Balancing Capacitors
Switched Capacitor-(MLI)	7 level	0	7	11	1	6
Flying Capacitor (MLI)		28	28	0	14	91
Binary Ladder (MLI)		0	6	0	6	0
Modified Ladder (MLI)		0	4	0	3	0
Neutral Point Clamped (MLI)		28	28	182	14	0
Cascade H-Bridge (MLI)		28	28	0	7	0
Conventional (MLI)		3	12	6	3	0
Modular (MLI)		3	7	0	3	0
Switched Series/Parallel (MLI)		6	14	0	3	1
Proposed		2	1	0	3	1

FA and PSO, the optimization problem and solution should be formulated by using the design of fundamental variables, which are mainly utilized throughout the optimization process. The next stage is optimization problem solving, it has been used to associate with constraints obtained and it represents in the design of variable parameters that must be identified. Due to some certain phenomena and resource limitations are included in the objective function. Based on the algorithm principle, there are two possibilities in the objective functions, Minimization (or) Maximization. A seven-level inverter, it is established a population of candidate solutions to give a new search point and accelerate the switching angle values are within the minimum computational time in integrated PV proposed scheme [13]. PSO implementation of calculating switching angle (θ_1, θ_2, $\theta_3 \ldots .$, θ_n) and gate signal values for the relevant inverter power devices, which are proposed with equal DC source, and determine the lower order harmonics of the inverter [14]. The bio-inspired algorithm applied in PWM inverter, it has been applied for renewable power conversion and application [15]. It's included the swarm-based intelligent analysis in terms of performance computational parameter, convergence speed, and accuracy. The speed of the computational and convergence of the swarms are obtained THD level gives a very high essential performance with finding the best optimum solution associate with the other methods such as modified genetic optimization algorithms.

1.1. Objective and motivation of the research work

The proposed research work deals with four important schemes for power quality development using AMLI. The proposed new topology is connected to a single-phase output (230 V, 50 Hz) with minimized semiconductor components such as switches, diodes, and filters, which is reduced cost of the inverter circuit shown in Table 1. The power quality enhancement of the AMLI using four distinct control strategies is suggested in the following categories: (1) Selection of PV string, (2) AMLI topology, (3) Intelligent control Fuzzy-PI DPFIC algorithm strategy, and (4) optimization control techniques (MGO). The proposed method of AMLI is simulated with MATLAB/Simulink R2019a software. The experimental validation of the prototype is tested by single-phase 7-level FPGA processor with different load conditions, which results are a minimal distortion of a multilevel output, and power quality improvement. The recommend proposed inverter can be applied to the three-phase systems and also it may be applied to wind-based conversation for P-Q development by using Internet of Things (IOT). The application of IOT in renewable energy (i.e., Solar, wind) production involve sensors that are implemented in Distribution, transmission, and generation. Other intelligent and optimization approach such as DPFIC strategy, Artificial Neural Network (ANN)-Fuzzy tuned approach, grey-wolf based an algorithm,

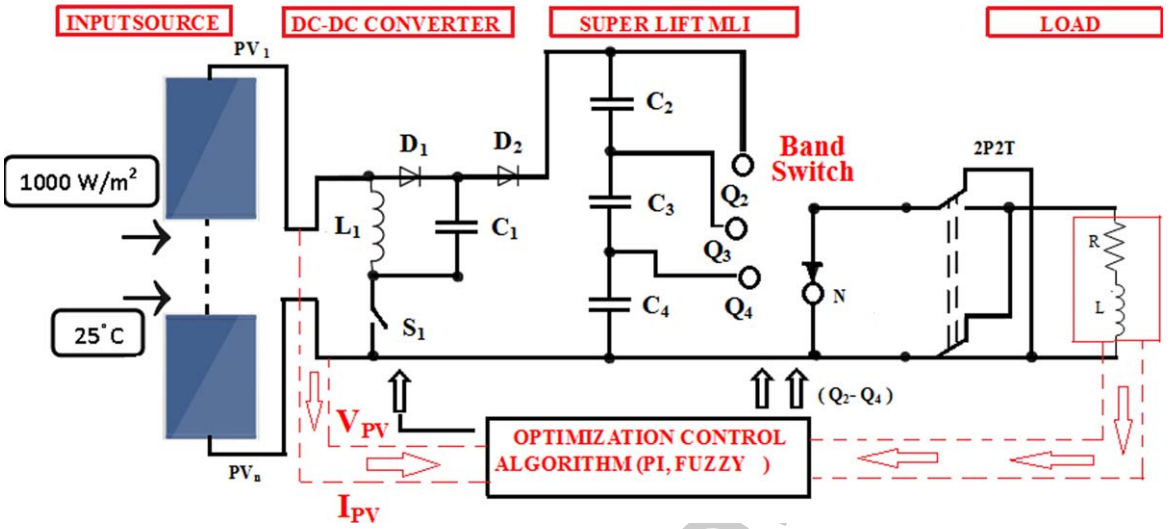


Fig. 1. Proposed seven levels AMLI.

Queen Bee assist optimization algorithm, and differential evolution algorithm should be applied in grid interface approach.

Maximum research on Renewable Energy (RE) - MLI is inspired to interconnection P-Q problems between the customer side and utility side of the transmission, i.e., solar, hydrogen, and wind connected electrical networks. The first solution is load conditioning, which means that the device is less complex to the power interruption. It's approved to work under the significant power distortion. The second approach leads a line conditioning device that stabilizes the disruption of the Non-linear load. RE output can be controlled by the optimization control scheme, it's utilized by electric power converters. The RE system is fed into power electronics converters, that emphasis on the growth of the customer needs, it can improve the high reliability, efficiency, reduces cost, and complexity of the circuit. The Photovoltaic (PV) cell benefits of transforming sunshine directly into electricity, which is even perfectly suited for most regional areas. Hence, it is highly preferred in comparison with other RE sources. In particular, Solar-PV has been a pollution-free, more acceptable level over the past two decades in terms of a minimum price and easily accessible from sunlight.

2. Asymmetric multilevel inverter

A modified Luo (DC/DC) converter and AMLI is dependent on DC sources, there are two sorts of MLI: 1) symmetrical type MLI 2) asymmetric type MLI. The maximum number of levels can be obtained with symmetric MLI [16]. This paper presented reduces multiple source asymmetrical type of modified MLI. In this regards number of levels increased by using multiple capacitors. The advantage of this proposed topology needs to less number of switch and minimized voltage stress across the capacitor as shown in Fig. 1.

2.1. Modified AMLI

This module basically consists of only one MOSFET Switch, two Freewheeling diodes and four parallel switching capacitor to generates seven level output (+3E 0 & –3E), (+2E 0 & –2E), (+E 0 & –E,). Whereas traditional MLI NPC, FC and CHB [17] requires twelve to Twenty two switches generate the seven level of output. By increasing the number of levels and employing several capacitors to obtain maximum voltage. In this regard, AMLI was formulated as follows:

$$2 \text{ diode } (3 \text{ capacitor}) + 1 \text{ switch} = 7 \text{ level}$$

$$2 \text{ diode } (7 \text{ capacitor}) + 1 \text{ switch} = 15 \text{ level}$$

$$2 \text{ diode } (10 \text{ capacitor}) + 1 \text{ switch} = 21 \text{ level}$$

3. Simulation for fuzzy-PI tuned controller

To improve the stability associate with AMLI under dealing with fuzzy PI tuned controller continues to be offered as being a good option towards

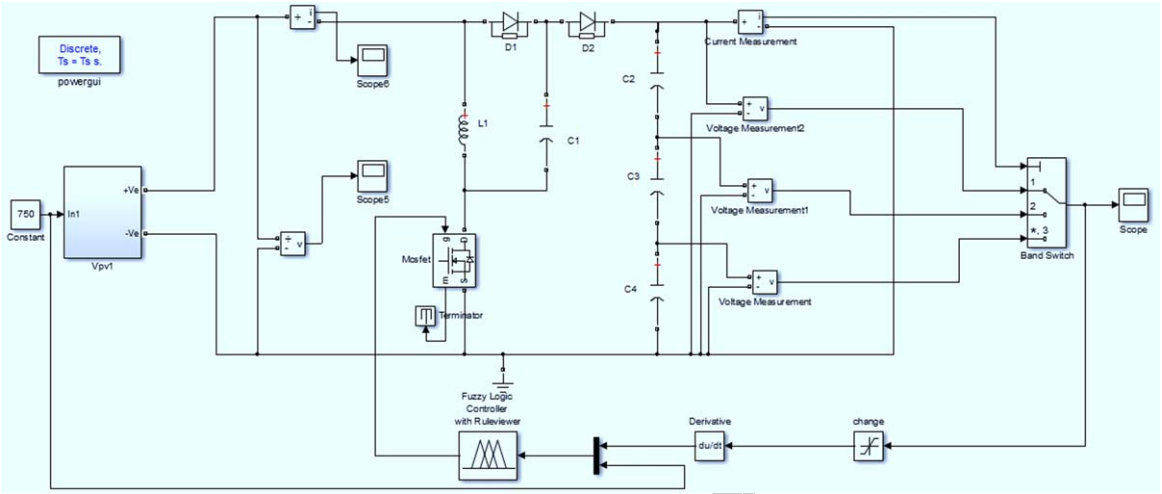


Fig. 2. Proposed closed loop Fuzzy-PI controller.

control over switching electrical power inverters. In this division evaluation is carried out an open and closed loop way. It may be any kind of operator, here it's utilizing PI tuned controller design [18]. The number of switches used here is one MOSFET switches, their gate signals are given by means of proposed algorithm. The load used here is a Resistive load and their corresponding references are fed to the controller and their gate signals are given by means of PI controller scheme. The ASL output steps with least number of devices by utilizing proposed seven stages MLI. The PI controller scheme effect of K_p should be reduce a large part of the overall error and K_i reduce the final error in a system uses to designed in the work with Ziegler-Nicholas tuning techniques in Fig. 2. The MOSFET gate signals are generated and fed to the inverter band switches. It provides the output of seven levels ASMLI. Digital computer assists a vital role in Fuzzy rationale strategy for making the process to simplify. FLC system can be providing an exact framework without usage of mathematical model. Through development of FLC expected MLI output explained in detailed about Fuzzy tuned PI control scheme shown in AMLI in Fig. 3. FLC is divided in to five modules: fuzzifier, database, rule based, decision maker and defuzzifier [19, 20]. The inputs Fuzzy operators are error $(E) = V_{reference} - V_{output}$ and the conversion of error $(COE) = E_n - E_n\text{-}1$.

Where the V_0 is end result voltage of the AMLI, Vreference is the preferred output voltage and δ_{mn} is change of band switching position inverter by the FLC at the n^{th} sampling instant, using δ_{mn} update

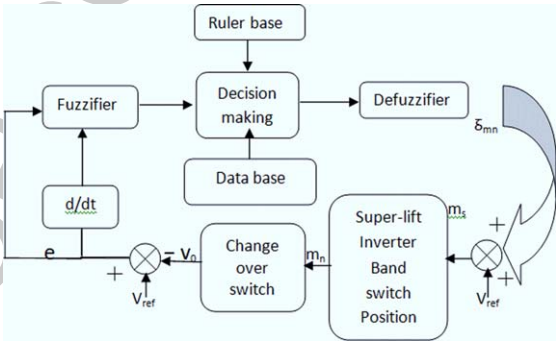


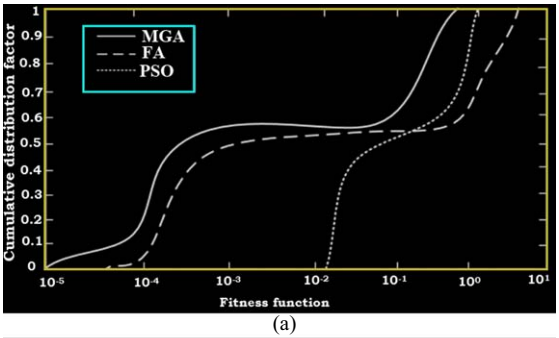
Fig. 3. Fuzzy – PI control scheme for AMLI.

the band switching position signal ms is obtained and fed to the AMLI which provides the appropriate conversion. The Fuzzification to be directed record highlights for knowledge and profitability alongside standards are utilized. The crisp values of triangular membership function. To obtain correct productivity defuzzification is performed on Fuzzy ruler view. The principles are made from an inference system using mamdani algorithm [21]. The contributions inputs are joined to the fuzzification block using preprocessor. The RMS productivity voltage of seven level AMLI is derive the fuzzy control rules created a based on the following criteria: i). at the point when the output of proposed MLI diverges from the reference, the change of modulation index must be a big. ii). Once the end result of MLI is approaching the reference a little change of modulation index is essential. iii). Once the MLI output is higher than the reference the variation of modulation index must be negative and

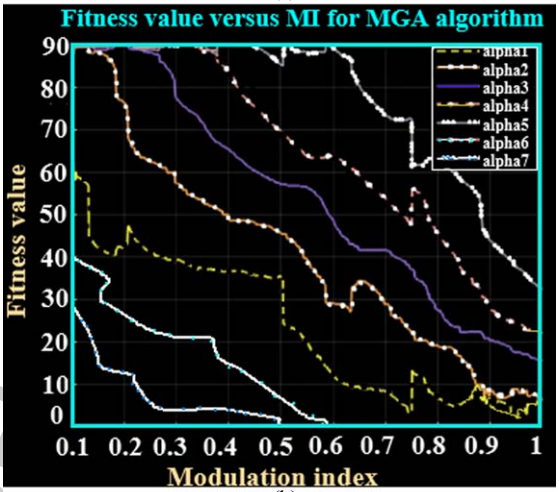
vice versa. The output surface view from AMLI result saturation block for limiting the most and minimal values of THD.

4. Simulation for modified genetic algorithm

For many applications, the MGA has been applicable for recognized techniques for achieving constraint, unconstrained problems, and it will give to create a solution for achieving maximum or minimize optimization problems. MGA approach like nature, biological evaluation control, and design of individual machine tool solution [21]. The MGA is employed in a new multi-cross over operator, in this time all operators of proposed algorithm have function their local search and beyond the original inspirations characteristics. At each generation, GA is select random variables of the current population parents to use them to generate the next generation of children [22, 23]. The objective function of each point MGA is encoded solution into a binary byte. It is associated with the fitness value of optimization, and the chromosomes are not constantly growing for all the time of generation. A propounded to determine the suitable fitness value with the help of optimization technic. It can be applied with an inverter optimum switching angle and MI for THD minimization. Large scale refers to the problem's size like a number of decision variables such as PV current/voltage, inverter switching angle, and duty cycle. While complexity is refer to the difficulty of the constraints. As a result, large-scale linear optimization issues are quite simple to solve. To minimize the objective function to lower value up to 10^{-37} but, the optimization algorithms are GA and FA to find individually to minimize the lower value of the objective function value 10^{-4} (GA) & 10^{-21} (FA). Main objective function of the research was compared convergence rate other metaheuristic optimization like PSO, FA optimization as shown in Fig. 4(a). The sensitivity model of computational parameters are shown in Fig. 4(b), and the proposed circuit to find best optimum switching angle value as shown in Fig. 4(c).



(a)



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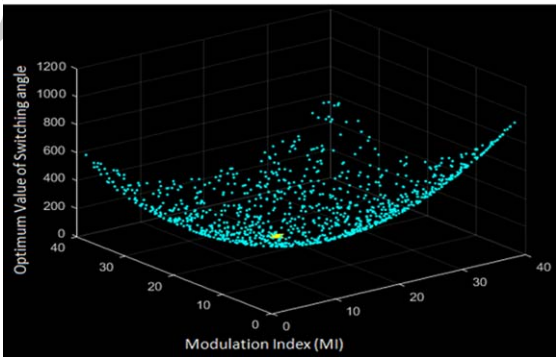


(c)

Fig. 4(a) Fitness function comparison of convergence rate. (b) Computational parameters, (c) Optimum switching angle.

4.1. Calculation of MI & switching angles

Flowchart for MGA optimization based on best optimum solutions are shown in Fig. 5. MGA creates a new population by utilizing a genetic operator, which is mutation and cross-over procedure based on massive local search operant. The members of higher level fitness having a complex value participation, and it will be similar to evaluating the mating pattern arrangement procedure.

MGA is improved local search strategy for simulating the natural evaluation process. In a 7-level MLI circuit, the GA is utilized to determine the operational switching angle into the various processes. These are the 6-stage of the proposed approach; (1). generation represent and initializes process, (2) fitness, (3) selec-

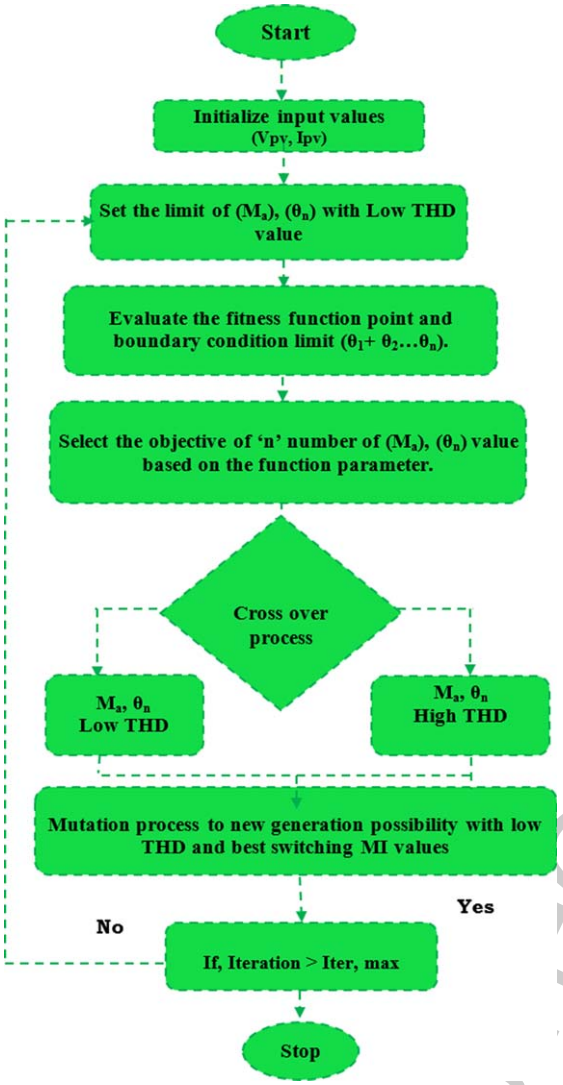


Fig. 5. Flow chart for MGA optimization process.

tion mechanism (4) cross-over operator, (5) mutation operator, (6) local search operator, and (7) end of termination. The step by step process of MGA, (1) Generation of chromosomes for each work anlaysis and size of the populations at initial random search are required. In general, there are six sets of chromosomes required, therefore to search best optimum switching angle position (θ_1 up to θ_4) among the population. The number of constrains and convergence rate of specific variables are proposed as per AMLI switching circumstance. The second step is fitness function selected according to the function. MGA was delivered the number of generation, and it is executed to the set of possible all sequence solution. One set of chromosomes are verified as less time taken to find the MI and switching angle values. The evaluation of the population transferred to the new population of the output values, which is minimized harmonics value of the best solution. MGA fitness cross over mechanism was established by the best solution using local search operator. Until the process should be again iteratively continued. The new population approach was proposed switching position into the new generation. The random switching position will be reduce the harmonics, and it has been optimizing and executed with the help of new chromosomes set. The fourth optimization stage is selection and cross-over, which is the process of selecting a chromosome set that is followed by a low or high-intensity population, and each chromosome solution is made up of switching levels that provide numerous switching angles with the greatest fitness value.

There are numerous sorts of probability cross-over in the new set of offspring of both the parents, and it also delivers diverse solutions in the form of modulation indices. To reduce harmonics, each of the cross-over methods can be applied. The fifth optimization phase is a mutation, in which each gene mutation is modified by the new mutation generation possibilities. The sixth optimization phase, which occurs at the end of the process, it is known as Termination. The fitness function was used to choose the chromosomes. The preceding process is repeated till the obtained level goes into maximal generation. If it is pleased with the existing answer, the programme will terminate with a new solution; otherwise, it will go to step 3. Proposed control method's objective function is to reduce the 3rd, 5th, 7th, 9th, 11th, 13th, and 15th harmonic order. The cost of the functions are related to the harmonics of the 15-level inverter. Then 'F' is the cost of the fitness function used to sum these (THD) harmonics fundamental formula, as shown in Equation (1). As per design of variables for established issues in section 4.1, and calculate continuous design of variables are shown in Equation (2). The output voltage generated by applying the switching angle was generated in each chromosome, and the harmonic magnitudes determined using FFT methods are essential.

$$\mathbf{Fitness}\,(\boldsymbol{\alpha}1 \text{ to } \boldsymbol{\alpha}7) = 100 \times \left[\frac{|V_3 + V_5 + V_7 + V_9 + V_{11} + V_{13} + V_{15}|}{V_{PV(1-7)}}\right] \quad (1)$$

Design of switching angle veriables (θ_n)

$$= \theta_{n-1} \times \left[\frac{\left| \frac{\pi}{2} - \theta_{n-1} \right|}{2^7 - 1} \sum_{k=0}^{7} 2^k n_k \right] \quad (2)$$

Where, $\alpha-$ is the firing angle, V_{PV} is photovoltaic input voltage, n_k- is the number of binary bits, k- is bit number, and it can rises in between 0 to 1. θ_0- Intial optimum switching angle is taken as zero. Modified GA optimization are suited naturally for unconstraint problems. Therefore, includes equal constraint objective function is obtained in Equation (3), and modulation index equation is given in (4). Where, M (α) is new fitness modified objective as follow,

$$M(\alpha) = f(\alpha) + 7n_k \quad (3)$$

4.2. *Fuzzy-PI based DPFIC approach*

To eliminate the line harmonics using fuzzy-PI technique based DPFIC for injecting current to the transmission lines voltage fluctuations is caused in transmission lines by non-linear loads, dynamic load conditions and low power factor, which results in reducing the usage of distributed system. A DC-DC converters are used to making the DPFIC approach. To control and regulate the voltage through the DC-link capacitors, and fuzzy-PI techniques are executed. Using the propounded method, line harmonics is terminated by injecting compensational current reference which handles the reactive power requirement for dynamic load conditions. Compared with a reference set value, a reference voltage is generated by the DC-link capacitor voltage of DPFIC [24–26]. By the resulted error value and with change of error value by fuzzy-PI controller which regulates the DPFIC through the reference current generator the reference power is generated as shown in Fig. 2. A reference current is generated by the reference current generator with the help of load current and source voltage to the current controller by introducing rapid active - reactive power (P-Q) theory [27–30]. The preset reference value is compared to the original filter current to give the gate pulse to the AMI by the hysteresis controller. An opposite harmonics from the line is drawn by the output of the voltage source inverter which flows through the filter inductor to the line reducing power balancing the unbalanced load current and improvement of power factor are achieved as a result of it.

Table 2
Control parameters of MGA

Parameters	Value
Size of the population	30
Structure of the Chromosomes/Selection pattern	Binary code/ Roulette wheel
Cross-over	0.52
Max. criteria	100 iteration
Probability of the mutation	0.298
Best MI value (M_a)	0.61
Optimum switching angle (θ_n)	$\theta_1 = 8.95$, $\theta_2 = 27.5$, $\theta_3 = 43.31$, $\theta_4 = 50.90$, θ_5-62.39, θ_6-74.37, θ_7-79.02

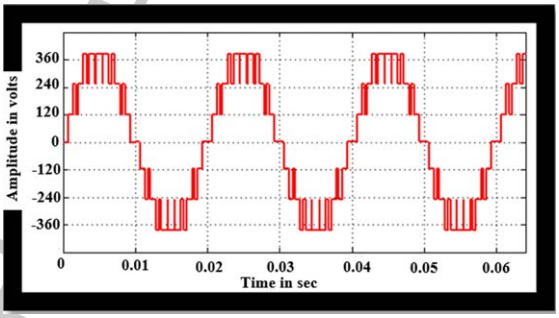


Fig. 6. Output voltage waveform modified genetic algorithm.

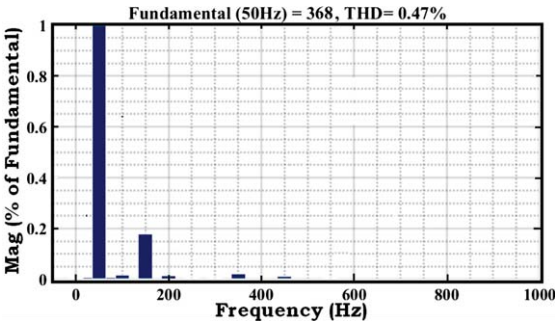


Fig. 7. FFT Analysis of modified genetic algorithm.

4.3. *Simulation results for modified genetic algorithm and fuzzy PI based DPFIC*

GA simulation results are carried out for MATLAB environment using a suitable toolbox. It has been verified with seven level topology, which is verified input from the S-PV panel. Table 2 shows the optimization of GA parameters is used for the entire program. Figure 6 shown the seven stage output volt-

Table 3a
Simulation parameter of AMLI

Parameter name	Value
Irradiation	1500 W/m^2
Open circuit voltage V_{oc}	70 Volts
Short circuit voltage I_{sc}	4.5 Amps
Inductor L_1	50 mH
Capacitor C_1	28μ F
Switching capacitor C_2, C_3 and C_1	80μ F
Output voltage from Fuzzy	148 v
Output voltage Vo from PI	126 v
Output current Io (Fuzzy, PI)	4.3–3.4 A

Table 3b
Comparison between experimental and simulated result

MI value	% THD			
	Open loop control (PWM)	Closed loop Fuzzy control	Closed loop Fuzzy-PI control	Proposed MGA controller
0.8	61.0	39.4	18.12	9.01
0.7	50.21	38.40	17.39	8.99
0.6	48.13	36.31	16.20	7.96
0.5	46.31	31.13	15.09	6.01
0.4	41.35	23.99	14.09	5.89
0.3	42.01	15.6	12.57	**0.47**
0.2	42.96	16.02	**10.40**	5.10

age (V_{rms}) of AMLI, the performance of the inverter is verified by different load conditions. The FFT spectrum analysis of the proposed MGA as shown in Fig. 7.

For a typical 7-level, asymmetric multilevel inverters have PV modules and parameters are shown in Table 3. This proposed circuit of fuzzy tuned PI best choice of boosts up the output voltage with a single source conversation in Fig. 8. The output of AMLI is three time of DC input voltage (PV module). PI control is designed to ensure the specifying desired nominal operating point, and it regulates inverter circuit keeps nearer to minimal functioning point in event of quick disturbances, collection point variations, finally modeling mistakes, and modules variations.

$$\textbf{Modulation Index (MI)} = \frac{\mathbf{V_{ref}}}{\mathbf{V_{carrier}}} \qquad (4)$$

A phase voltage is (V_m) 325 V, 50 Hz as shown in Fig. 11(a). Power quality of the line is drastically reduced when the load draws a current from the source as shown in Fig. 11(b) which is affected by

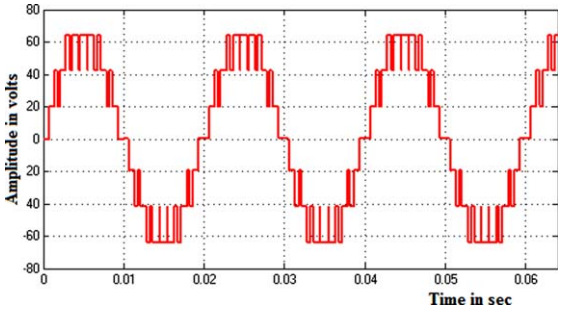


Fig. 8. Output voltage waveform Fuzzy tuned PI Control.

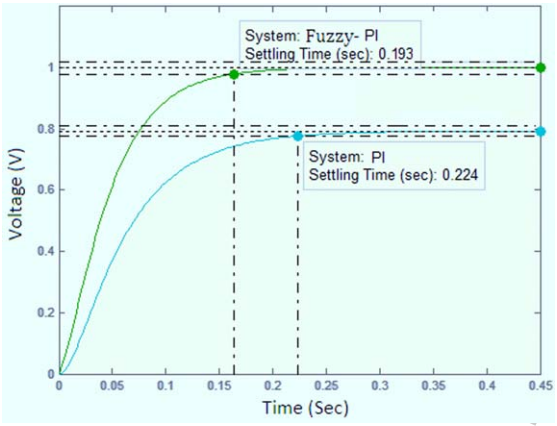
the non-linear load conditions. To improve the power quality of the line in a DPFIC is designed, which internal avoidance of the source current being affected by the non-linear load. As shown in Fig. 11(c) the DPFIC is connected with the line after 0.02 second. A non-linear load affects the source currents from 0 to 0.2 s. A sudden surge current is produced in the line with a current range of 150A which is caused when the DPFIC is connected at 0.02 s to the line and within 0.015 s, it settles down to the rated current. A constant current magnitude is maintained with sinusoidal shape from 0.015 s. Even with the non-linear loads the angle between source voltage and current remains zero.

Figure 12(a) and (b) shown that to improve the quality of the line current, the output current of DPFIC controller is injected to the line. In Fig. 12(c) depicts that simulated result of the DC-link capacitor voltage.

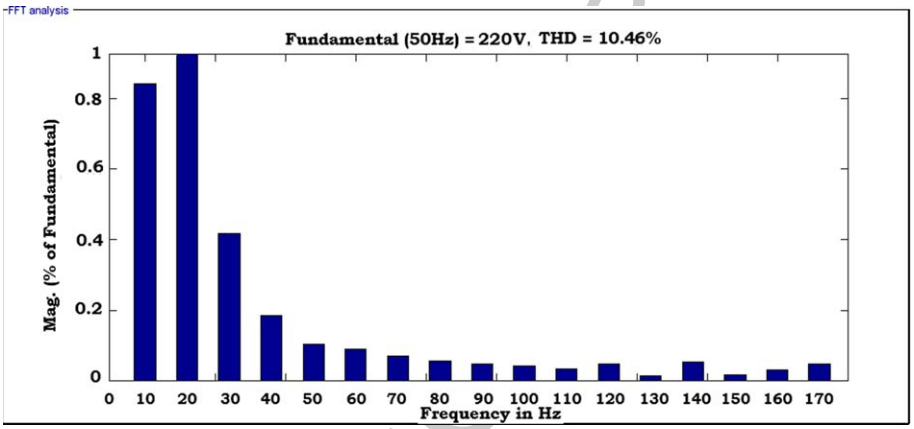
5. Hardware results

An experimental setup is operating and associated with the help of FPGA-Xilinx Spartan 3-AN kit with battery improvement platform. The fuzzy logic PI tuned VHDL Matlab code into FPGA proposed model presented. The performance gate signal is provided by the FPGA controller kit's buffer, and the conversion over switch is turned on, with the band switch set to 3E, 2E, E, 0 & -E, -2E, -3E, respectively. The operational conditions used in the simulation are the same as those used in the low-power experimental model in Fig. 13.

Performance of the control algorithm was tested and compared the results for both simulation and experimental as shows in Tables 4 and 5 displays literature review of intelligent algorithms. The design specifications of AMLI output voltage are as fol-



(a)



(b)

Fig. . 9(a) Matlab scope view PI Vs Fuzzy tuned PI settling time. (b) FFT Analysis of closed loop fuzzy tuned PI Control.

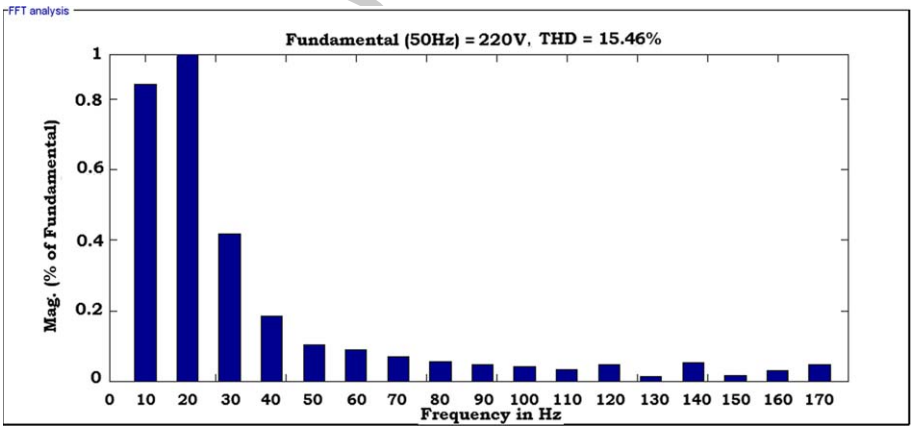


Fig. 10. FFT Analysis of closed loop fuzzy control.

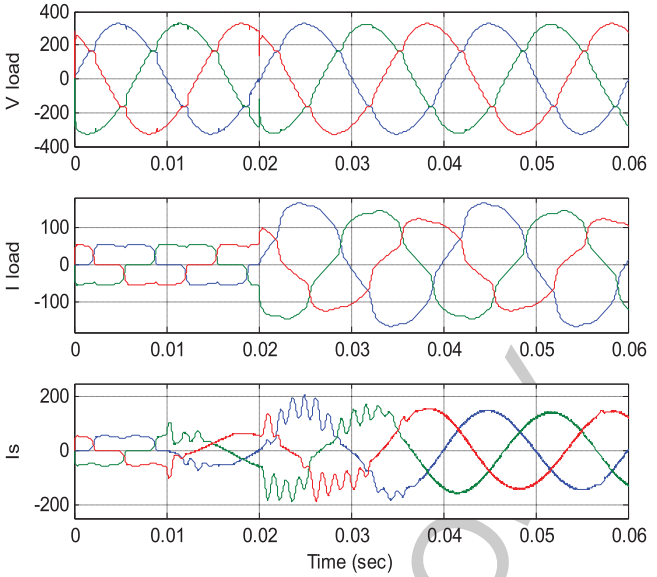


Fig. 11. (a) Source voltage (b) Load current (c) After filtering: Source current.

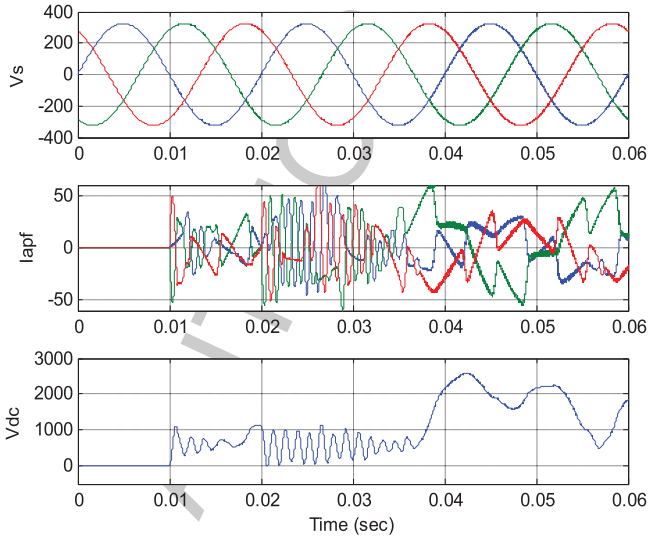


Fig. 12. (a) Source voltage (b) I_{DPFIC} (c) V_{dc} Plots.

lows: solar power 70 V, 3.5 A was operated with an output frequency of 50 Hz, and a carrier switching frequency of 1 kHz, and a resistive load of 100 ohms. The inverter stage control with respective standalone mode to provide a standard output voltage of 128 V_{rms}/50 HZ and current of 2.5 A in Fig. 14. The performance of controller is a feasible operation system which is verified for comparison the experimental harmonics result as shown in Figs. 15 and 16.

The main impact of the proposed control scheme is to reduce harmonics of the proposed inverter load. In this research involved the creation of a single solar power supply in 7-level without any additional filters and control power switching devices. The P-Q enhancement strategies for the proposed inverter have

Fig. 13. Hardware setup.

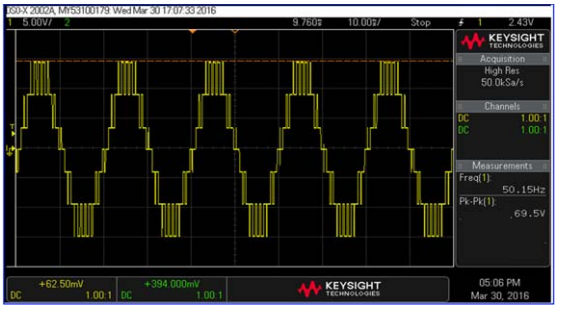


Fig. 14. Output voltage of AMLI.

Table 5
Literature review comparison of different optimization algorithms/controllers

Algorithms			
Author	Algorithm	Level	THD%
Azeem.H et al. [24]	FLC	7	20.27%
Elbarbary Z.M et al. [25]	Fuzzy-PI	7	20%
Dhivya, M. et al. [16]	Fuzzy	15	14.6%
Ponraj, R.P et al. [26]	GA	9	3.6%
Santhiya K et al. [15]	Fuzzy	–	15
Khalili TajEddine et al. [27]	GA	7	12.85%
Shivam Prakash Gautam et al. [28]	GA	7	13.8%
Salehi, Reza et al. [29]	GA	7	26.72%
JR Albert et al. [3]	FA	15	4.35%
Thenmalar Kaliannan et al. [14]	PSO	15	10.4%
Rachid, Taleb et al. [22]	GA	9	9.01%
Proposed MGA	**MGA**	7	**0.47%**

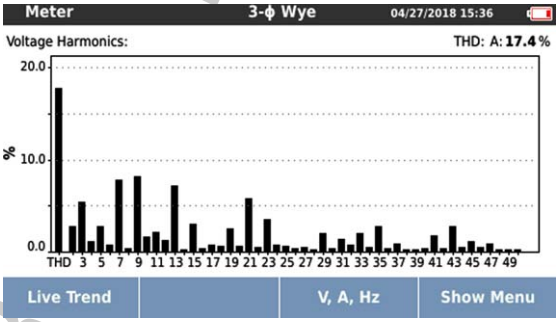


Fig. 15. Hardware FFT analysis of PI Controller (Closed Loop Controller).

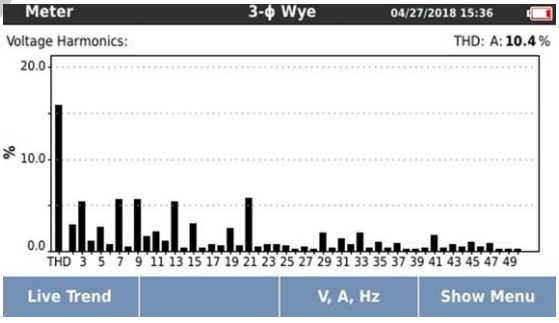


Fig. 16. Hardware FFT analysis of FLC Controller (Closed Loop Controller).

been implemented using three separate approaches such as fuzzy, fuzzy-Pi tuned controller, MGA optimization strategy. The ultimate aim of the overall proposed method is improved P-Q enhancement in various factors such as reactive power development, and AMLI different load with reduced harmonic conditions.

Table 4
Comparison of simulation and hardware results

Intelligent Techniques	Simulation				Hardware			
	R Load		Induction Motor		R Load		Induction Motor	
	$\%V_{THD}$	$\%\ I_{THD}$	$\%V_{THD}$	$\%\ I_{THD}$	$\%V_{THD}$	$\%\ I_{THD}$	$\%V_{THD}$	$\%\ I_{THD}$
FLC	10.59	10.44	11.15	12.36	18.2	19.4	18.23	19.5
PI	16.32	15.67	17.52	17.82	21.98	12.4	19.52	25.52
MGA	**0.91**	**1.2**	**0.47**	**1.2**	**17.4**	**17.9**	**10.4**	**11.01**

6. Conclusion

A combination of 3 different methods are proposed in this research methodology. The Fuzzy-PI, DPFIC, and modified GA optimization approach both in simulation, and experiment analysis with least distortion productivity voltage was prescribed. The P-Q analyzer are used to measure the seven level AMLI output. The performance measures of the asymmetric multilevel productivity voltage waveform, such as harmonic distortion values are studied, and contrast is made by appropriate values find in different schemes such as open-loop, and closed-loop system. AMLI minimum harmonics presence is 0.46% simulation and 10.4% in hardware. Hardware 7- level prototypes with less switching stress, and low distortion output was verified across the motor load. In future, the AMLI concept will be a great choice for power electronic frameworks, particularly for photovoltaic and wind power electronic applications.

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