A NEW OPTIMIZED GWO ALGORITHM BASED SINGLE PHASE GRID CONNECTED PV SYSTEM USING SINGLE SWITCH HIGH GAIN DC-DC CONVERTER

JOHN SUNDAR D[1], SENTHIL KUMARAN M[2]
[1] Research Scholar, Anna University, Chennai-600025, India
[2]Associate Professor, Department of Electrical and Electronics Engineering,
SSN College of Engineering, Kalavakkam, Tamil Nadu -603110, India
[1]johnsundar.me@gmail.com, [2]senthilkumaranm@ssn.edu.in

Abstract *– A novel topology of a single phase grid connected system based on photo voltaic system through high gain single switch dc to dc Zeta converter is proposed. In this topology the single phase grid is connected to the PV system, a Zeta converter and a single phase Voltage Source Inverter. A new optimized Grey Wolf Optimization (GWO) is used to extract maximum power from the PV system. For comparison with the conventional schemes the proposed topology is modeled with the help of reference frames which includes direct axis and quadrature axis elements. The GWO based MPPT algorithm shows excellent performance under various testing conditions and the outcomes are compared with Fuzzy based MPPT algorithm. The steady state and transient response of the controllers are discussed and implemented for their various operations of the PV fed energy system. The grid current synchronization is achieved by using PI controller which reduces the THD, complying with the IEEE harmonics standard. The proposed system aslo reduces the power quality issues in the PV based single phase grid connected system. The results are validated with Matlab simulation and DSPIC30F2010 controller.*

Keywords: *Distributed Generation, PV System, Zeta Converter, Fuzzy MPPT algorithm, GWO algorithm, DSPIC30F2010 Controller.*

1. Introduction

Distribution energy generation system based on non conventional energy resources, i.e. PV system and Wind generation system is playing the main contribution for green energy generation. But from the PV system, oscillatory output voltage and discontinuous input current operation is acquired, it includes higher level ripple contents and partial shading effect. From the wind power, the Permanent magnet Synchronous generator converts mechanical energy into three phase electrical energy. The PMSG output is not constant, it have higher order harmonics due to Permanent Magnet and oscillations in nature.

The authors in [1-2] discussed a few MPPT strategies taken from the writing and investigated with their advantages and disadvantages. It is difficult to choose the better option with the available so many MPPT techniques. The important aspects to be considered while selecting particular algorithm are the ease of implementation, number of sensors required, the occurrence of multiple local maxima, monetary costs and area of application. But the distributed generation requires constant power and voltage operation. In order to attain constant high power operation DC-DC converter is used. In existing topologies transformer based grid connected PV systems are used. This transformer is of high cost and increases the leakage reactance problems. Also it requires galvanic isolation. The DC-DC Boost converters are utilized to overcome the transformer based grid connected distribution system. This boost converter topology maintains continuous input current operation and single frequency output ripple suppression. The different MPPT algorithms are used to maintain constant voltage operation. In boost DC-DC converter only boost operation is possible. Also low output voltage gain with higher order ripple contents. Buck-boost converter overcomes the drawbacks of existing boost converter. Buck-boost converter does both buck and boost operation with single order frequency suppression in the output voltage but these converters experiences discontinuous input current operation. This increases the switching loss and reduces the performance of the system.

A theoretical input parallel output parallel (IPOP) DC-DC converter is discussed in [3] which comprise of two fell phases of buck-boost and boost to obtain higher voltage gain and galvanic isolation at appropriate obligation cycle and lower spillage energy. Different distributed generators (DGs) can be associated with DC network through IPOP technique utilizing the proposed converter, which is non resistive hot module in and out of DGs in practical application. The Cuk and SEPIC converter overcome the disadvantages of traditional Buck-boost and boost topology with less output voltage gain.

In this paper [4] a novel investigation on the ideal decision of two principle parameter portraying the P&O algorithm is discussed. The proposed optimization approach customizes the P&O MPPT variables for the dynamic conduction of the framework created by the particular converter and PV exhibit received. The outcomes demonstrate that the structure of effective MPPT controllers the effectiveness and adaptability of P&O MPPT strategy can be abused by enhancing it as it the dynamic characteristics for the framework. To extricate the highest power from the PV and Wind based system, MPPT algorithm is used. P&O algorithm supports for all DC-DC converters. This P&O algorithm is used in only low power applications. Incremental conductance and Hills Climbing algorithm overcomes the drawbacks of P&O algorithm but provides very low efficiency.

A single phase, double grounded, transformerless PV interlink based buck boost method is discussed in [7] to overcome the drawback of transformer inclusion. The proposed design is minimal and utilizes fewer segments. One and only PV sources with one buck support inductance is utilized between the two half cycle, which averts awry task and variable confuse issues. THD and DC segment of the current provided to the lattice is lower contrasted with existing topology.

Overcoming all the drawbacks of MPPT algorithms, PI controller based optimized algorithms extracts most of the power from the PV system and provides higher efficiency. A new IC controller based duty ratio calculator with direct control is developed in [10] to eliminate the disadvantage of incremental conductance algorithm. A Fuzzy Logic Estimator (FLE) is utilized to compute the newer duty ratio to follow the most extreme power point in a PV cluster. This method achieves MPP all the more precisely contrasted with fixed advance strategy and quicker amid dynamic and consistent state conditions. The outcomes acquired affirm the benefits of the proposed calculation. In this proposed work, the conventional drawbacks are overcome by single switch high output gain DC-DC Zeta converter. To maintain higher efficiency and reduce the ripple contents Fuzzy based MPPT algorithm and highly efficient optimized GWO algorithm is used.

2. Proposed Zeta Converter

Zeta converter is the highest version of boost converter and SEPIC converter. The figure 1 shows the proposed dc to dc Zeta converter. Inductance L1 and L2 stores the energy; inductor L2 maintains the output current as continuous. Zeta converter input current also remain continuous due to this property converter efficiency becomes high. The capacitor C1 and C2 acts as the filters and reduce the ripples in the voltage and current. Duty cycles define the mode of the Zeta converter buck or boost because it can act as Buck-boost converter with non-inverting output.

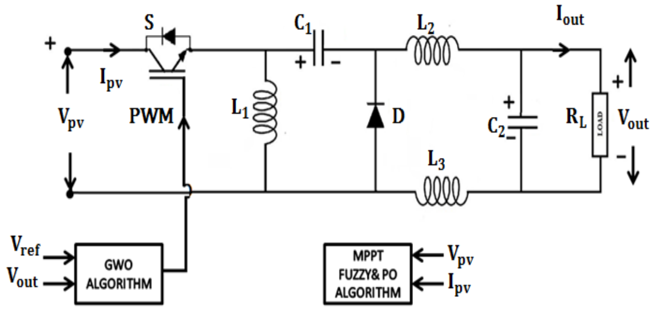

Fig. 1. Proposed high gain DC-DC Zeta Converter

This converter achieves double frequency ripple suppression in the output voltages. In this paper Zeta converter has proposed. This converter increases the performance of the overall system such that with lower duty cycle it supports high output voltage gain. The GWO algorithm provides max power tracking from the input supply and increase the converter efficiency. In grid side, reactive power has been increased due to the nonlinear loads. Due to the nonlinear characteristics of grid, current becomes non uniform, so that a power quality becomes a major issue in grid side. This power quality problem is a major concern for affecting the grid performance. In this paper PI controller achieves grid current compensation and this makes grid current and voltage are in phase including near unit power factor operation. Finally proposed system achieves high voltage stability in the grid side. The proposed scheme is a grid connected topology it does not require any battery storage system. Generally the DC-DC Zeta converter achieves 90% efficiency, the fuzzy logic based MPPT and GWO algorithm increases the efficiency.

The Distributed generator consists PV system as the input source, this DC voltage is applied to the Zeta converter, due to the temperature irradiation variation the solar output voltage have higher order ripple contents also partial shading effect arises, this variable DC voltage is fed to the converter. Two different methods are available for connections it means cascaded and parallel connection. In this work parallel operation is achieved for continuous voltage supply. Zeta converter has one inductor and one capacitor in series and another one in parallel. This reduces ripples from the input voltage and current. Zeta converter series inductor and diode combination achieves solution for partial shading effect. The main benefit of Zeta converter is its input current is continuous with good output voltage gain.

The series and parallel diode combination provide dv/dt protection in the form of snubber protection, whereas low duty cycle converter provides high output voltage from PV energy system. The reference voltages and currents are measured from the input section for implementing MPPT algorithm.

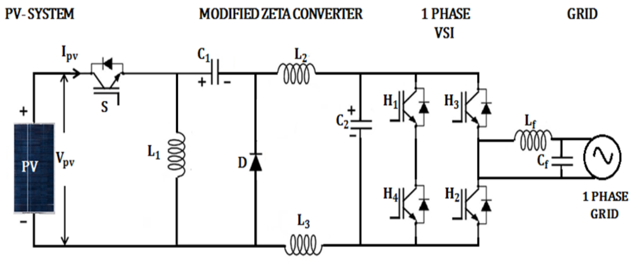

Fig. 2. Proposed System circuit diagram

The reference signal and the 10kHztriangular carrier signal are compared and the pulse is given to the Zeta converter single switch. The MPPT algorithm achieves constant output voltage with in the form of reduced voltage ripples. This voltage is given to the voltage source inverter. The single phase VSI transforms the dc voltage into ac voltage in the form of pulsated output voltage. This pulsated AC voltage is given to the inductive filter for making it into sinusoidal output voltage. This voltage is given to the single phase grid. Due to nonlinear loads harmonics are injected in the source voltage and current. Hence to avoid the harmonics, the actual voltage and current are calculated in the grid. The maximum power is taken as reference and it is compared with actual power, the PI controller based grid synchronization is achieved for reactive power compensation.

3. Analysis of Proposed System

3.1 PV Panel Modeling

In general, the PV system is modeled as shown below.

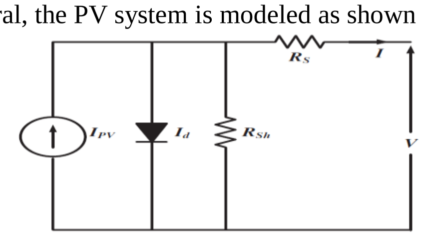

Fig 3. One Diode model of the PV system

Where

I_{PV} - Photovoltaic current

I_d – diode current

Rs- Series resistance

Rsh-Shunt Resistance

I-Output current

V-Output voltage from PV

The current obtained from the PV panel is given in the equation (1)

$$I = I_{pv} - I_o\left[e^{\frac{(V+Rs.I)}{Vk.\alpha}} - 1\right] - \frac{V+I.Rs}{Rsh} \quad (1)$$

Where

$I_o \rightarrow$ Saturable current of the PV

$V_k \rightarrow$ Maximum Thermal Voltage

$\alpha \rightarrow$ Diode ideality Constant.

Four solar panels are used in the proposed system. The output from the PV system is applied to the Zeta Converter.

3.2 Zeta Converter

Zeta Converter (Fig 2) is the type of buck boost converter that can increase or decrease the input voltage. Also the converter maintains the input current continuous, due to this advantage converter provides higher efficiency. Diode which is available in the Zeta Converter provides d_v/d_t protection.

The design of elementary Zeta converter fed PV application is discussed. The components such as input inductor and capacitor L_1 and C_1,output inductor L_2 and output dc link capacitor C_2 helps to work in continuous conduction mode with reduced stress on its devices and its components. Depends on the duty cycle the operation of mode can be changing.

$$Duty\ cycle = V_{out}/V_{out} + V_{solar} = 150/(150+36) = 0.81 \quad \text{---- (2)}$$

Where V_{out} is the average value of output voltage of luo converter that is equal to bldc motor input voltage.

The estimated output current can be written as

$$I_0 = P_{out}/V_{out} \quad \text{----- (3)}$$

Rated power as $P_{out} =$700 Watts

$$Io=700/150=4.67\ A \quad \text{----- (4)}$$

Then estimate the maximum permitted ripple values of L_1 and C_1

$$\Delta I_L = I_o \times \frac{V_0}{V_{in(min)}} \quad \text{------- (5)}$$

$$= 4.67 \times \frac{150}{36} + 30\%\ ripples$$

=23.95 A

The inductor L1 of the modified Zeta converter is calculated using the following equation,

$$L_1 = D\ V_{solar(in)}/f_{sw}\,\Delta I_{l1} \quad \text{------- (6)}$$

=0.81x36/10x10^3x23.95

L1 =7mH

The inductor L2 &L3 of the modified Zeta converter is calculated using the following equation,

$$L_2 = (1\text{-}D)\, V_{out} / f_{sw}\, \Delta I_{l2} \qquad \text{------- (7)}$$

= (1-0.81)x150/10x10^3x23.95

$L2 = 7mH = L3$

The change in capacitor voltage across C1 is

$$\Delta V_{cs} = I_0 \times D / C_s\, f_{sw} \qquad \text{------- (8)}$$

$=4.67 \times 0.81/10 \times 10^{-6} \times 10 \times 10^3$

ΔV_{cs} =3.78 V

The capacitor C1 of the modified Zeta converter is calculated using the following equation,

$$C_1 = I_0 \times D / \Delta V_{cs} f_{sw} \qquad \text{------- (9)}$$

$=4.67 \times 0.81/(3.78 \times 5\%) \times 10 \times 10^3$

$C1 = C2 = 20\mu F$

4 Control strategies for Zeta Converter

The control strategy adopted here works based GWO algorithm.(Fig 3) The purpose of this controller is to regularize the output voltage from the converter. For that purpose, a comparator which compares VDC actual with Vref .

The error is given to the PI controller. The control parameters are fine-tuned by GWO algorithm. Finally the controlled signal generates reference signal and it is compared with carrier wave. Based on that, pulses are generated and given to the Zeta converter.

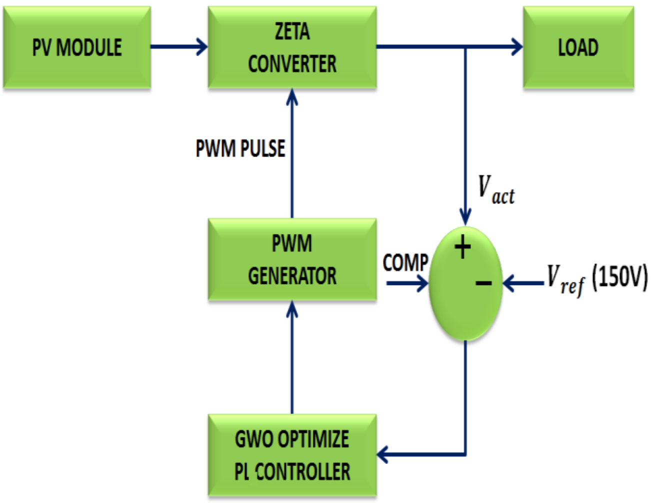

Fig. 3. Control Strategy for Zeta Converter

4.1 GWO Algorithm

GWO is a swarm intelligence algorithm. This algorithm is proposed by mimicking grey Wolf looking for its food that is based on the leadership hierarchy and its natural chasing characteristics. This method utilizes four different types of wolves to imitate the hierarchy, as α, βW, gamma (δ) and ω on the basis of fitness value. The wolf α is regarded as the better solution and is treated as the decision maker, as well as the head of the hierarchy. The wolf βW and δ are the consecutive best solutions such that they help the wolf α in making decisions. At last ω is the remaining wolves that follow the leaders. The attacking behavior in the algorithm is given by the below equations

$$\vec{e} = |\vec{f}.\vec{x}p(t) - \vec{x}p(t)| \qquad \text{---- (10)}$$

$$\vec{x}(t+1) = \vec{x}p\,(t) - \vec{a}.\vec{e} \qquad \text{---- (11)}$$

where t is the present iteration, a, e and f are the coefficient, xp and x are the position vector of the prey and position vector of grey wolf. The vectors a, f was estimated as follows:

$$\vec{a} = 2.\vec{b}.\vec{r1} - \vec{b} \qquad \text{---- (12)}$$

In the optimization techniques such as GA, PSO, ACO and GWO, an automatic iterative search will be evaluated with the help of a specific criterion called as objective function. The PI controller parameters Kp and Ki are optimized so that the error voltage e(t) will be minimized to get the desired performance.

The transfer function of PI controller is,

$$G_c(s) = K_p + \frac{K_i}{s}$$

The Kp and Ki values are tuned by ACO algorithm. The output u(t) of the PI controller is given by,

$$u(t) = K_p e(t) + K_i \int_0^t e(t)\, dt$$

In this case, with the concern of control objectives, the best pertinent function for minimizing the error-integrating function is Integral Time Absolute Error (ITAE), Integral Absolute Error (IAE), Integral Time Squared Error (ITSE) and Integral Square Error (ISE) [24]. Out of these errors integrating function, IAE criterion is employed in this work.

$$IAE = \int |e(t)| dt \qquad (15$$

The above equation defines the performance index of IAE mathematically.

Where, 't'-time

e(t)-difference between the reference set point Vref and VDC of Zeta converter and controlled signal.

The IAE highlights the error value by weighing it with time.

The optimized K_p& K_i values are fine-tuned by GWO algorithm.

The algorithm for GWO is

Step1: Assume the grey wolf population as

Xi(i=1,2,….n), Kp, Ki, X α, X^{β},Xδ

Step2: Set the iteration to 0

Step 3 : For each Kp and Ki, search for the fitness function

Step4: Obtain X α, X^{β}, X^{γ}

Step5: while(t<max umber if iteration)

For each search agent

Step6: Calculate the fitness function

Step7: Update X^{β} X alpha and X

Step8: t=t+1

Go to Step 4

end while

return X alpha.

With the fine tuned parameters of Kp and Ki by using GWO algorithm, the PI controller generates reference signal for PWM generation. This reference signal and carrier signal are compared to generate PWM pulses. This PWM pulse is applied to Zeta Converter.

4.2 Fuzzy logic based MPPT Algorithm

The outputs of solar energy system are non-reliable as the solar irradiations are subjected to change. This makes it difficult to achieve efficient operation of the system. In order to get a reliable output and to help efficient operation of the system a maximum power point tracing method is applied. A MPPT method constantly monitors the power output of the power generating system. If there is change in the power output the operating point of the MPPT moves to a greater level this method repeated even when there is lower output by shifting the operating point in the opposite direction. A MPPT algorithm is a simple and reliable algorithm which aids in efficient operation of renewable energy based power production system. Here we have implemented a fuzzy logic MPPT algorithm [6].

5. Grid Synchronization

The architecture of DC-link voltage controller for single phase two level PV inverter is shown in figure 4. The original link voltage of PV inverter (Vdc) is taken and forward to a low pass filter to minimize the switching ripples. The difference of the filtered DC-link voltage and reference voltage (Vdc*) is fed to PI controller to regulate the DC-link voltage.

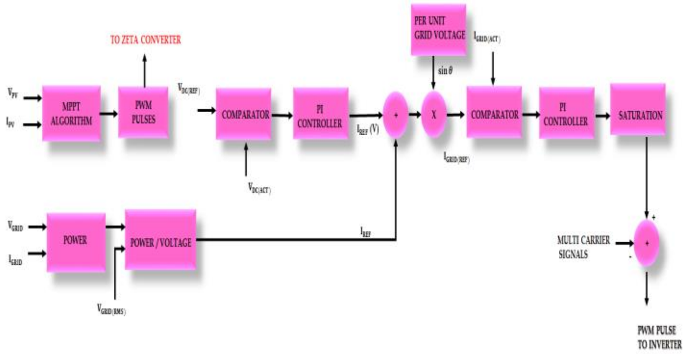

Fig. 4. Grid synchronization control technique using PI controller

The voltage error (Verr) in nth sampling instant is given as

$$\Delta v_{err}(n) = v_{dc}^{*}(n) - v_{dc}(n) \qquad (17)$$

The yield of the PI controller at nth sampling time is

$$i_{inv}^{*}(n) = i_{inv}^{*}(n-1) + K_{P1}\left(\Delta v_{err}(n) - \Delta v_{err}(n-1)\right) + K_{I1}\Delta v_{err}(n)$$

where KP1 and KI1 are proportionality and integral gain of the dc voltage controller. The outputs of the voltage controllers are the peak amplitude of the active currents which are integrated with the grid voltages to produce the reference currents for the PV inverter. By this control method, the PV inverter can give the local load with a maximum current up to reference value. If the requirements of load are greater than the generation from PV then additional currents are obtained from the grid.

In this mode, the actual inverter current is compared with the reference value. The errors are given to PI controllers. The yield of the PI controllers produces a variation in the duty cycle (dˆ) and is mixed to the static duty ratio (D) to produce a modulating signal.

6. Results

The procedure of the proposed work is verified through MATLAB/ SIMULINK software platform. The same is also experimentally verified by using DSPIC30F2010 controller. Table1 and 2 represents the parameters specification/ratings of the solar system and Zeta Converter.

6.1 Tables

Table 1. Specifications for Solar panel

COMPONENTS	**RATINGS/ SPECIFICATIONS**
Number of panels	**3**

Number of cells in series	**36**
Cell	**125mm×31.25mm**
Open Circuit voltage	**21.4 V**
Optimal operating voltage	**16.8 V**
Short circuit current	**1.21 A**
Optimal operating current	**1.19 A**
Operating temperature	**-40 to +85^{0}C**
Maximum system voltage	**1000V DC**

Table 2. Specifications of Zeta converter

Components	**Symbols**	**Rating**
Source Voltage	v_{in}	0 to 48 V DC.
Source Current	i_i	25 A (Max)
Capacitors	C_1,C_2	20uF
Inductor	$L1$, $L2$	7mH
Output load current		5 Amps
Switching frequency	f	10 KHZ
Output Power	P_0	700W
Switching devices(all)		IRF250
Diodes(all)		MUR1560
Driver Circuit		TLP 250

The prototype model of the work was implemented with specifications mentioned in table 1 and 2. The results taken from both simulation and hardware setup are highlighted and discussed in the following subsection.

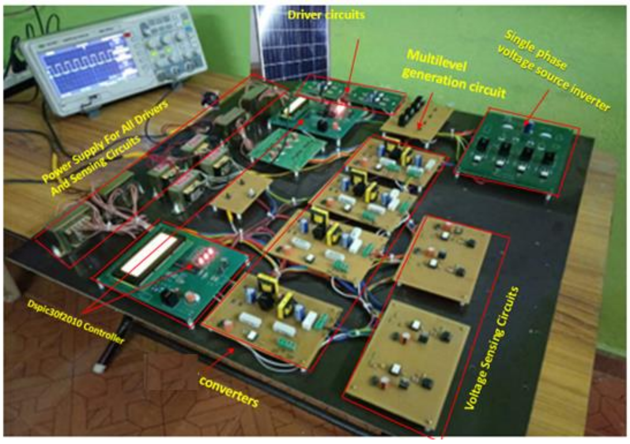

Fig. 5. Hardware Setup

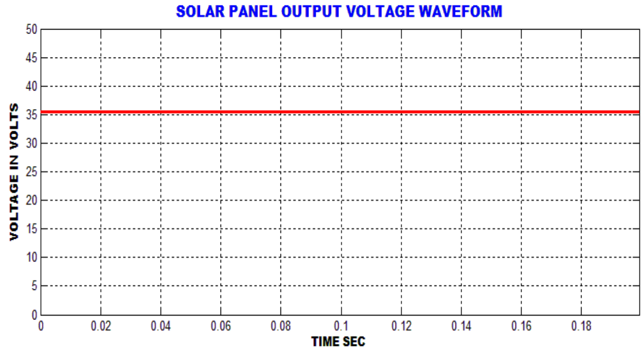

Fig. 6(a). Simulation results of Input DC voltage waveform to the Zeta converter (35.6 V)

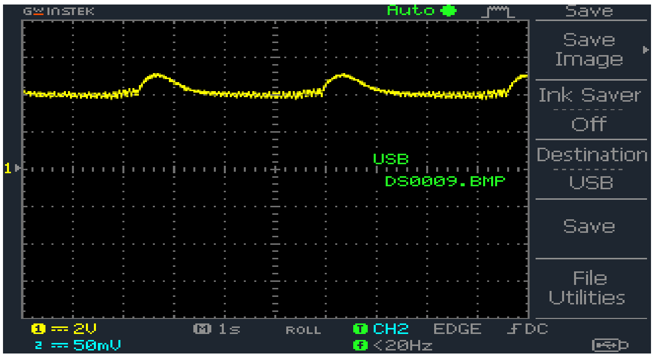

Fig. 6(b). Hardware results of Input DC voltage waveform to the Zeta converter

The figure 6 (a) and (b) shows the Solar voltage to the Zeta converter, due to solar panel input variation, solar output voltage have higher order ripples. This voltage is given to the Zeta converter.

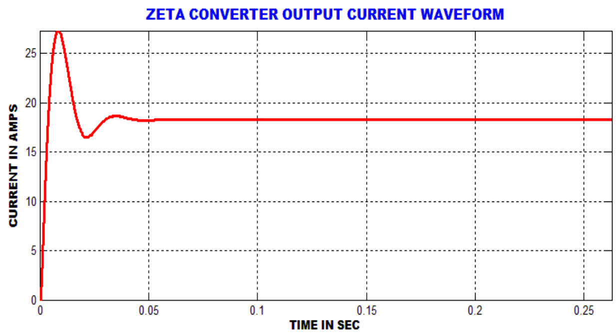

Fig. 7(a). Simulation results of Input current waveform from the Zeta converter

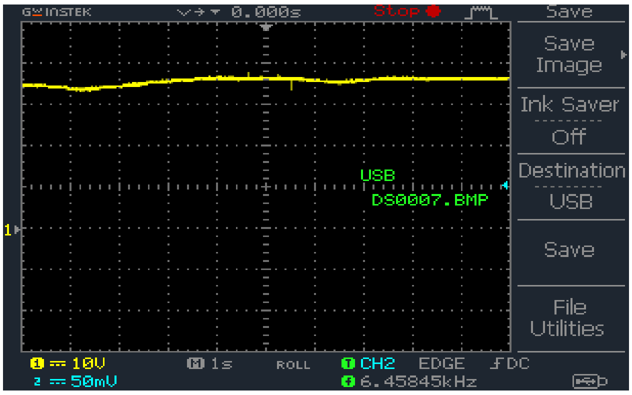

Fig. 7(b). Hardware results of Input current waveform from the Zeta converter

The figures 7(a) and (b) show the Zeta converter input inductor current waveform, the inductor L1 present in Zeta converter maintains the input current continuously.

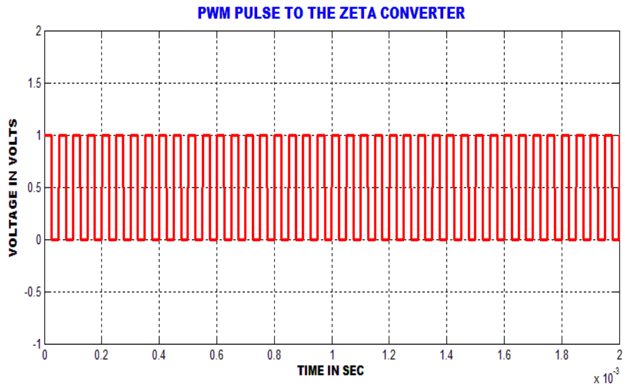

Fig. 8(a). Simulation results of PWM pulse to the Zeta converter

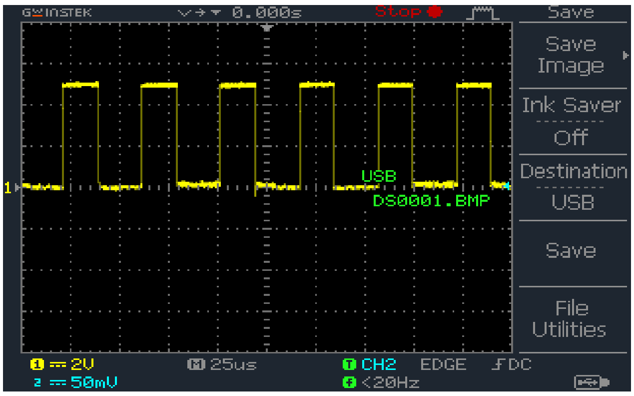

Fig. 8(b). Hardware results of PWM pulse waveform to the Zeta converter

The figure 8(a) and (b) shows the PWM pulse applied to the Zeta converter, the MPPT GWO algorithm is carried out for producing the PWM pulses with switching frequency 10 kHz. The GWO algorithm is the self-tuning optimized MPPT algorithm.

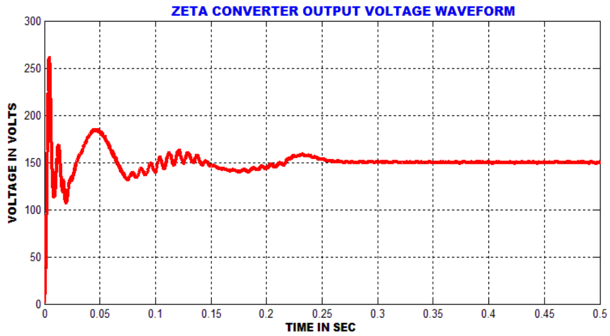

Fig. 10(a). Simulation results of Zeta converter output voltage using FL algorithm

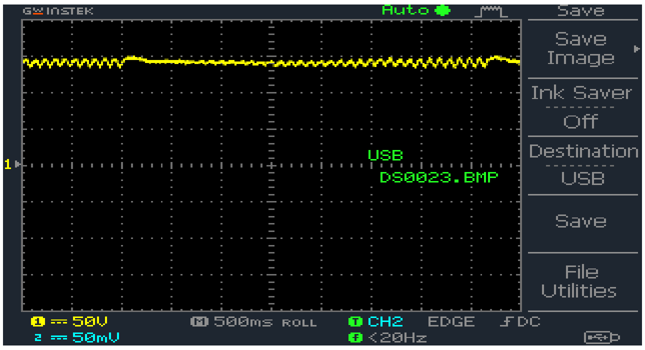

Fig. 9(b). Hardware results of Zeta converter output voltage using FL algorithm

The figure 9 (a) and 9 (b) show the output voltage of the Zeta converter using fuzzy logic algorithm.

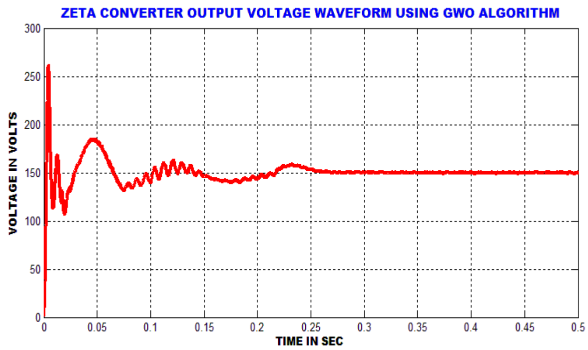

Fig. 10(a). Simulation results of Zeta converter output voltage using GWO algorithm.

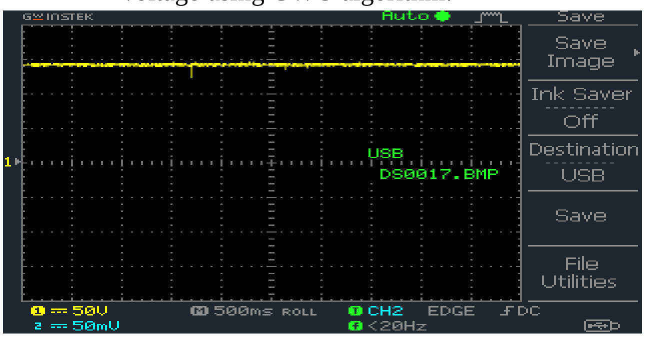

Fig. 10(b). Hardware results of Zeta converter output voltage using GWO algorithm.

The figure 10 (a) and 10 (b) shows the output voltage of the Zeta converter using GWO algorithm. Compared to Fuzzy logic algorithm, it provides more voltage stability.

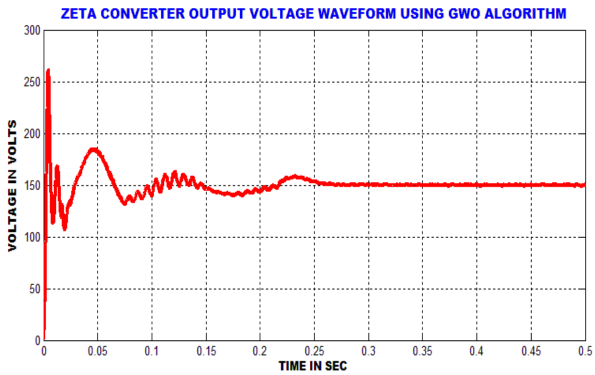

Fig. 9(a). Simulation results of Zeta converter output voltage using GWO algorithm.

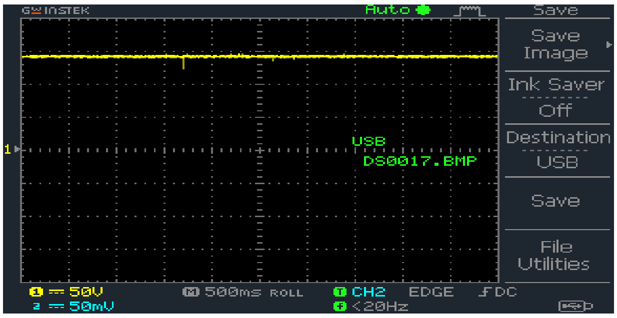

Fig. 9(b). Hardware results of Zeta converter output voltage using GWO algorithm.

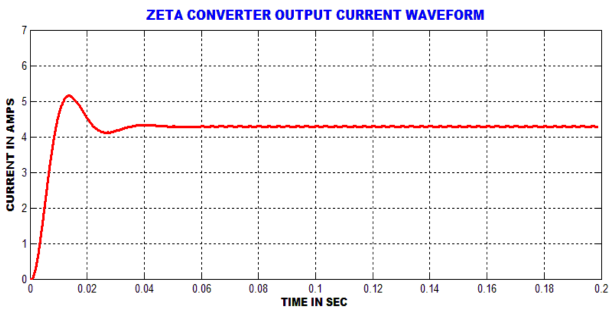

Fig. 11(a). Simulation results of output DC current of the Zeta converter

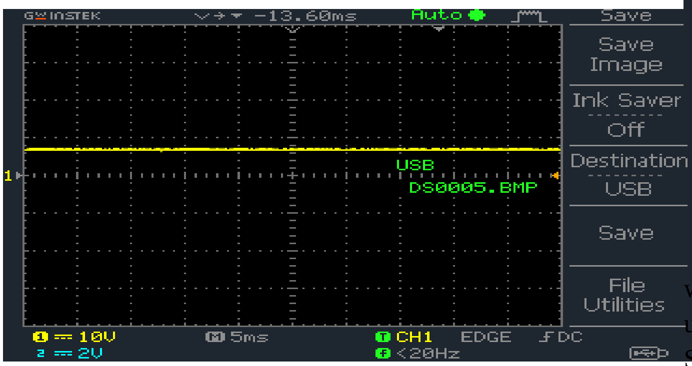

Fig. 11(b). Hardware results of Output DC current waveform of the Zeta converter

The figure 11 (a) and 11 (b) shows output current waveform of Zeta converter. Due to nonlinear loads current have noises.

The figure 12(a) show the inverter output voltage with inductive filter because voltage injected in the grid should be sinusoidal. PI controller achieves grid current compensation.

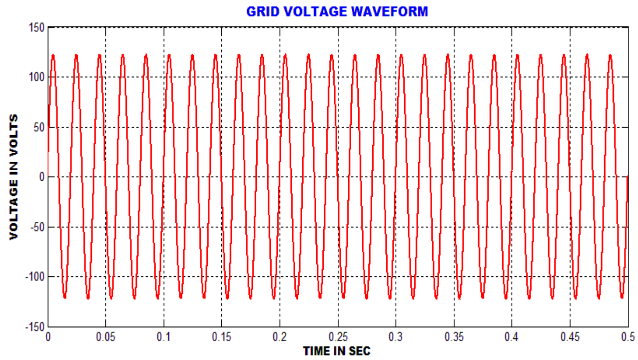

Fig. 12(a). Simulation result of Grid Voltage waveform

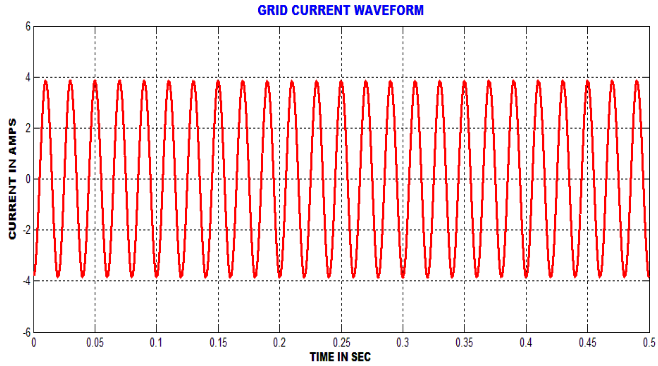

Fig. 12(b). Simulation result of Grid current waveform

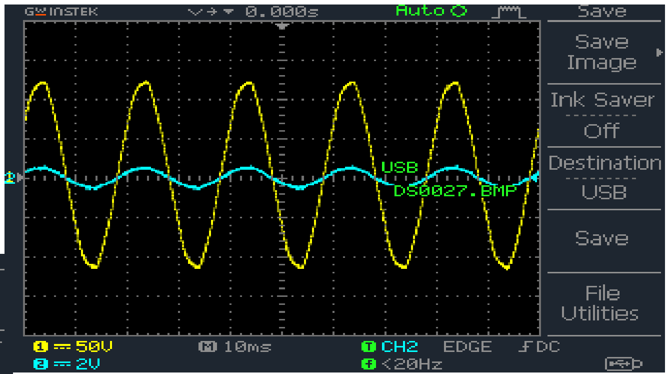

Fig. 12(c). Hardware results of Grid voltage and current waveform

The figure 12 (c) shows grid voltage and current waveform, it indicates both are in phase. This achieves near unity power factor operation. This system looks likes STATCOM device.

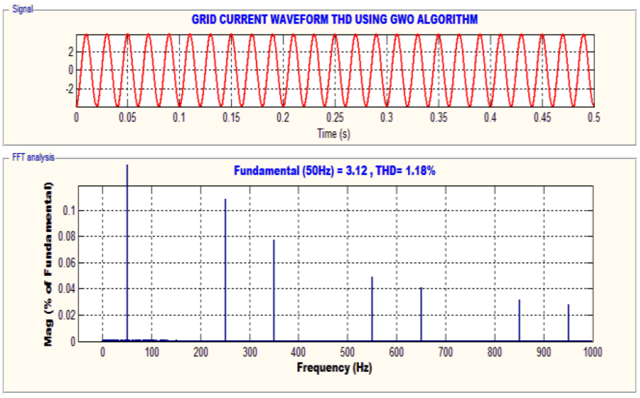

Fig. 13(a). Simulation results of Current THD waveform with GWO algorithm.

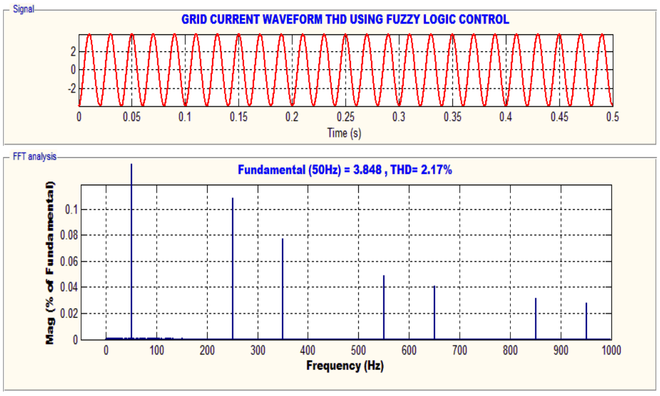

Fig. 13(b). Simulation results of Current THD waveform with Fuzzy logic algorithm

The figure 13(a) shows the THD waveform of grid voltage, its shows only 1.18 percentage. This system satisfies IEEE harmonics standard. Zeta converter and MPPT algorithm maintains constant voltage to the grid with the help of inverter. PI controller achieves steady state operation in grid.

Comparison of Boost Converters

The proposed system is validated through fuzzy logic based MPPT algorithm and GWO algorithm.

S. NO	PARAMETERS	LUO VOLTAGE	EFFICIENCY	I THD
1	Output Voltage (FUZZY)	142 V	90	2.17
2	Output Voltage (GWO)	150V	94	1.18

7. Conclusion

Distribution System using PV based Zeta converter has been successfully implemented. The performance of the overall system is analyzed using MATLAB simulation and DSPIC30F2010 controller. The fuzzy logic algorithm extracts only the maximum power from the input sources, compared to other all algorithms fuzzy logic algorithm provide has less ripple content with the aid of Zeta converter. Here The PI controller achieves the grid current synchronization. Due to this, inverters have very less Total Harmonic Distortion. And inverter obeys the power quality issues and harmonics standard theory levels. Comparison is shown for fuzzy and GWO. In between the Zeta converter with fuzzy logic and GWO MPPT algorithm provides good performance. Finally this application is mainly useful for reactive power compensation in smart grids and power grids.

References

1. Joseph Vardi and Benjamin Avi-Itzhak, *Electric Energy Generation; Economics, Reliability and Rates*: MIT, 1981, p.75-94. [1] M. Koteswararao and P. Pawanputhra, "Control Performance Evaluation of Solar PV Cells Connected to an AC Grid," Indian Streams Research Journal, vol. 3, no. 11, pp. 1-7, 2013
2. T. Esram and P. L. Chapman, "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques," IEEE trans. Energy Converters, vol. 22, no. 2, pp. 439–449, 2007
3. Da Fang1, Weiyu Xu1, "Input-Parallel Output-Parallel DC-DC Converter with MPPT Technique for Grid Connection of Multiple Distributed Generators," IEEE Conference on Industrial Electronics and Applications (ICIEA), vol. 1, pp. 2329-2332, 2013.
4. Eswaramoorthy, K & K. Shunmughanaathan, V. (2016). "A Simple And Geometry Based Fast Space-Vector Pwm Technique For 15 Level Cascaded Multilevel Inverter With Reduction Of Switches". Asian Journal of Research in Social Sciences and Humanities. 6. 2305. 10.5958/2249-7315.2016.01170.9.
5. N. Femia, G. Petrone, G. Spagnuolo, and M. Vitelli, "Optimization of Perturb and Observe Maximum Power Point Tracking Method," IEEE Trans. Aerospace .Electro systems ,vol. 20, no. 4, pp. 963–973, 2005.
6. M. Amelian, H. Saberi "Small Signal Stability Improvement of a Wind Turbine-based Doubly Fed Induction Generator in a Micro grid Environment," International Conference on Computer and Knowledge Engineering, Vol. 1, pp. 2093-2099, 2014
7. Syafaruddin Karatepe E, Hiyama T. "Artificial neural network-polar coordinated fuzzy controller based maximum power point tracking control under partially shaded conditions," IET Renew Power Gener, vol.3, pp.

239–53,2009.
8. Hiren Patel and Vivek Agarwal "A Single-Stage Single-Phase Transformer-Less Doubly Grounded Grid-Connected PV Interface," IEEE Transactions on Energy Conversion, vol.24, pp. 93-101, 2009.
9. Somashree Pathy, R Sridhar "A Modified Module Integrated - Interleaved Boost Converter for Standalone Photovoltaic (PV) Application," IEEE International Conference on Renewable Energy Research and Applications (ICRERA), vol. 1, pp. 989-994, 2013.
10. S. Reza, S. Salwah, and B. Salim, "Neuro computing Real-time frequency-based noise-robust Automatic Speech Recognition using Multi Nets Artificial Neural Networks: A multi-views multi-learners approach," Neuro computing, vol. 129, pp. 199–207, 2014.
11. T. Radjai, L. Rahmani, S. Mekhilef, and J. Paul, "Implementation of a modified incremental conductance MPPT algorithm with direct control based on a fuzzy duty cycle change estimator using dSPACE," Sol. ENERGY, vol. 110, pp. 325–337, 2014.
12. Eswaramoorthy, K & K. Shunmughanaathan, V. "Control Of Three Phase Four Wire Asymmetrical Fifteen Level Inverter Using Hybrid Bi-Tri Dimensional Space Vector Pulse Width Modulation", Journal of Electrical Engineering,2018, vol. 18,4.

AUTHOR DETAILS

[1]**JOHN SUNDAR D** was born in Chennai, India. He received his Bachelor of Engineering degree in Electrical and Electronics Engineering from Shri Andal Alagar College of Engineering, Mamandur under Anna University in the year 2007, and his Master of Engineering degree in Power Electronics and Drives from Anna University (St.Joseph's College of Engineering, Chennai, India), in 2010. He is presently working towards his full time Ph.D. degree at Anna University, Chennai, India. His current research interests include Grid Connected Inverters, Power Quality, and DC-DC Converters.

[2]**SENTHIL KUMARAN M** received the Bachelor's and Master's degrees from the University of Madras in 1999 and 2001 respectively, in Electrical and Electronics Engineering. Since then he has been in the field of teaching and guiding at undergraduate and postgraduate levels. He received his Ph.D. in the year 2013 from Anna University, Chennai. He is currently serving as an Associate Professor in the Department of Electrical and Electronics Engineering at SSN College of Engineering, Kalavakkam, Chennai. His research interests include electrical machines and drives, power electronics and signal processing, specifically matrix converters applied in wind energy systems and power quality.