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# BLDC Motor Driven Solar PV Array Fed Water Pumping System Employing Zeta Converter

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#### **ABSTRACT:**

This paper proposes a simple, cost effective and efficient brushless DC (BLDC) motor drive for solar photovoltaic (SPV) array fed water pumping system. A zeta converter is utilized in order to extract the maximum available power from the SPV array. The proposed control algorithm eliminates phase current sensors and adapts a fundamental frequency switching of the voltage source inverter (VSI), thus avoiding the power losses due to high frequency switching. No additional control or circuitry is used for speed control of the BLDC motor. The speed is controlled through a variable DC link voltage of VSI. An appropriate control of zeta converter through the incremental conductance maximum power point tracking (INC-MPPT) algorithm offers soft starting of the BLDC motor. The proposed water pumping system is designed and modeled such that the performance is not affected under dynamic conditions.

To be able to develop a complete solar photovoltaic power electronic conversion system in simulation, it is necessary to define a circuit- based simulation model for a PV cell in order to allow the interaction between a proposed converter (with its associated control arrangement) and the PV array to be studied. To do this it is necessary to approach the modelling process from the perspective of power electronics; that is to define the desired overall model in terms of the manner in which the electrical behaviour of the cell changes with respect to the environmental parameters of temperature and irradiance. M.Sai Ganesh M.E (PSA) HOD, Department of EEE, Baba Institute of Technology and Sciences, Visakhapatnam - 530 048.

The authors cover the development of a general model which can be implemented on simulation platforms such as PSPICE or SABER and is designed to be of use to power electronics specialists. The model accepts irradiance and temperature as variable parameters and outputs the I/V characteristic for that particular cell for the above conditions.

#### **INTRODUCTION:**

The drastic reduction in the cost of power electronic devices and annihilation of fossil fuels in near future invite to use the solar photovoltaic (SPV) generated electrical energy for various applications as far as possible. The water pumping, a standalone application of the SPV array generated electricity is receiving wide attention now a days for irrigation in the fields, household applications and industrial use. Although several researches have been carried out in an area of SPV array fed water pumping, combining various DC-DC converters and motor drives, the zeta converter in association with a permanent magnet brushless DC (BLDC) motor is not explored precisely so far to develop such kind of system. However, the zeta converter has been used in some other SPV based applications. Moreover, a topology of SPV array fed BLDC motor driven water pump with zeta converter has been reported and its significance has been presented more or less in. Nonetheless, experimental validation is missing and the absence of extensive literature review and comparison with the existing topologies, have concealed the technical contribution and originality of the reported work. The merits of both BLDC motor and zeta converter can contribute to develop a SPV array fed water pumping



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system possessing a potential of operating satisfactorily under dynamically changing atmospheric conditions. The BLDC motor has high reliability, high efficiency, high torque/inertia ratio, improved cooling, low radio frequency interference and noise and requires practically no maintenance. On the other hand, a zeta converter exhibits following advantages over the conventional buck, boost, buck-boost converters and Cuk converter when employed in SPV based applications.

- Belonging to a family of buck-boost converters, the zeta converter may be operated either to increase or to decrease the output voltage. This property offers a boundless region for maximum power point tracking (MPPT) of a SPV array [7]. The MPPT can be performed with simple buck [8] and boost [9] converter if MPP occurs within prescribed limits.
- This property also facilitates the soft starting of BLDC motor unlike a boost converter which habitually steps up the voltage level at its output, not ensuring soft starting.
- Unlike a classical buck-boost converter [10], the zeta converter has a continuous output current. The output inductor makes the current continuous and ripple free.
- Although consisting of same number of components as a Cuk converter [11], the zeta converter operates as non-inverting buck-boost converter unlike an inverting buck-boost and Cuk converter. This property obviates a requirement of associated circuits for negative voltage sensing hence reduces the complexity and probability of slow down the system response [12].

These merits of the zeta converter are favorable for proposed SPV array fed water pumping system. An incremental conductance (INC) MPPT algorithm [8, 13-18] is used to operate the zeta converter such that SPV array always operates at its MPP. The existing literature exploring SPV array based BLDC motor driven water pump [19-22] is based on a configuration shown in Fig. 1. A DC-DC converter is used for MPPT of a SPV array as usual. Two phase currents are sensed along with Hall signals feedback for control of BLDC motor, resulting in an increased cost. The additional control scheme causes increased cost and complexity, which is required to control the speed of BLDC motor. Moreover, usually a voltage source inverter (VSI) is operated with high frequency PWM pulses, resulting in an increased switching loss and hence the reduced efficiency. However, a Z-source inverter (ZSI) replaces DC-DC converter in [22], other schematic of Fig. 1 remaining unchanged, promising high efficiency and low cost. Contrary to it, ZSI also necessitates phase current and DC link voltage sensing resulting in the complex control and increased cost.



Fig. 1 Conventional SPV fed BLDC motor driven water pumping system

### Fig.1.1 Conventional SPV fed BLDC motor driven water pumping system [21].

To overcome these problems and drawbacks, a simple, cost-effective and efficient water pumping system based on SPV array fed BLDC motor is proposed, by modifying the existing topology (Fig. 1) to as shown in Fig. 2. A zeta converter is utilized in order to extract the maximum power available from a SPV array, soft starting and speed control of BLDC motor coupled to a water pump. Due to a single switch, this converter has very good efficiency and offers boundless region for MPPT. This converter is operated in continuous conduction mode (CCM) resulting in a reduced stress of its power devices and components. Furthermore, the switching loss of VSI is reduced by adopting fundamental frequency switching resulting in an additional power saving and hence an enhanced efficiency. The phase currents as well as the DC link voltage sensors are completely eliminated, offering simple and economical system without scarifying its performance.



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The speed of BLDC motor is controlled, without any additional control, through a variable DC link voltage of VSI. Moreover, a soft starting of BLDC motor is achieved by proper initialization of MPPT algorithm of SPV array. These features offer an increased simplicity of proposed system.



Fig. 2 Proposed SPV-Zeta converter fed BLDC motor drive for water pump.

The advantages and desirable functions of zeta converter and BLDC motor drive contribute to develop a simple, efficient, cost-effective and reliable water pumping system based on solar PV energy. Simulation results using MATLAB/Simulink and experimental performances are examined to demonstrate he starting, dynamics and steady state behavior of proposed water pumping system subjected to practical operating conditions. The SPV array and BLDC motor are designed such that proposed system always exhibits good performance regardless of solar irradiance level.

#### **1.2. CONFIGURATION OF PROPOSED** SYSTEM:

The structure of proposed SPV array fed BLDC motor driven water pumping system employing a zeta converter is shown in Fig. 2. The proposed system consists of (left to right) a SPV array, a zeta converter, a VSI, a BLDC motor and a water pump. The BLDC motor has an inbuilt encoder. The pulse generator is used to operate the zeta converter. A step by step operation of proposed system is elaborated in the following section in detail.

#### **1.3. OPERATION OF PROPOSED SYSTEM:**

The SPV array generates the electrical power demanded the motor-pump.

This electrical power is fed to the motor-pump via a zeta converter and a VSI. The SPV array appears as a power source for the zeta converter as shown in Fig. 2. Ideally, the same amount of power is transferred at the output of zeta converter which appears as an input source for the VSI. In practice, due to the various losses associated with a DC-DC converter [23], slightly less amount of power is transferred to feed the VSI. The pulse generator generates, through INC-MPPT algorithm, switching pulses for IGBT (Insulated Gate Bipolar Transistor) switch of the zeta converter. The INC-MPPT algorithm uses voltage and current as feedback from SPV array and generates an optimum value of duty cycle. Further, it generates actual switching pulse by comparing the duty cycle with a high frequency carrier wave. In this way, the maximum power extraction and hence the efficiency The VS, converting DC output from a zeta converter into AC, feeds the BLDC motor to drive a water pump coupled to its shaft. The VSI is operated in fundamental frequency switching through an electronic commutation of BLDC motor assisted by its built-in encoder. The high frequency switching losses are thereby eliminated, contributing in an increased efficiency of proposed water pumping system.

#### **EXISTING SYSTEM:**

The PV inverters dedicated to the small PV plants must be characterized by a large range for the input voltage in order to accept different configurations of the PV field. This capability is assured by adopting inverters based on a double stage architecture where the first stage, which usually is a dc/dc converter, can be used to adapt the PV array voltage in order to meet the requirements of the dc/ac second stage, which is used to supply an ac load or to inject the produced power into the grid. This configuration is effective also in terms of controllability because the first stage can be devoted to track the maximum power from the PV array, while the second stage is used to produce ac current with low Total Harmonic Distortion (THD).



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### fig 1.3 existing system of spv array fed water pumping system

#### **DRAWBACKS:**

- There is no dynamic response.
- High Total harmonic Distortion (THD).

#### **PROPOSED SYSTEM:**

Proposed SPV array fed water pumping system with an incremental conductance (INC) MPPT algorithm is used to operate the zeta converter such that the SPV array always operates at its MPP and the BLDC motor experience a reduced current at the starting. A three phase voltage source inverter (VSI) is operated by fundamental frequency switching for the electronic commutation of BLDC motor. Simulation results using MATLAB/Simulink software is examined demonstrate the starting, dynamics and steady state behavior of the proposed water pumping system subjected to the random variation in the solar irradiance. The SPV array is designed such that the proposed system always exhibits satisfactory performance regardless of the solar irradiance level or its variation.



fig 1.4 proposed system of spv array fed water pumping system

#### **ADVANTAGES:**

- Belonging to the family of buck-boost converters, the zeta converter can be operated either to increase or to decrease the output voltage.
- The aforementioned property also facilitates the soft starting of the BLDC motor unlike a boost converter which habitually step-up the voltage level at its output, not ensuring the soft starting.
- Unlike a simple buck-boost converter, the zeta converter has a continuous output current. The output inductor makes the current continuous and ripples free.
- reduces the complexity and probability of slow down the system response

#### **APPLICATIONS:**

- Household applications and industrial usage.
- Solar photovoltaic (spv) generated electrical energy applications

#### **BLOCK DIAGRAM:**



#### Fig 1.5 block diagram of proposed system

#### **1.4 PHOTO VOLTAIC SYSTEM:**

Photovoltaic systems research seems largely to be divided into two, fairly distinct areas; namely array physics, design and optimisation, and solar power con-



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version systems. This paper is not concerned with the design of the arrays but rather with development of a model of an array that is useful for power electronics applications. Better, more efficient converter systems may be developed by matching the control and drive requirements of the converter system to the characteristics of the array. Alternative energy specialists often appear not to have sutlicient expertise in power electronics to be ahle to develop advanced converter systems, which can match the input characteristic of the power electronic system to those of the array, in order to make best use of the array. Examples of such nonoptimal systems can be found in the field of solar array/battery combinations for stand-alone use [2--4] and in the area of utility interactive systems [5-8, 3].

A number of powerful component-based electronics simulation systems, such as SPICE and SABER, have become available over recent years, and such systems are often used during the development of power-electronics systems. In their basic form they do not provide a circuit model, or a component model, of the solar array itself, and thus are ditlicult to integrate with current electronics simulation technology used in the generic modelling of PV power electronic systems at a circuit level.

#### **1.5 BLDC MOTOR:**

The use of permanent magnets (PMs) in electrical machines in place of electromagnetic excitation results in many advantages such as no excitation losses, simplified construction, improved efficiency, fast dynamic performance, and high torque or power per unit volume . The PM excitation in electrical machines was used for the first time in the early 19<sup>th</sup> century, but was not adopted due to the poor quality of PM materials. In 1932, the invention of Alnico revived the use of PM excitation systems, however it has been small and fractional horse power dc limited to commutator machines. The popularity of PMBL motors are increasing day by day due to the availability of high energy density and cost effective rare earth PM materials like Samarium Cobalt (Sm-Co) and Nd-Fe-B which enhance the performance of PMBLDCM drives and reduce the size and losses in these motors. The advancements in geometries and design innovations have made possible the use of PMBL motors in many of domestic, commercial and industrial applications. PMBL machines are best suited for position control and medium sized industrial drives due to their excellent dynamic capability, reduced losses and high torque/weight ratio. PMBL motors find applications in diverse fields such as domestic appliances, automobiles, transportation, aerospace equipment, power tools, toys, vision and sound equipment and healthcare equipment ranging from microwatt to megawatts. Advanced control algorithms and ultra fast processors have made PMBLDC motors suitable for position control in machine tools, robotics and high precision servos, speed control and torque control in various industrial drives and process control applications. With the advancement in power electronics it is possible to design PMBL generators for power generation onboard ships, aircraft, hybrid electric cars and buses while providing reduced generator weight, size and a high payload capacity for the complete vehicle.

#### **1.5.1 CLASSIFICATION OF BLDC MOTOR:**

BLDC motors are classified into two sub categories. The first category uses continuous rotor-position feed back for supplying sinusoidal voltages and currents to the motor. The ideal motional EMF is sinusoidal, so that the interaction with sinusoidal currents produces constant torque with very low torque ripple. This called a Permanent Magnet Synchronous Motor (PMSM) drives, and is also called a PM AC drive, brushless AC drive, PM sinusoidal fed drive, sinusoidal brushless DC drive, etc. The second category of PMBL motor drives is known as the brushless DC (BLDC) motor drive and it is also called a trapezoidal brushless DC drive, or rectangular fed drive. It is supplied by threephase rectangular current blocks of 120° duration, in which the ideal motional EMF is trapezoidal, with the constant part of the waveform timed to coincide with the intervals of constant phase current.



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These machines need rotor-position information only at the commutation points, e.g., every 60° electrical in three-phase motors. The PMBLDC motor has its losses mainly in the statordue to its construction; hence the heat can easily be dissipated into the EMF atmosphere. As the back is directly proportional to the motor speed and the developed torque is almost directly proportional to the phase current, the torque can be maintained constant by a stable stator current in a PMBLDC motor. The average torque produced is high with fewer ripples in PMBLDC motors as compared to PMSM. Amongst two types of PMBL motors, PMSM is, therefore, preferred for applications where accuracy is desired e.g. robotics, numerical controlled machines, solar tracking etc. However, the PMBLDCM can be used in general and low cost applications. These motors are preferred for numerous applications, due to their features of high efficiency, silent operation, compact in size and low maintenance.

#### **1.5.3 Application Potential of PMBLDC Motors:**

Classic electric motors are mostly preferred for motion control, in general and household appliances, in particular. The most common motors for household appliances are single phase AC induction motors, including split phase, capacitor start, capacitor run types and universal motors. These motors operate at constant speed directly from AC mains irrespective of efficiency; however. consumers now demand appliances with low energy consumption, improved performance, reduced acoustic noise, and many more convenience features. Therefore, household appliances are expected to be one of largest end product market for PMBLDC motors over the next few years. The major household appliances include fans, blowers, washing machines, room air-conditioners, refrigerators, vacuum cleaners, food processors, etc. The possibilities of cost reduction have to be explored to commercialize PMBLDCM drives, apart from technological advancements. The cost of a PMBLDCM drive has two main components; one is motor and other is the controller.

Extensive research attempts have been made to reduce the cost and increase the efficiency of the motor. Comparative analysis has also been presented in the literature for the choice of the motor to suit a particular application.

### Power Quality Improvements In A Zeta Converter

This implemented concept deals with a reduced sensor configuration of a power factor correction (PFC) based zeta converter for brushless DC (BLDC) motor drive for low power applications. The speed of the BLDC motor is controlled by varying the dclink voltage of the voltage source inverter (VSI) feeding BLDC motor drive. A low-frequency switching of the VSI is used for achieving the electronic commutation of BLDC motor for reduced switching losses. The PFC-based zeta converter is designed to operate in discontinuous inductor current mode; thus utilising a voltage follower approach which requires a single voltage sensor for dc-link voltage control and PFC operation. The proposed drive is designed to operate over a wide range of speed control with improved power quality at ac mains.

The performance of the proposed drive is validated with experimental results obtained on a developed prototype of PFC converter. Brushless DC (BLDC) motor is an ideal motor for low and medium power applications because of its high efficiency, high energy density, high torque/inertia ratio, low maintenance requirement and a wide range of speed control. It is a three phase synchronous motor with three phase windings on the stator and permanent magnets on the rotor. It is also known as electronically commutated motor as there are no mechanical brushes and commutator assembly, rather an electronic commutation based on rotor position sensed by Hall-Effect position sensor is used. It finds applications in a wide range of household appliances, industrial tools, heating, ventilation and air conditioning and many others.



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The requirement of improved power quality at ac mains is becoming essential and increasingly important. A limit on the allowable harmonic current drawn from ac mains is imposed by international power quality standard which in-turn limits the total harmonic distortion (THD) of supply current and power factor (PF) at ac mains. Hence, this recommends the use of improved power quality converters for achieving a unity PF (UPF) at ac mains with limited amount of harmonic distortion in the supply current. In a conventional scheme of diode bridge rectifier (DBR) with high value of dclink capacitor fed BLDC motor drive, a high amount of harmonics current is drawn at ac mains. This combination draws peaky current and leads to a very highly distorted supply current and very low PF at ac main. Fig. 1a shows the conventional DBR fed BLDC motor drive and Figs. 1b-d show the measured power quality indices for this conventional DBR fed BLDC motor drive.

very high THD of supply current, that is, А 65.9% and a very low PF, that is, 0.72 is achieved at ac mains, which is not under the acceptable limits. Many single phase power factor correction (PFC) converters are reported in the literature for feeding the BLDC motor drive. Two-stage PFC converters have been in wide practice which use two different converters for PFC and dc-link voltage control. Generally, a boost converter is used of first stage for PFC followed by a second stage which depends on the type of application and voltage level required for that particular application. It requires higher number of components and thus has higher losses associated with it. Moreover, two different controllers for PFC and dc-dc conversion stage are required, which increase the system cost and complexity. Single-stage PFC converters, as the name suggests, require a single converter for performing both tasks of voltage control as well as PFC operation. The most conventional scheme of feeding the BLDC motor is by using a PFC boost converter.

A constant dc-link voltage is maintained at the dc-link capacitor of the voltage source inverter (VSI) feeding the BLDC motor. The speed control is achieved by using the pulse width modulation (PWM)-based switching of VSI, which has high switching losses corresponding to the PWM switching frequency. A concept of variable dc-link voltage for speed control of BLDC motor has been proposed in. This allows the operation of VSI in fundamental frequency switching for achieving an electronic commutation of BLDC motor. Based on this concept, a PFC-based single ended primary inductance converter fed BLDC motor drive has been proposed in . However, this scheme utilises a higher number of sensors for controlling the stator current of the



Fig. 3.1 Measured power quality indices for conventional DBR fed BLDC motor drive

A Conventional DBR fed BLDC motor drive b–d Measured power quality indices at ac mains of a conventional DBR fed BLDC motor drive BLDC motor. Hence, this type of scheme finds application in higher end drives for precise speed control and is not suitable for low power, low cost household type appliances. Moreover, sensor reduction in a PFCbased BLDC motor drive is required for reducing the cost of complete drive.



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PFC The converter be designed can to operate in continuous inductor current mode or discontinuous inductor current mode (CICM) (DICM) operation. The PFC converter operating in CICM using a current multiplier approach requires sensing of dc-link voltage (V<sub>dc</sub>), supply voltage (v<sub>s</sub>) and input current (i<sub>in</sub>). An inherent PFC is achieved in PFC converter operating in DICM using a voltage follower approach; and it requires sensing of dc-link voltage (V<sub>dc</sub>), hence requiring a single voltage sensor. Proper selection of a PFC converter is required for achieving a wide range of speed control of BLDC motor by varying the dc-link voltage. A widely used boost PFC converter is not suitable for this application because of its limitation of boosting the voltage higher than input voltage. Hence the operation of BLDC motor cannot be performed at lower speeds. A PFC-based zeta converter is used for this application because of its capability of bucking and boosting the voltage and its operation as an excellent PF corrector. A PFC zeta converter and a bridgeless configuration zeta converter fed BLDC motor drive have been proposed in. respectively, but it is limited to simulation studies. This paper presents an experimental verification of PFC zeta converter feeding a BLDC motor drive.

#### 3.2 Proposed PFC zeta converter fed BLDC motor drive

Fig. 2a shows the proposed PFC-based zeta converter feeding a BLDC motor drive and Fig. 2b shows a VSI feeding the BLDC motor drive. The speed of BLDC motor is controlled by varying the dc-link voltage of VSI. The PFC zeta converter is designed to operate in DICM, hence it acts as an inherent PF corrector. The complete operation of BLDC motor drive is realised using a single voltage sensor. An electronic commutation of BLDC motor is utilised for reducing the switching losses. The performance of the proposed drive is validated experimentally on a developed prototype. An improved power quality is achieved for a wide range of speed control with power quality indices within the limits.



Fig. 3.2 Proposed PFC zeta converter fed BLDC motor drive a Proposed PFC zeta converter fed BLDC motor drive b VSI feeding BLDC motor drive

#### 3.3 Operation of PFC zeta converter

The PFC zeta converter is designed to operate in DICM, such that the current in input side inductor (iLi) becomes discontinuous, whereas the current in output side inductor( $iL_0$ ) and the voltage across intermediate capacitor (vC1) remain in continuous conduction for a complete switching cycle. Figs. 3a-c show the three different modes of operation of a PFC zeta converter in a complete switching cycle and its associated waveforms are shown in Fig. 3d. Three different modes of operation are as follows.

Mode I ( $0 < t < t_1$ ): As shown in Fig. 3a, when switch  $(S_W)$  is turned on, the input side inductor (Li) and the output side inductor (Lo) start charging. The intermediate capacitor (C1) discharges in this mode of operation and charges the dc-link capacitor as shown in Fig. 3d. Therefore, the voltage across intermediate capacitor (VC1) decreases and the dc-link voltage (Vdc) increases in this mode of operation.



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Mode II (t1 < t < t2): When the switch (Sw) is turned 'off', the energy stored in the input and the output inductors (Li and Lo) starts discharging to intermediate capacitor (C1) and the dc-link capacitor (Cd) as shown in Fig. 3b. The diode (D) starts conducting in this mode of operation. Hence, the voltage across the intermediate capacitor (vC1) and dc-link voltage increases in this mode of operation as shown in Fig. 3d.

Mode III ( $t^2 < t < t^3$ ): This is the discontinuous conduction mode of operation, that is, the current in input inductor (iLi) reaches zero and becomes negative as shown in Fig. 3c.The dc-link capacitor supplies the required energy to the VSI feeding BLDC motor; hence the dc-link voltage (V<sub>dc</sub>) starts decreasing in this mode of operation as shown in Fig. 3d.

#### 3.4 Design of PFC zeta converter

The PFC zeta converter is designed to operate in DICM such that the current flowing in input inductor  $(L_i)$  becomes discontinuous in a switching period. A front-end converter of 300 W is designed to feed a BLDC motor of 251 W (full fications are given in Appendix). Therefore, for a wide variation of speed, the dc-link voltage has to be controlled from a very low value (Vdcmin = 50 V) to rated value (Vdcmax = 200 V) of dc-link voltage.

The input voltage, Vs applied to the PFC converter as vs(t) = Vmsin(2pfLt)V(1)

where Vm is the peak input voltage (i.e.  $\sqrt{2}$ Vs where Vs is the supply root mean square voltage), fL is the line frequency, that is, 50 Hz.Now, the voltage appearing after the DBR is given as

$$Vin(t) = Vmsin(2pfLt)$$
 (2)

The output voltage,  $V_{dc}$ , of zeta converter which is a buck–boost configuration is given as

Vdc=(D/(1-D))Vin

(3)

where D represents the duty ratio. The duty ratio, D is calculated by substituting the expression of Vin from (3) as

$$D = Vdc/(Vdc+Vin)$$
(4)

Moreover, the speed of the BLDC motor is controlled by varying the dc-link voltage of the VSI, hence the instantaneous power, Pi at any dc-link voltage (Vdc) can be taken as linear function of Vdc as

Pi=( Pmax/Vdcmax)Vdc (5) where Vdcmax represents maximum value of dc-link voltage.



Fig. 3.3 Different modes of operation of a PFC zeta converter in a complete switching cycle and its associated waveforms a–c Different operating modes of PFC zeta converter in DICM d Key waveforms

#### 3.5 Operation of Zeta converter in ccm mode:

Vast majority of power converters used nowadays employ front-end diode bridge rectifiers. Such rectifiers draw pulsating currents which leave behind a great amount of harmonics, and considerably low power factor. For a single converter of this type used with a single-phase load such as in a consumer electronic equipment, the

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problems may not seem serious. However, a great number of those equipments in parallel connection at a point of common coupling (PCC) to draw power simultaneously introduce some serious effects concerning reactive power and harmonic. The situations are quite common in offices and industries.

### **PV FED ZETA CONVERTER DESIGN 4.1. INTRODUCTION:**

Nowadays a dc-dc converter is widely used as power supply in electronic systems. A zeta converter is a fourth order dc-dc converter capable of amplifying and reducing the input voltage levels without inverting the polarities. The reason being is that it includes two capacitors and two inductors as dynamic storage elements. Compared with Cuk or a Sepic converters, the Zeta converter has received the least attention. Among the renewable options, solar PV energy has been drawing increasing interest in recent years as an alternative and important source of energy for the future. Solar cells transform energy from an essentially unlimited source "the Sun" into useable electricity. PV systems constitute an environmentally friendly alternative way for energy production using the energy from the sun. PV system, virtually zero running cost energy is the input source of power.

They operate quietly without emissions, even if the load increases. With recent developments, solar energy systems are easily available for industrial and domestic use with the added advantage of minimum maintenance. However, the output power induced in the photovoltaic modules depends on solar radiation and temperature of the solar cells. Photovoltaic modules have a very low conversion efficiency of around 15% for the manufactured ones. Besides, due to the temperature, radiation and load variations, this efficiency can be highly reduced. In fact, the efficiency of any semiconductor device drops steeply with the temperature.

In order to ensure that the photovoltaic modules always act supplying the maximum power as possible and dictated by ambient operating conditions, a specific circuit known as Maximum Power Point Tracker (MPPT) is employed therefore, to maximize the efficiency of the renewable energy system, it is necessary to track the maximum power point of the PV array. In most common applications, the MPPT is a DC-DC converter controlled through a strategy that allows imposing the photovoltaic module operation point on the Maximum Power Point (MPP) or close to it. The proposed scheme consists of a solar panel, a zeta dc- dc converter, and MPPT controller. In this Maximum power point tracking is achieved by using Perturbation and Observation (P&O) method, also known as hill climbing method, is popular and most commonly used in practice because of its simplicity in algorithm and the ease of implementation.

#### **Results:**





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### **CONCLUSION:**

Mathematical analysis of ZETA converter is carried out for design values of the capacitor and inductor. A simple power electronic controller for interfacing PV array with the load has been simulated using ZETA converter. The subsystems of overall scheme such as PV array model, ZETA converter model have been built and tested individually before integrating to the overall system. A maximum power point tracking algorithm has also been incorporated. The simulation studies of the proposed scheme MPPT have been carried out and the results are furnished. The values of parameters used for simulation are listed.