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ANFIS based MPPT Controller for Grid Connected Photo Voltaic System

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Abstract: In recent years, solar power has been extensively utilized in power grid, mainly victimization in electrical phenomenon (PV) generation units. During this regard, this paper proposes associate adaptive Nero Fuzzy logical thinking System (ANFIS) based mostly formula for varying the step size of the progressive electrical phenomenon (INC) most electric receptacle Tracking (MPPT) technique in PV. Within the projected method, the degree of ascent or descent are calculable per the variable voltage step size is of the power-voltage relation. For this benefit, a unique treatment is place forward supported found seven effective regions round the purpose of most PV power. To disagree the step size of the duty cycle, a ANFIS system is evolved according to the locations of the fuzzy inputs conserving the seven regions. The evolved fuzzy inputs are simulated by the power- voltage relation slope, specifically the current- voltage ratio. the appropriate membership functions and ANFIS rules are designed accordingly. The gain of the projected technique is to increase the varied step size of the electrical phenomenon by incremental conductance (IC) method. Then the following speed and the output DC power of the PV array are bestowed as steerage for illustrating the event reached in MPPT.

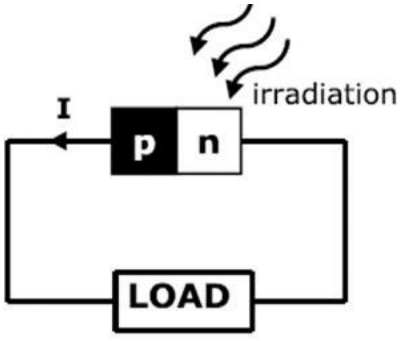
Key Words - PV panel, MPPT technique, FIS, ANFIS, zeta converter, Boost converter, P-V relation

I. INTRODUCTION

In recent years, the non-renewable source such as fossil fuels are extensively used for the development of human needs which leads to the environmental damages and the negative outcomes are took place at the surroundings which includes ozone depletion, greenhouse gas emission and acid rain. Now-a-days, the regulations for renewable strength technology guide the capital subsidies to sell its packages and to offer subsidies in taxes and promoting solar PV applications has higher economic benefits [1]. Due to innovation in research and era development in manufacturing, the fee of photovoltaic (PV) array is reducing day with the aid of using day. In this era, the dependency of the PV array has improved. Various techniques are to be had to version and simulate the PV array. The existing and new topologies are working and generated by the use of Mat Lab/Simulink.

II. PV SYSTEM WORKING OF A PV CELL

The fundamental concept that is used in the operation of a PV cell is the photoluminescence effect. Once the sunlight (irradiance, temperature) reaches the PV cell the energy is absorbed by the electrons present in the semiconductor which gets excited and migrate from valence band to the conduction band leaving behind a hole or a space [2].



When the electrons move from valence band to the conduction band that creates a potential to the terminal. By this when a circuit is connected to the two ends of the terminals to form a closed loop, the circuit works [3].

SHADING EFFECT

In a series connection the modules, the current flows through the circuit, but the shaded part cannot produce the same current, it must allow the same current. Current flows, so the shaded

part acts like a load and consumes electricity. The shaded region is considered as load, then the state of this problem is known as hot-spot. In some dangerous cases, the system can be easily damaged. In such conditions, to reduce the damages caused by this problem we use a bypass diode. The shaded state shown in the PV cell in the block diagram that have more than one point of maximum performance, so that for this state, keeping track of the point of maximum performance becomes very complicated.

MPPT - MAXIMUM POWER POINT TRACKING

The Maximum Power Point Tracking (MPPT) is actually an electronic system to control the force a photovoltaic system to achieve peak

Performance [4]. The modules move, change directions, and are pointed directly at an optimal angle or optimum angle to the sun's rays without the aid of a single mechanical component. By changing the operating point electrically, the maximum Power Point Technique can provide the module with the maximum allowable power [8].

The different MPPT Techniques are as follows

- Perturbation and Observation algorithm (P&O)
- Incremental Conductance algorithm (In-Cond)
- Ripple Correlation technique
- Short Circuit Current technique
- Open Circuit Voltage technique

DC-DC CONVERTER

A DC-DC converter is an electronic device that is used to convert high frequency power conversion according to the user needs. They can be used as a switching device to smoothen the switching noise to regulate the DC voltage. The range of power level can vary from very low to very high (in both extreme points). The main application is to integrate the voltage level from a partially decreased voltage level of a battery to save the space instead of using complex circuits.

There are several types of DC-DC converters that are used to transform the voltage level based on the availability of power, load in demand, supply. Some of the DC-DC converters are discussed:

- Buck converter
- Boost converter
- Buck-Boost converter

BOOST CONVERTER

The boost converter is a DC-DC power converter that is also used as a step up voltage source. It is used to step up the input power to its output power for higher effective outputs.

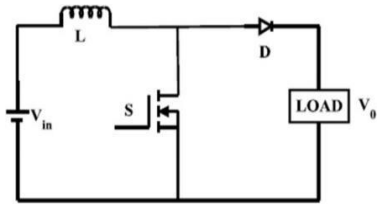


Fig 2: Circuit Diagram of boost converter

The fundamental idea behind a boost converter is how well an inductor can tolerate changes in current flow by either increasing or lowering the magnetic field's capacity to store energy. The output voltage of a boost converter is always higher than the input voltage [10].

Here zeta converter is also discussed to compare with boost converter to know the efficiency.

ZETA CONVERTER

The DC-DC converter has a special sequence of placing the converters and the zeta converter is placed in the order Fourth in nonlinear system in consideration with the energy inputs.

The Buck-Boost-Buck converter is considered with the in terms of power consumption and the Boost-Buck-Boost converter is considered in relation to the output of the circuit.

The zeta converter is depending on the load resistance, operating frequency, inductance value and so on. The ideal zeta converter switch is illustrated here

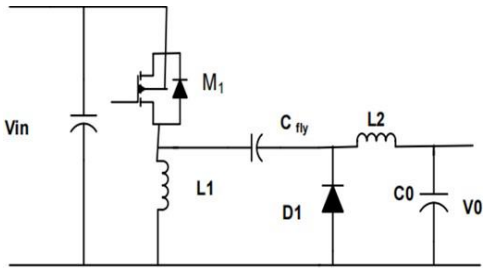


Fig 3: Circuit Diagram of Basic Zeta Converter. The analysis used for the following

Assumptions are elaborated:

- Solid-state switching devices are ideal
- Converter operates continuously in the "iL1" mode (inductive current mode)
- Line ripple frequency of the DC voltage is ignored [9].

III. PROPOSED SYSTEM

The proposed scheme offers fast convergence speed, MPPT tracking points are low, the stationary error becomes zero or nil, the tracking of the PV cells has highly effective compared to recently developed algorithms. The achievements of the PV grid connected power generation was noticed and proved through partial result of hybrid ANFIS- PSO inverter control using the d-SPACE interface with the swing of solar radiation.

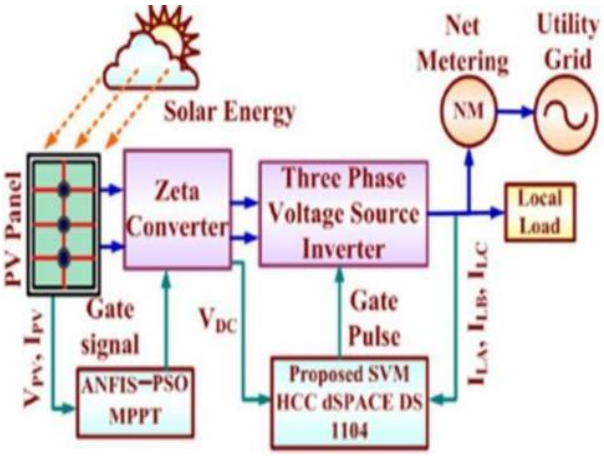


Fig 4: Block diagram of the proposed system

MODES OF OPERATION

By analyzing the zeta converter, it exhibits two different modes of operation shows the equilibrium position that the current flows through L1 is equal to IIN, and the current flows through L2 is equal to IOUT. This condition shows that there is no direct current flowing through the flying capacitor CFLY.

MODE 1 [M1 ON]

When the switch M1 is in ON state (closed) the voltages VL1 and VL2 are equal to Vin since the same current flows through the inductors L1 and L2. The diode D1 is switched OFF during the time interval with a reverse voltage of -(Vin+Vo). The inductor L1 and L2 receives energy from the voltage source Vin and their respective current source IL1 and IL2 linearly increases in the ratio of Vin / L1 and Vin / L2, accordingly. As a result, the switching current IM1 = IL1 + IL2 increases linearly in a relation Vin / L, where L = L1* L2 / (L1 + L2). At this point in time, the capacitor CFLY is discharged and the capacitor C0 is charged. This is called as **charging mode.**

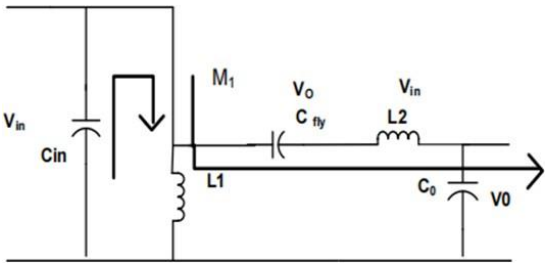


Fig 5: Zeta converter during MOSFET ON time

MODE 2 [M1 OFF]

There is no DC voltage on the either side of the inductor. Hence, the ground potential CFLY is on the left and VOUT is on the right, resulting in the DC voltage across CFLY being equal to VOUT.

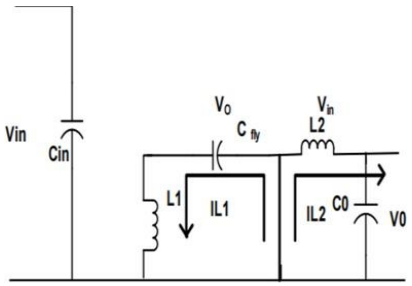


Fig 6: Zeta converter during MOSFET OFF time At this stage when the switch M1 is turned

OFF, the diode D1 is forward biased (in ON position). The voltage at L1 and L2 is equal to -Vo and the inductances L1 and L2 transfer the stored energy to the capacitance CFLY. linear now in a relation –V0 / L1 or –V0 / L2. The diode current is ID1 = IL1 + IL2 also in linear declination to the ratio of −V0 / L. At this point the voltage across the switch is M1is VM = Vin + Vo. This stage of operation is known as **discharging mode**.

ANFIS: ADAPTIVE NEURO FUZZY INFERENCE SYSTEM

Adaptive Neuro Fuzzy Inference System are also called as Artificial Network Based Fuzzy Inference System is a form of labored (artificial) neural network which is designed from Takagi- Sugeno fuzzy inference system which was developed in the year 1990's. An ANFIS is a custom built fuzzy system which is used to map the input elements (membership functions) associated or enrolled in the system. Effectively, there are almost zero restrictions to the nodal working to an adaptive network, with the exception of the differentiation according to parts.

Fundamentally, the one and only limitation to the configuration of the network should be of the feed forward type. With these limited constraints, the adaptive neural network applications are immediate and immense immutable realms.

The proposed architecture is known as ANFIS and stands for Fuzzy Inference System based on adaptive networks. In this we tend to describe about the parameters are set to break down to apply in the hybrid system. To study the regulations for the ANFIS architecture for the sake of accessibility we accept that the fuzzy inference system under considerations has the number of inputs are two named as x and y, then the one and only output is named as z. The base principle is continued with two fuzzy input rules of Takagi and Surgeon types: [7]

RULE 1:

If x is A1 and y is B1, then f1 = p1x + q1y + r1

RULE 2:

If x is A2 and y is B2, then f2 = p2x + q2y + r2

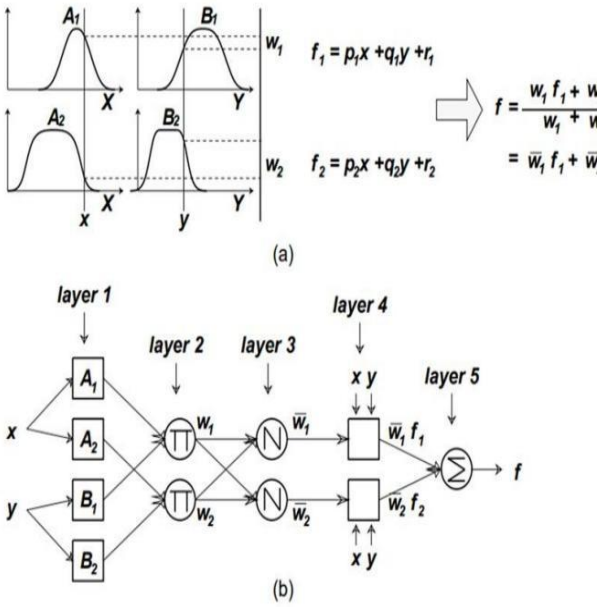


Fig 7: (a) 3rd type fuzzy reasoning

Fig 8: (b) equivalent ANFIS (type-3 ANFIS)

The circuit diagram shows the adaptive control technique with the PV integration grid system [5, 6].

IV. SIMULATION DIAGRAM

The new control proposed in the solar photovoltaic system will help to achieve the following goals:

- Increasing the utility of the solar photovoltaic system on the roof.
- Improving the power factor through reactive power compensation.
- Incentives of the energy supplier to keep the power factor close MPPT does not provide the required results if the exposure changes.

The balance converter gives better results Alternative to the MPPT controller if the exposure varies over the year. This system was implemented in Mat lab**.**

The Fig. 9 shows the Simulink view for the solar panel with zeta converter connected with two main subsystems namely PV subsystem and the ANFIS subsystem.

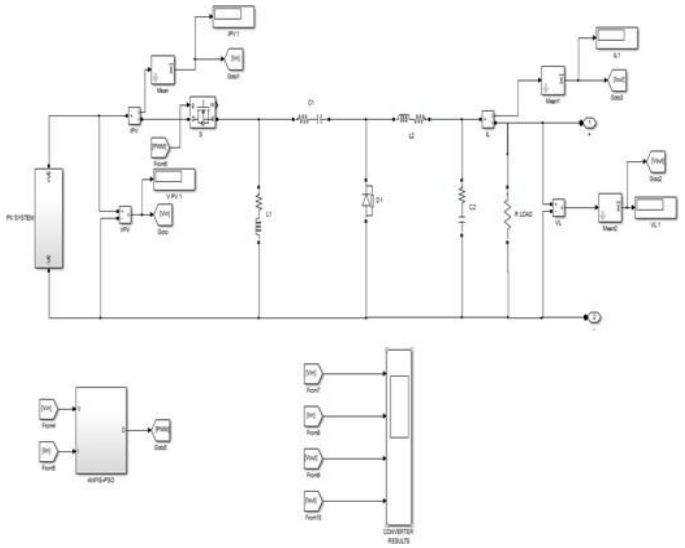


Fig 9: Proposed system Simulink view for Solar Panel with Zeta Converter

The Fig. 10 shows the solar panel subsystem which has two inputs namely temperature and irradiance where the values are made constant for the solar system

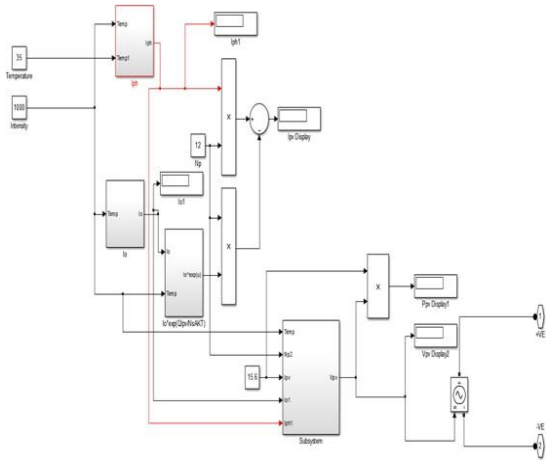


Fig 10: Solar Panel Sub System

The Fig. 11 shows the ANFIS subsystem which also has fuzzy controller subsystem and works with switches, samples, delta, repeating sequence and filters.

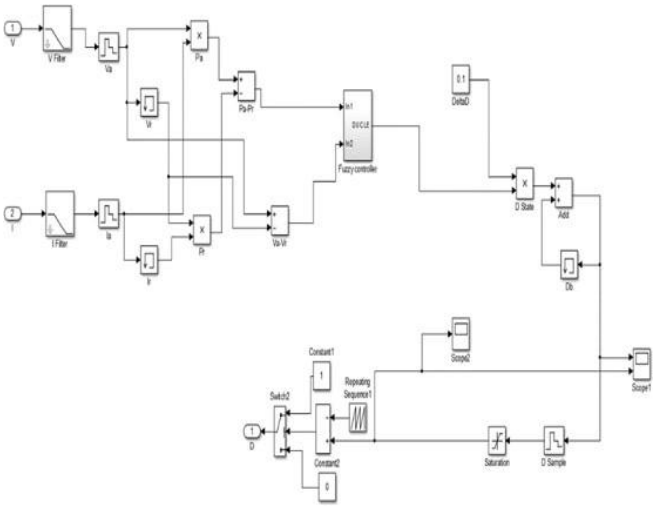


Fig 11: ANFIS Subsystem

The Fig. 12 represents the Neuro-Fuzzy logic controller subsystem works with duty cycle, reference, saturation.

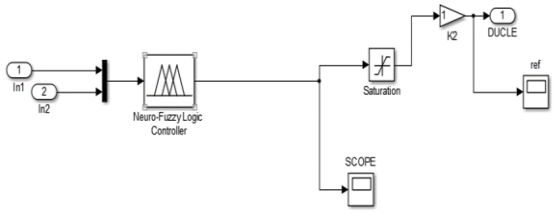


Fig 12 Neuro-Fuzzy Logic Controller Sub System

The Fig. 13 shows the three phase grid connected photo voltaic system works with PWM generator, 3 phase inverter, 3 phase I-V measurement, L filter, transformer, grid connection, power factor calculation, 3 phase power instantaneous, line –line connection of voltage and current.

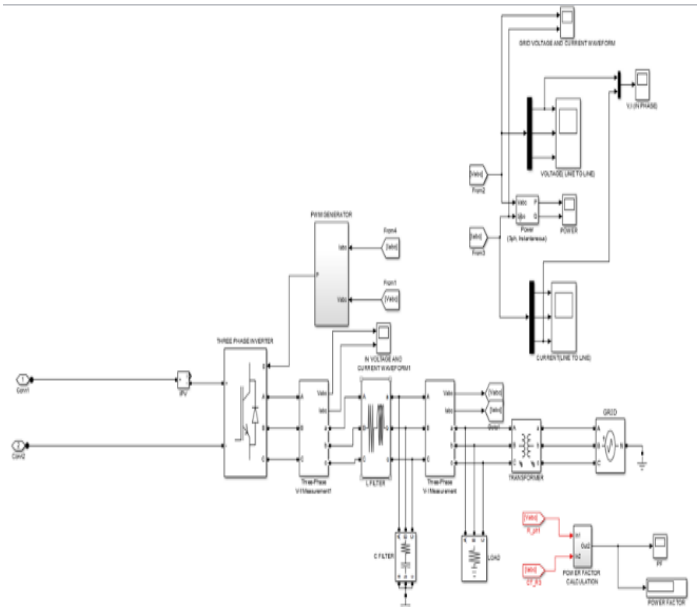


Fig 13 Three Phase Inverter with Grid Controller

V. RESULTS & DISCUSSION

The following diagram from 14 to 24 is the graph of zeta converter

The Fig. 14 waveform shows the input waveform of the voltage ranges from 18 to 66V and current from the converter ranges from 240 to 340I from the solar PV panel.

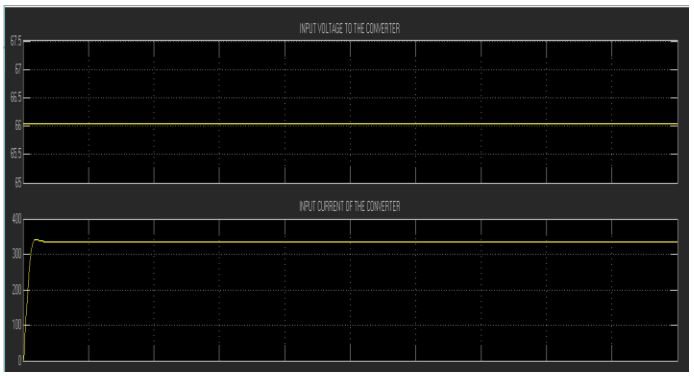


Fig 14 Input voltage and current waveform of the converter

The Fig. 15 **SHOWS** the value 0.5 to 0.9 and gradually increases from 0.95 to its peak value

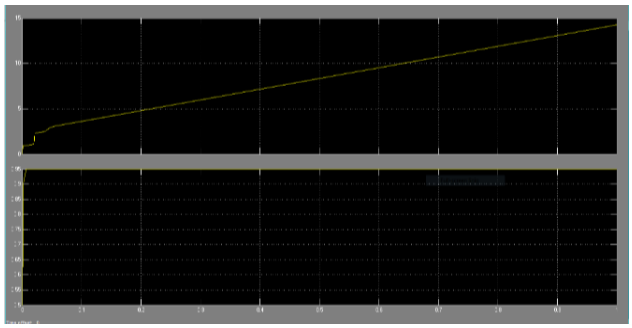


Fig. 15 Output of the ANFIS subsystem

The Fig. 16 shows the waveform of the zeta converter reaches the peak value of off-set time ranges from +0.9 to -0.9(extreme point in both the ranges) Peak value of the Zeta converter waveform. The peak offset time or the ripple factor of the zeta converter is 0.02 to 0.35 and returns to the steady state in 0.04.

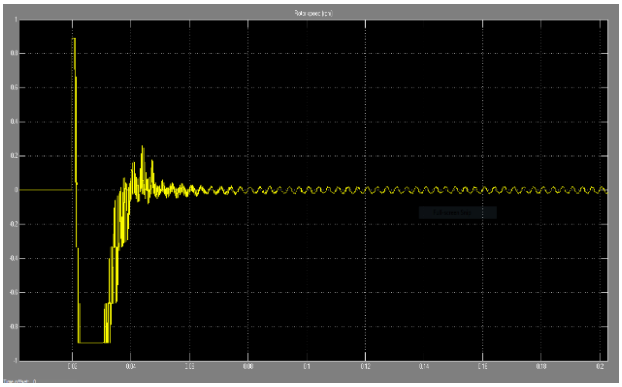


Fig. 16 Ripple factor of the zeta converter

The Fig. 17 shows the three phase inverter is connected to the three phase input voltage and current measurement and is connected the inductance filter and the capacitance filter.

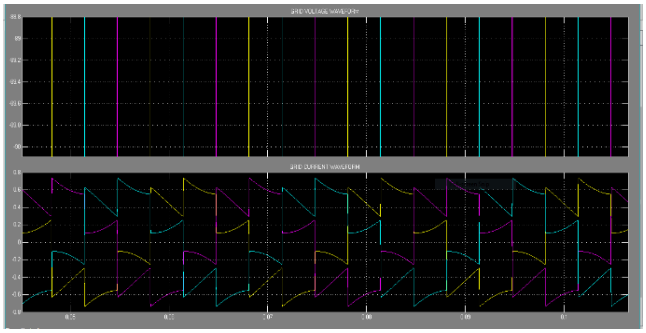


Fig. 17 Three phase input voltage and current measurement waveform.

The Fig. 18 shows the grid connected three phase voltage and current waveform.

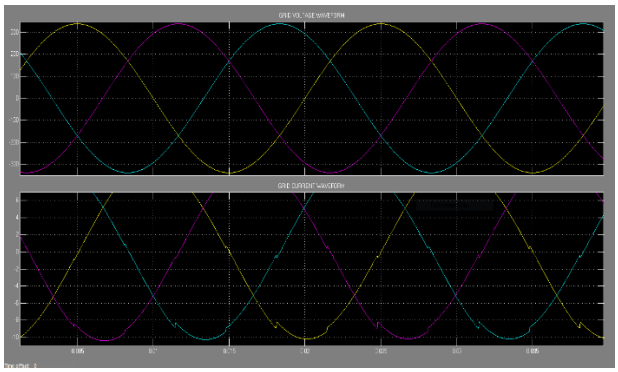


Fig. 18 Grid connected voltage and current waveform.

The Fig. 19 waveform shows three phase voltage and current measurements to obtain three phase power.

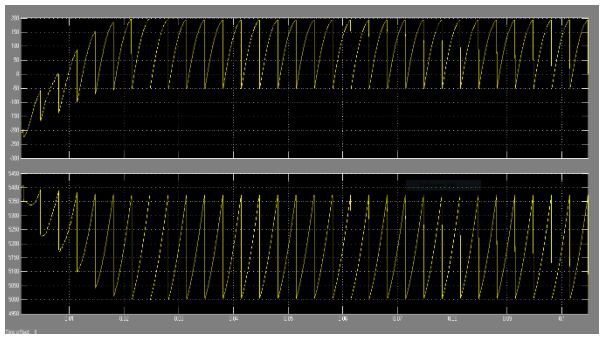


Fig. 19 Three phase instantaneous inputs (Vabc, Iabc) represents Power

The Fig. 20 waveform shows the busbar is connected to Vabc to obtain the Line-Line Voltage waveform

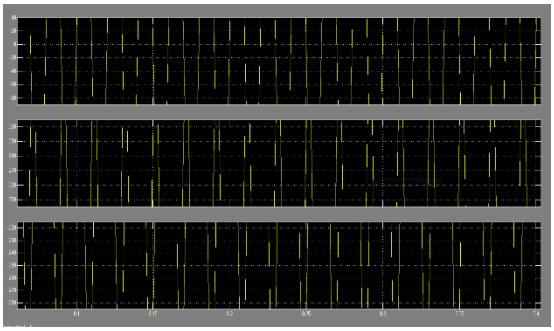


Fig. 20 Vabc connected with busbar to obtain Voltage (line-line)

The Fig. 21 waveform shows the busbar is connected to Iabc to obtain the Line-Line Current waveform.

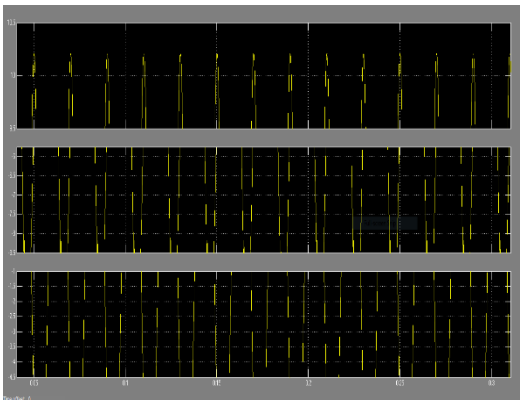


Fig. 21 Iabc connected with busbar to obtain Current (line-line)

The Fig. 22 waveform shows the inphase waveform of voltage and current by connecting Voltage (line-line) and Current (line-line) as inputs

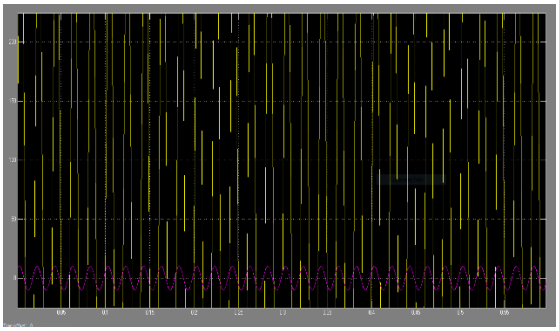


Fig. 22 Inphase waveform of voltage and current

The Fig. 23 waveform shows the power factor of two inputs namely Vabc, Iabc for power factor calculation and the obtained power factor is 0.9848 is shown in output waveform

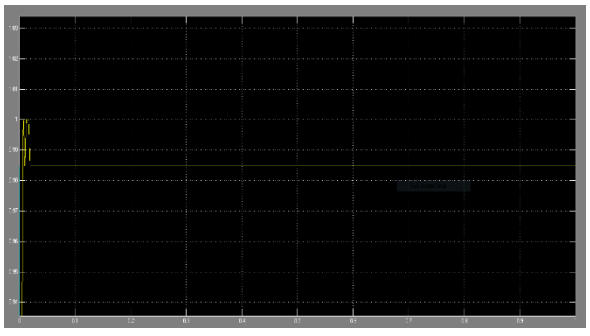


Fig. 23 Power factor waveform

The Fig. 24 waveform shows the output waveform of the voltage ranges from 1200 to 1350V and current from the converter ranges from 0 to 15I from the solar PV panel using zeta converter.

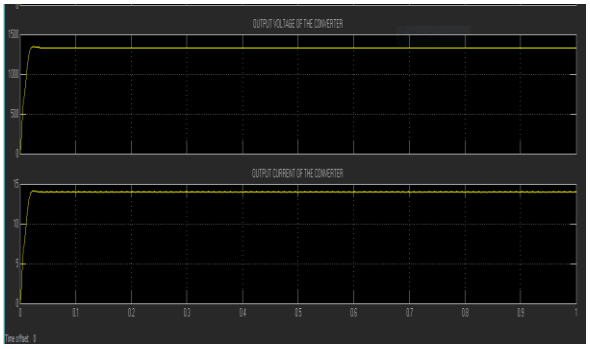


Fig. 24 Output voltage and current waveform of the converter using zeta converter

The following Fig. 25 is the output graph of boost converter

The Fig. 25 waveform shows the output waveform of the voltage ranges from 0 to 1200V and current from the converter ranges from 0 to 13I from the solar PV panel.

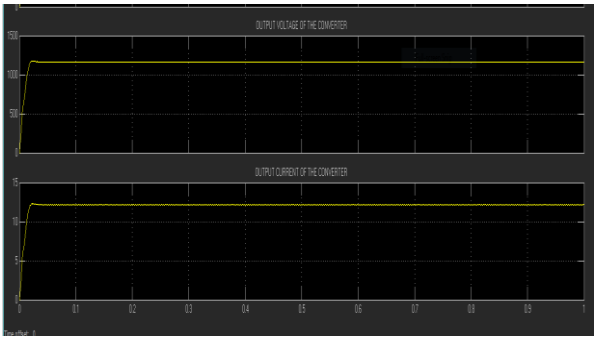


Fig 25 Output voltage and current waveform of the converter using boost converter

VI. DISCUSSION

The zeta converter has the implementation to offer a non-inverted output with higher efficiency that of other DC-DC converter, no ripple factor so that to reduce the loss due to noise, a low voltage diode for cost effectiveness and a continuous conduction mode. While on the other hand the load on the converter output can be used as a output they can vary. In this we can use high potential DC loads. The work of a converter topology is possible to regulate the output voltage from its own input voltage, so that it varies greater or lesser in the output voltage. We can actually calculate readings of the zeta converter corresponding to the input power. The SEPIC converter is a single-ended- primary-inductor converter is also a type of DC-DC converter that allows the electric potential of the output can be integrated or differentiated or even it can also be equal to the input. The LUO converter is a series connection of DC-DC converter (boost converter especially) to form a circuit.

The circuit performs a positive end to positive end DC-DC voltage by incremental transformations. There by we can also replace the zeta converter with SEPIC converter but the output efficiency will be low when compared to zeta converter.

VII. CONCLUSION

Here in conclusion we consider the voltage range, power factor range, efficiency, current range, ripple factor, duty cycle. The projected technique is confirmed and also the trials are hooked up with the simulation of a grid-connected PV system and also obtained better efficiency. The simulation work is performed and evaluated with the MatLab/Simulink.

The one input waveform shown in Fig. 14 and by comparing the output of this single circuit with two different converters outputs (zeta converter, boost converter) and two output waveforms of Fig. 24 and Fig. 25 are obtained.

The Fig. 14 shows the input waveform of the voltage ranges from 18 to 66V and current from the converter ranges from 240 to 340I from the solar PV panel. The Fig. 24 shows the output waveform of the voltage ranges from 1200 to 1350V and current from the converter ranges from 0 to 15I from the solar PV panel using zeta converter.

The Fig. 25 waveform shows the output waveform of the voltage ranges from 0 to 1200V and current from the converter ranges from 0 to 13I from the solar PV panel.
Hence we conclude that the zeta converter is highly effective than boost converter.

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