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Design and Implementation of Modified Zeta Converter for Solar Water Pumping Application

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Abstract— The linear increase in the growth of the population demands a requisite for energy resources. Knowing the loathsome truth that non-renewable sources will ultimately exhaust, the significance of renewable sources cannot be undervalued. Considering various factors, many work areas are reliant upon fossil fuels for the generation of electricity. The use of fossil fuels will increase the quality of power production but will drain one day, and industries must change to renewable sources. The earliest system that strikes a chord with regard to renewable energy is the photovoltaic (PV) energy system. In this specific circumstance, interest in solar systems is expanding step by step, and its installations are becoming broad. The implementation of the solar water pumping method used for irrigation purposes using a Zeta converter was best suited for small and minor farmers, but still, the efficiency of the system can be upgraded with the use of filters. The vantage of the ZETA converter has less result voltage ripple and smooth water pumping application. The PV-based system has reached the point where it is used in Electric vehicles by enhancing the standard operating condition of the converter under the steady and dynamic behavior of a PV system. Eventually, it can be worked considerably under minimum solar irradiance. Maximum power point tracking (MPPT) of the signal had dominant performance in a zeta converter circuit while sign levels ripple current, and voltage on the output side was compact.

Keywords-Renewable Energy Sources, Solar Photovoltaic, Zeta Converter, Maximum Power Point Tracking, Water Pumping.

I. INTRODUCTION

The consistently expanding interest in energy worldwide is draining non-renewable fossil fuels quickly, and the utilization of inexhaustible, non-fossil fuel sources is becoming prominent. The quick advancement and enormous expansion to the renewable power sector are predominantly liberated by hydro, solar, and wind power. In any case, in most countries, among every one of the renewable energy sources, wind ranches contribute the most power due to being effectively accessible and having a low conservation cost. Solar energy can be a significant part of India's strategy, not only to add new limits but to expand energy security, address natural calamities, and lead the enormous market for sustainable power. Besides, India is honored with a respectable prolonged daylight hours across the nation that changes roughly from 2000 hours to 3000 hours per year. For terrains, solar water pumping is an appealing decision for energy reaping [1]. Photovoltaic technology is the predominant encouraging method for electricity generation at lower power. The consistent decrease in cost/peak watt over late years and the effortlessness by which the installed power can be expanded by computing panel boards. Solar energy is accumulated and made available when sunlight is feasible, depending on the demand. There are benefits in avoiding using vast banks of lead acid batteries, which are massive and extravagant and have one-fifth of the lifetime of a photovoltaic panel. This being significant, nonetheless, that the shortfall of batteries

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does not possess great value about the effectiveness of the end-to-end power transformation chain, from panel to mechanical pump.

The DC motor is not reasonably possible for water pumping because of its commutator and brushes game design. The BLDC engines are utilized in solar water pumping applications making a note of the previously quoted faults of DC engines. According to the power electronics perspective, the DC-DC converters are utilized to help the resulting voltage of the PV panel, and Maximum Power Point Tracking (MPPT) for the solar PV array is additionally utilized to extricate the most significant power from the solar panels [3].

The viability of Fuzzy Direct Torque Control (FDTC), which gives high efficiency based on the Fuzzy Speed Controller (FSC) with the Conventional Direct Torque Control (CDTC) in terms of pumped water, reduction in flux and torque ripple, diminution of losses, and decrease in the stator current harmonic, the DC-DC boost-buck converters with a boost controlled by an MPPT algorithm is used to pull out the maximum power from the PV panel array.

Most of the world's water pumping depends on conservative energy created by diesel engines. Solar Water Pumping System (SWPS) lessens the requirement for electricity generated by coal, gas, or diesel. The utilization of diesel or propane-controlled water pumping systems brings about the requirement for expensive power, as well as noise and air contamination. An SWPS has 2-4 times the forthright expense, working and default costs, and reserve expenses of a diesel pump. SWPS are environmentally favorable, have negligible maintenance, and are free of fuel [5].

Many patterns in the innovation of pumps are persistently advancing. Numerous Original Equipment Manufacturer (OEMs) are exploring and fostering Computational Fluid Dynamics (CFD) and Computer-Aided Design (CAD)/ Computer Aided Manufacturing (CAM) coordination to make new high-effectiveness pump designs. Comparing traditional pump selection methods, these design plans produce the highest-efficiency solutions for various applications. Incorporating Variable Frequency Drives (VFDs) for better operational power management will give energy investment funds, a decline in maintenance cost, and expanded uptime. This coordination of these strategies is vital for next-generation centrifugal pumps.

The restrictions were examined in each period of the system design, including the PV board design, battery re-energize process, the drive of the IGBT transistor, the option of the center tap transformer, and inverter effectiveness. The simulated PV array exhibits the impacts of temperature and irradiance upon the generated power of the PV array. The stand-alone PV pumping system aims to effectively implement the inverter by having low harmonic items present in the inverter so that no additional filters are required, subsequently diminishing the expense of such an inverter. One more objective of such an implementation is the minimal expense of development and switching frequency selection, so switching losses stay small. From the results, raising the switching frequency did not bring about a lower Total Harmonic Distortion (THD) worth of the output current waveform.

The Maximum Power Point Tracker streamlines volume of power acquired from the photovoltaic array used to charge the devices which consume electrical power. MPPT works the Photovoltaic modules that license them to create all the power they can do. MPPT is undoubtedly non robotic global positioning system that "genuinely moves" the modules to make them point more straightforwardly at the sun. MPPT is an entirely electronic system that differs the operating point of the modules so the modules can distribute maximum power. Traditional MPPT methods are hill climbing, perturbation and observation, and incremental conductance methods, while intelligent control algorithms are fuzzy-logic, artificial neural networks, flower pollination algorithms, and particle swarm optimization. The Perturb and Observe (P&O) Maximum Power Point Tracking (MPPT) algorithm in solar Photovoltaic (PV) is famously attributable to its effortlessness. Major setbacks in the P&O algorithm are operating point divergence and the trade-off between fast convergence and balanced state oscillations decelerating the usage [7].

Incremental Conductance Algorithm (ICA) improves the steady-state error, sudden acknowledgment to variable solar radiation, concurrence velocity. This process is used because it combines speed and accuracy. This is achieved by deriving the relationship P×V concerning voltage or current. Maximum Power Point (MPP) [8] can be computed using the dp/dv and -i/v relationship. This produces an accurate and is fast in tracking MPP reducing oscillation in various changing atmospheric conditions.

The lineup of the paper evolves: Chapter 2 presents system description, chapter 3 depicts the working of modified zeta converter, chapter 4 explains the design of proposed system, chapter 5 describes results and discussion, and chapter 5 concludes the paper.

II. SYSTEM DESCRIPTION

The solar energy conversion system has many advantages compared to other renewable energy power conversion systems like wind energy power conversion systems, fuel cell-based power generation, and ocean thermal energy conversion systems. In this proposed system solar panel is the source, Brushless DC Motor (BLDC) yoked with a Centrifugal pump

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is selected as the load, and a modified Zeta converter [9]-[10] is used as a power electronic interfacing unit. An ICA is infused to the system to enhance the gross tracking efficiency of solar panels. The general block diagram of the proposed system is shown in fig.1

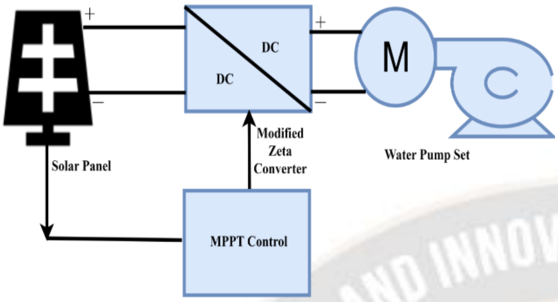

Fig. 1. Block diagram of proposed system

A solar panel output power depends upon solar irradiation, geographical location, and temperature. In general output voltage of solar is consistently low due to the variation of environmental parameters. Due to this fact, the load requirement cannot be satisfied using a panel without an auxiliary circuit. Therefore, Power Electronic Interfacing (PEI) is necessary to convert unregulated power into regulated power. That means power conditioning will be done using power electronic interlinking devices like dc-dc converters, inverters, AC voltage controllers. In this context, a BLDC motor chained with a centrifugal pump is selected as a load that is operated with dc power. In this regard, an efficient dc-dc converter is necessary for the recommended solar pumping system. So a modified zeta converter is selected as a power electronic interfacing unit that can operate efficiently without compromising voltage gain and isolation. In the proposed system, the modified Zeta converter works in continuous conduction mode. The proposed work application is in rural villages for agricultural irrigation purposes. An ICA generates PWM pulses to operate the dc-dc converter at its maximum power point. A BLDC motor, known as an electronically commutating motor, receives power from a modified zeta converter, and the motor operates at its constant speed. The BLDC motor speed depends on the voltage available across the modified zeta boost converter, which will depend upon the operation of the MPPT control. BLDC motor is coupled with a centrifugal pump, which is a non-positive displacement pump. The entire system can be installed in a rural area where the traditional grid is not admissible.

III. MODES OF OPERATION OF MODIFIED ZETA CONVERTER

The modified zeta converter is a non-isolating type dc-dc converter, a family of the buck-boost converter. The modified zeta converter is derived from the Single Ended Primary Inductor Converter (SEPIC) [11]. Proposed topology gives output voltage with reference to the input, unlike the cuk converter. Moreover, the operation modes depending on the duty ratio value. If the duty ratio of the proposed converter is above 50%, converter works in boost mode; else, the converter works in buck mode. Compared to the conventional dc-dc converter [12], the modified zeta converter has the following advantages: less switching stress, non-pulsating output current, isolation, and high adaptability. In water pumping applications, the isolation of input and output is desirable. In the case of a modified zeta converter, a power electronic switch helps to maintain the isolation. The switch for the modified zeta converter has a high power rating. The design of the modified zeta converter is shown in fig. 2. The modified zeta converter consists of two coupled inductors, one coupling capacitor, one input and output capacitor, and power MOSFET.

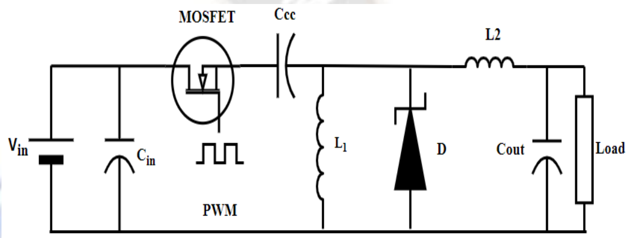

Fig. 2: Circuit diagram of modified zeta converter

Modified zeta converter can be deployed based on following modes: continuous conduction mode and discontinuous conduction mode. In this study, the proposed converter is operated in continuous conduction mode because of the load used in the system is water pump [13]-[14]. To operate the motor pump set, continuous conduction mode is desirable. In the case of continuous conduction mode, the inductor current never falls to zero value. In this mode of operation, the inductor charges partially before the operation. The continuous conduction mode ensures the complete utilization of passive components and the best utilization power switch. The continuous conduction mode is segmented into modes one and two, respectively. In the case of mode one operation, power MOSFET is in off condition and the provided inductor is charged partially.

To realize the voltages at various circuit junctions, the essential way is to observe the circuit at DC when there is no existence of power. The coupling Capacitor (C_C) is connected in shunt with the output capacitor C_{out} so that C_C charges to the output voltage V_{out} during steady-state continuous conduction mode. The fig.3 shows the voltage between L_1 and L_2 during continuous conduction mode operation. When the power switch is off condition, L_2 is in parallel with C_{out}, so the voltage through L_2 must be V_{out}. Since C_{out} is charging to V_{out},

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the voltage across the power switch is the sum of V_{in} and V_{out} when the power switch is off.

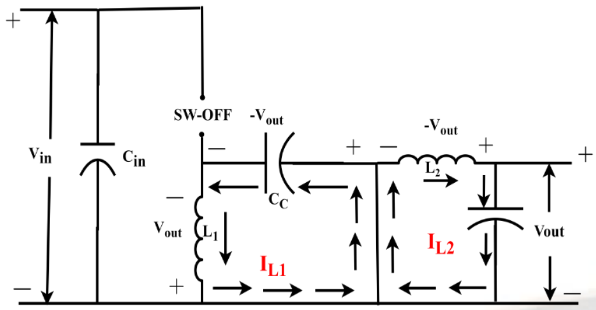

Fig.3: Mode-1 operation of modified zeta converter

Therefore, the voltage through L_1 is $-V_{out}$ concerning the drain of the power switch. When the power switch is on, the C_C charged to V_{out} is in series with L_2. Therefore, the voltage across L_2 is $+V_{in}$, and diode D_1 is the sum of V_{in} and V_{out}. The current flow during the first mode of operation is shown in fig. 3.

The mode-2 operation is depicted in fig.4. When the power switch is on, energy from the input source is stocked in L_1, L_2, and C_C. Similarly, L_1 also provides I_{OUT}. On the point the power switch turns off, the current through L_1 abides to flow from the current supplied by the coupling capacitor C_C, and L_1 powers to I_{OUT} again.

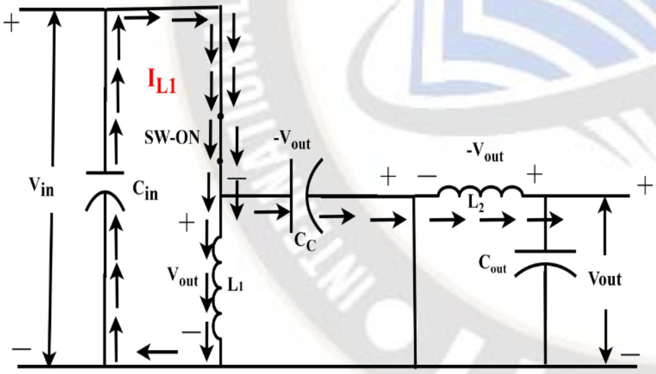

Fig. 4: Mode-2 operation of modified zeta converter

In the selected converter, the output becomes positive for the input, which is desirable for the solar water pumping system [15]-[18].

IV. DESIGN OF SOLAR WATER PUMPING SYSTEM

The optimum sizing of the system is essential. In the case of the solar based water pumping system, the design includes sizing of the solar panel, zeta converter design, and the water pump set design [19]-[25]. The design parameters are specified in table I.

Table I: System Parameters

Sl. No	Specifications	Rating
1	PV panel rating	325 W
2	Operating voltage	12 V
2	Output voltage	24 V
3	Power rating of the load	100 W
4	Switching frequency	100 kHz

4.1 Design of modified zeta converter

Initially rage of duty cycle is to be determined. The range of duty cycle is determined using (1) and (2)

$$D_{\max} = \frac{V_{out}}{V_{in(\min)} + V_{out}} \tag{1}$$

In (1), D_{max} denotes the highest value of duty ratio, V_{out} will be the required output voltage across the load, and $V_{in(min)}$ indicates the minimum voltage available from the solar panel. The minimum value of the duty ratio is given by

$$D_{\min} = \frac{V_{out}}{V_{in(\max)} + V_{out}} \tag{2}$$

In (2), $V_{in(max)}$ represents the maximum available voltage at the input terminals. The maximum value of input current is calculated using (3)

$$I_{in(\max)} = I_{out} \times \left(\frac{D_{\max}}{1 - D_{\max}} \right) \tag{3}$$

The selection of inductance is made based on the expression (4). The Large inductor ripples current increases the Electromagnetic Interference (EMI) Problem, and too little inductor ripple current result in the unstable operation of Pulse Width Modulation (PWM) [26], which will impact smooth switching operation.

$$\Delta I_{L(PP)} = K \times I_{in} \tag{4}$$

In (4), $\Delta I_{L(PP)}$ is denoted as inductor current ripple, I_{in} is evaluated as the input current, and K varies from 20% to 40%. The coupled inductors are estimated using (5)

$$L_1 = L_2 = \frac{V_{in} \times D}{2 \times \Delta I_{L(PP)} \times f_s} \tag{5}$$

In (5), the variable f_s is indicated as the switching frequency of power MOSFET. To ensure maximum efficiency, the L_1 and L_2 are divided using the factor of K_1. The value of K_1 is selected as 90%. The current through L_1 and L_2 is calculated using (6) and (7)

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$$I_{L1} = I_{out}\left[\frac{D}{1-D} + \frac{\Delta I_{L(PP)}}{2}\right]$$

(6)

$$I_{L2} = I_{out} + \frac{\Delta I_{L(PP)}}{2} \quad (7)$$

The output capacitor is designed using (8)

$$C_{out(\min)} = \frac{\Delta I_{L(PP)}}{8 \times \Delta V_{C_{out}(PP)} \times f_s} \quad (8)$$

Where $\Delta V_{C_{out}(PP)}$ is determined by considering the 2.5% of the output voltage. Similarly, the input capacitor (C_{in}) is calculated using (9)

$$C_{in} = \frac{D_{\max} \times I_{out}}{\Delta V_{C_{in}(PP)} \times f_s} \quad (9)$$

In (9) $\Delta V_{C_{in}(PP)}$ is calculated as 2% of the input voltage. The coupling capacitor connects input and output stage. The design equation of coupling capacitor is given in (10)

$$C_{cc} = \frac{D_{\max} \times I_{out}}{\Delta V_{C_c(PP)} \times f_s} \quad (10)$$

The output capacitor should holds a high RMS current when compared to the capacitor's RMS current rating. The RMS current of output capacitor is given by (11)

$$I_{C_{out(RMS)}} = \frac{\Delta I_{L2(PP)}}{\sqrt{3}} \quad (11)$$

The input capacitors which are coupling capacitors has source current and sink current at same level but on opposite switching cycles. Alike Buck Converters [27]-[28], both capacitor need the RMS current rating to be, The RMS value of input current is given by (12)

$$I_{C_{in(RMS)}} = I_{CC_{(RMS)}} = I_{out}\sqrt{\frac{V_{out}}{V_{in}}} \quad (12)$$

The power MOSFET's switch must be carefully selected to minimize power dissipation losses considering the peak voltage and currents. The current rating of power MOSFET will determine the ZETA converter's maximum output current. A 1Ω resistance is connected in series with the input capacitor to match the cell's internal resistance and impedance. To verify the design, the 12V DC supply provides the input to the converter. A 100 kHz, 66% duty cycle PWM is applied to the MOSFET's Gate terminal. The maximum voltage that can withstand the switch and current through the switch is calculated using (13) and (14), respectively.

$$V_{SW} = V_{out} + V_{in\,(\max)} \quad (13)$$

$$I_{SW} = I_{L1} + I_{L2} \quad (14)$$

The diode at the output is designed to tackle the peak point current as SW i.e., I_{SW}. The diode should have the ability to withstand a reverse voltage which is greater than SW's maximum voltage because in order to account for transient and rising. Using equation (1)-(14), the parameters design values of the modified zeta converter are estimated as shown in table II.

Table II. Design parameters of modified zeta converter

Sl. No	Specification	Quantity
1	Maximum Duty Cycle ($D_{\max}$)	0.66
2	Minimum Duty Cycle (D_{min})	0.57
3	Maximum Input Current ($I_{in(max)}$)	4.31 A
4	Peak to Peak Ripple Current $atV_{in(max)}$, ($\Delta I_{L(PP)}$)	1.23 A
5	Peak to Peak Ripple Current at $V_{in(min)}$, ($\Delta I_{L(PP)}$)	0.52 A
6	RMS Current Value of Output Capacitor ($I_{out(rms)}$)	0.77 A
7	RMS Current Value of Input and Coupling Capacitor ($I_{in(rms)}$)	2.82 A
8	Inductors (L_1 and L_1)	75 μH
9	Input Capacitor (C_{in})	15 μF
10	Output Capacitor (C_{out})	3.3 μF
11	Coupling Capacitor C_{cc}	33 μF
12	Maximum Voltage across Diode V_{D1}	42 V
13	Maximum Voltage across MOSFET V_{SW}	42 V

The design of the solar water pump is explained below: The centrifugal pump is selected for the solar water pumping system [29]-[30] due to the following advantages such as high volume of water discharge, very less floor space requirements, silent operation compared to reciprocating pumps, lightweight and low cost. Assume that there is a requirement of 10,000 liters per day from a depth of 3 meters. One cubic meter is a thousand liters of water; therefore 10,000 liters = 10 m^3. Considering 5.3 peak hours with insolation of 5.3 kWh/ m^2/day. The required peak flow rate is calculated using (15)

$$Flow\,rate = \frac{Daily\,water\,requirement}{Peak\,sun\,hours} \quad (15)$$

The calculated value of the flow rate is 1.88 m^3/hour. The discharge is usually expressed in terms of gallons per hour. So

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the discharge (flow rate) in gallons per hour is 496.64 gallons/hour. The selection of the head is essential for water pumping. The total vertical head is the sum of vertical discharge and drawdown. Therefore, total vertical head is determined as 4 m. The frictional head is calculated using (16)

$$Friction\,head = \frac{FLV^2}{2gD} \tag{16}$$

In (16), F is denoted as the friction factor, L is the pipe's total length, V represent the velocity of the water in m/s, g is the acceleration due to gravity in m/s^2 , D is the diameter of the pipe which is considered as 0.02 m. The friction factor depends on the type of pipe used. The PVC pipe is used in this system. The friction factor of the PVC pipe is considered 0.08. The Total Dynamic Head (TDH) is the summation of the vertical head and friction head. The pump efficiency is calculated using (17)

$$Pump\,efficiency, \eta_p = \frac{TDH \times Q \times FC}{P_e} \tag{17}$$

In (17), TDH is the total dynamic head, Q is the flow rate, FC being conversion factor, and P_e is the electrical power input to the motor. The required running hours per day of the pumping system are calculated using (18)

$$Required\,running\,hours\,per\,day = \frac{Amount\,of\,\,water\,\,pumped\,\,per\,day}{Maximum\,\,flow\,rate\,of\,\,dc\,\,pump} \tag{18}$$

The required electrical energy per day is the product of power consumption and running hours per day. The designed dimensions of the water pump are presented in table III.

Table III. Designed parameters of solar water pump

Sl. No	Parameters	Designed values
1	Total Dynamic Head	5.4 m
2	Vertical Discharge	3 m
3	Drawdown	1 m
4	Total Pipe Length	4.1 m
5	Diameter of Pipe	20 mm
6	Daily Water Requirement	10,000 litres/day
7	Efficiency	62.74%

V. RESULTS & DISCUSSION

Initially, the solar data of Bengaluru North region, India is analysed during the year 2021-22. The viability of solar water pumping is verified using the solar data of Bengaluru North region, India. The latitude and the longitude of the region where the solar water pumping system is going to implement are exactly at latitude 13.073 and longitude 77.532. The important external factors affecting the performance of SPV system are temperature and irradiance [31]-[32]. Those factors are directly impacted on the performance of SPV Panel. The solar irradiance is directly proportional to output power of an SPV panel, where the panel temperature is inversely proportional to the panel voltage. In this regard, the solar data of Bengaluru North, India is collected and illustrated in Table IV and V respectively.

Table IV. Monthly Average temperature

Month	2021
January	21.2
February	23.6
March	26.4
April	28.8
May	26
June	22.7
July	22.2
August	22.5
September	22.3
October	23.2
November	22.7
December	19.7

Table V. Diffuse/global ratio

Month	2021
January	0.3
February	0.25
March	0.26
April	0.26
May	0.35
June	0.57
July	0.59
August	0.54
September	0.57
October	0.33
November	0.31
December	0.33

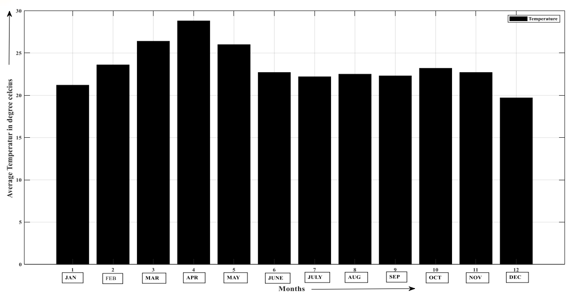

Fig. 5. Average temperature during different month

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From the fig. 5 it is observed that during the month of April the solar irradiance is on the higher side compared to all other months. On average it can depicted that in the month of March, April and May the irradiance will be high.

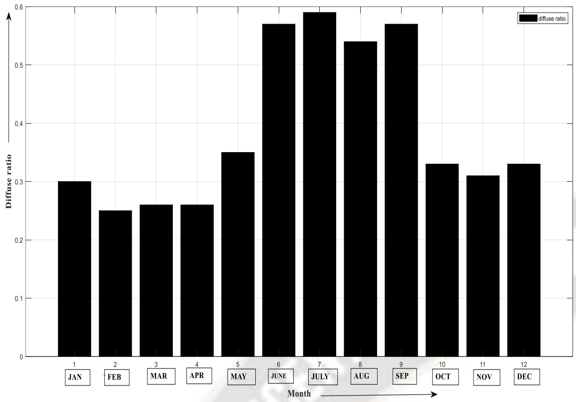

Fig. 6. Diffuse ratio during different month

From the above fig. 6 the diffuse ratio at different month varies and found to be high in the month of July and on an average at the months of June, July and September the ratio is higher. The average temperature comparing all months is around 23^0C and the average count of diffuse ration is around 0.4

Hence, Implementation of solar water pumping system is viable in Bangalore north region. The MATLAB simulation of modified zeta converter based solar water pumping system is developed. The Simulink model is depicted in fig. 7.

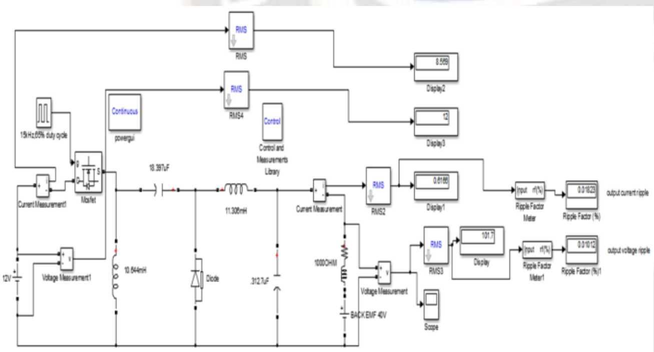

Fig. 7. MATLAB/Simulink model of modified zeta converter based solar water pumping system.

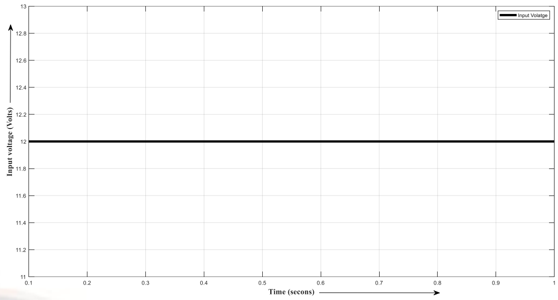

Fig. 8. Input voltage vs simulation time

With Fig. 7 the design of solar pump system is integrated with zeta converter producing good performance output. The output from Fig. 8 interprets that the input voltage remains constant with simulation times and no ripples is found.

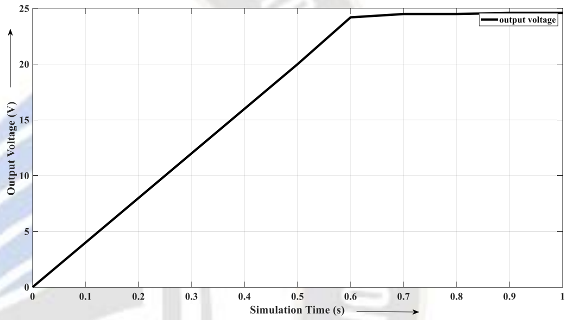

Fig. 9. Output voltage vs simulation time

From the output waveform depicted in Fig.9 it linearly increases with time. It can be observed that the output reaches to a maximum point and is tracked by MPPT algorithm and remains stable to give highly efficient output with no ripples.

Table VI: Analysis of various converters

Converter	V_i (V)	I_i (A)	V_o (V)	I_o (A)	P_i (W)	P_o (W)	Efficiency (%)	Gain	O/P current ripple	O/P Voltage ripple
Conventional Buck-Boost Converter	12	0.55	48.6	0.08	6.61	4.21	63.75	4.05	0.014	0.002
Two stage cascaded boost converter(interleaved)	12	5.72	93.6	0.53	68.64	50.13	73.03	7.825	0.097	0.046
SEPIC Converter	12	0.35	46.9	0.06	4.22	3.25	77.01	3.91	0.03	0.053
Landsman Converter	12	1.18	21.1	0.61	14.17	12.94	91.30	1.76	0.008	0.025
LUO Converter	12	1.46	21.1	0.61	17.55	12.93	73.67	1.76	0.016	0.047
Modified Zeta	**12**	**8.57**	**101**	**0.93**	**102.55**	**93.93**	**91.33**	**8.48**	**0.018**	**0.010**

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Converter										
CUK Converter	12	1.18	21.1	0.61	14.16	12.93	91.31	1.76	0.02	0.08
CUK-SEPIC hybrid	12	1.165	20.3	0.60	13.98	12.28	87.83	1.695	0.02	0.067

A detailed comparative analysis of various dc-dc converters used in solar water pumping applications is carried out using MATLAB/Simulink environment. The input parameters are maintained identically for all the dc-dc converters. The simulation is carried out for 5 s, and output parameters such as voltage across the dc motor pump, gain and efficiency are determined. Table VI summarizes the comparative analysis of various dc-dc converters for solar water pumping applications. It is observed that the modified zeta converter performs well compared to the conventional dc-dc converters with respect to the power conversion efficiency and the voltage gain (step-up ratio).

VI. CONCLUSION

A solar panel fed with modified Zeta converter has been proposed to drive the application system. The framed system has been designed, demonstrated, and simulated utilizing MATLAB with Simulink and SimPowerSystems framework toolbox. The simulated results give a clear picture of efficiency of the application that withstands minor variation in the atmospheric condition and losses. With best utilization power switch modified zeta converter has proved its performance for solar pumping system application. Additional features projected by the proposed system might include high power rating of switch and the output which depends on duty ratio value. The framed system is extremely helpful for other low power applications. PV based charging system can be developed for small electric vehicles. The modified zeta converter shows an overall performance efficiency of 91.33 % with a voltage gain of 8.48. So the modified zeta converter can maintain high efficiency without compromising its voltage gain. Also, found that the performance parameters of the modified zeta converter are superior as compared to the conventional dc-dc converters. The performance of the system can be upgraded still by removing the ripples at the output. Finally with the use of MPPT algorithm with zeta converter the results are concluded that it works with minimum solar radiance and produce ripple less output. It is concluded that a modified Zeta converter is one of the important elements of a solar water pumping system.

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