

# PV Fed Zeta Converter

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**Abstract:-** This project envisages a zeta converter fed by photovoltaic module as input power source. A Zeta converter is a fourth-order DC-DC converter made up of two inductors and two capacitors and capable of operating in either step-up or step-down mode. 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.

**Keywords -** Photo voltaic module, P&O algorithm, Zeta Converter

## I. 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 [1]. The reason being is that it includes two capacitors and two inductors as dynamic storage elements. Compared with a Cuk or 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

## II. ZETA CONVERTER

A zeta converter is a fourth order non linear system being that, with regard to energy input, it can seen as buck-boost-buck converter and with regard to the output, it can be seen as boost-buck-boost converter.

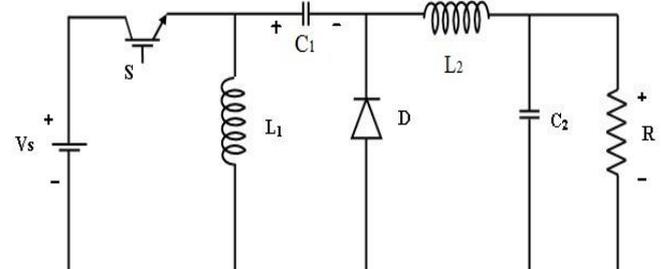


Fig.1 Basic Zeta converter circuit

The ideal switch based realization of zeta converter is depicted. A non-isolated zeta converter[2] circuit is shown in the fig.1 above. Although several operating modes are possible for this converter depending on inductance value, load resistance and operating frequency, here only continuous inductor current „ $i_{L1}$ “ analyzed using the well known state-space averaging method[3] .

The analysis uses the following assumptions.

1. Semiconductors switching devices are considered to be ideal.
2. Converter operating in continuous inductor current mode.
3. Line frequency ripple in the dc voltage is neglected.

### III. MODES OF OPERATION

Zeta converter exhibits two different modes as follows:

Mode1: The first mode is obtained when the switch is ON (closed) and instantaneously, the diode *D* is OFF. An equivalent circuit shown in Fig.2. During this period, the current through the inductor *L1* and *L2* are drawn from the voltage source *V<sub>s</sub>*. This mode is the **charging** mode.

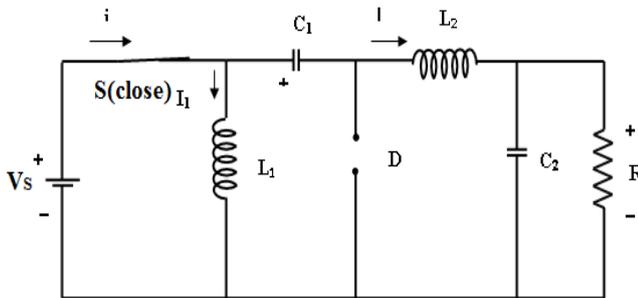


Fig.2 Equivalent circuit of converter (switch ON)

Mode2: The second mode of operation starts when the switch is OFF and the diode *D* is ON position, the equivalent circuit shown in Fig.3. This stage or mode of operation is known as the **discharging** mode since all the energy stored in *L2* is now transferred to the load *R*.

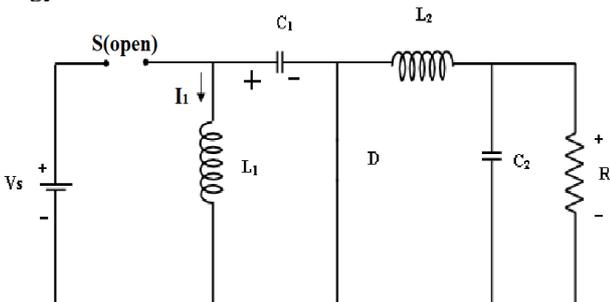


Fig.3 Equivalent circuit of converter (switch OFF)

### IV. PHOTOVOLTAIC SYSTEM

With increasing concerns about fossil fuel deficit, skyrocketing oil prices, global warming, and damage to environment and ecosystem, the promising incentives to develop alternative energy resources with high efficiency and low emission are of great importance. Among the renewable energy resources, the energy through the photovoltaic (PV) effect can be considered the most essential and prerequisite sustainable resource because of the ubiquity, abundance, and sustainability of solar radiant energy. Regardless of the intermittency of sunlight, solar energy is widely available and completely free of cost. Solar cell is the basic building block of solar panel. A number of solar cells are arranged in series and parallel combinations to form a solar PV module.

current electricity without environmental impact and contamination when is exposed to solar radiation. Being a semiconductor device, the PV system is static, quite, and free of moving parts, and these make it have little operation and maintenance costs. Even though the PV system is posed to its high capital fabrication cost and low conversion efficiency, the skyrocketing oil prices make solar energy naturally viable energy supply with potentially long-term benefits. The output characteristics of PV module depends on the solar insolation, the cell temperature and output voltage of PV module. Since PV module has nonlinear characteristics, it is necessary to model it for the design and simulation of maximum power point tracking (MPPT) for PV system applications. The mathematical PV models used in computer simulation have been built for over the past four decades. Almost all well-developed PV models describe the output characteristics mainly affected by the solar insolation, cell temperature, and load voltage. However, the equivalent circuit models are implemented on simulation platforms of power electronics. Recently, a number of powerful component-based electronics simulation software Package has become popular in the design and development of power electronics applications. The simplest equivalent circuit of a PV cell is a current in parallel with a diode. The output of the current source is directly proportional to the light falling on the cell. During darkness, the PV cell is not an active device; it works as a diode, i.e., a p-n junction .It produce neither a current nor a voltage. However, if it is connected to an external supply (large voltage) it generates current , called diode current or dark current. The diode determines the V-I characteristics of the PV cell[4][5]. Fig.4 shows the equivalent circuit of a solar cell

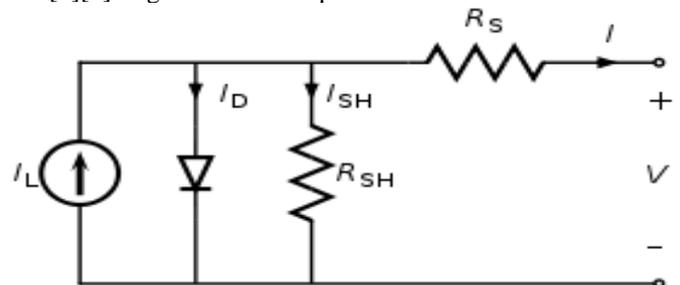


Fig.4 equivalent circuit of a solar cell

Here *I* and *V* represent the output current and voltage of solar cell. *Rs* and *Rsh* are series and shunt resistances respectively. *IL* and *ID* are photo current and diode current. The current-voltage characteristics of solar cell are governed by the equation following:

$$I = I_L - I_0 \left( \exp\left(\frac{q(V + IR_S)}{AkT}\right) - 1 \right) - \frac{V + IR_S}{R_{SH}}$$

The solar energy conversion using photovoltaic system and zeta converter circuit are presented. The block diagram of proposed scheme with PV array is given in fig.5 below. The system consists of following components: 1.) PV array 2.) Zeta converter 3.) MPPT system 4.) resistive load.

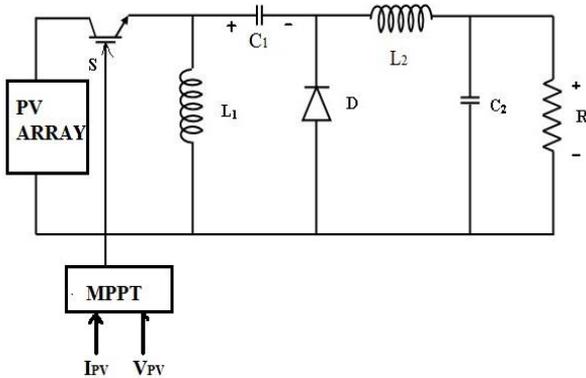


Fig.5 block diagram of proposed PV system

The PV panel converts solar radiation into electrical power that is fed to the ZETA DC-DC converter. A maximum power point tracker (MPPT) is used for extracting the maximum power from the solar PV module and transferring that power to the load. The peak power is reached with the help of a DC-DC converter by adjusting its duty cycle such that the resistance corresponding to the peak power is obtained. An automatic tracking can be performed by utilizing Perturb & Observe (P&O) algorithm. The algorithm changes the duty cycle of the DC-DC converter to maximize the power output of the module and make it operate at the peak power point of the module.

### V.PARTICLE SWARM OPTIMISATION

Particle swarm optimization (PSO) is a population based stochastic optimization technique developed by Dr. Eberhart and Dr. Kennedy in 1995, inspired by social behavior of bird flocking or fish schooling. PSO shares many similarities with evolutionary computation techniques such as Genetic Algorithms (GA). The system is initialized with a population of random solutions and searches for optima by updating generations. However, unlike GA, PSO has no evolution operators such as crossover and mutation. In PSO, the potential solutions, called particles, fly through the problem space by following the current optimum particles.

PSO simulates the behaviors of bird flocking. Suppose the following scenario: a group of birds are randomly searching food in an area. There is only one piece of food in the area being searched. All the birds do not know where the food is. But they know how far the food is in each iteration. So what's the best strategy to find the food? The effective one is to follow the bird which is nearest to the food. PSO learned from the scenario and used it to solve the optimization problems. In PSO, each single solution is a "bird" in the search space. We call it "particle". All of particles have fitness values which are evaluated by the fitness function to be optimized, and have velocities which direct the flying of the particles. The particles fly through the problem space by following the current optimum particles. PSO is initialized with a group of random particles (solutions) and then searches for optima by updating generations. In every iteration, each particle is updated by following two "best" values. The first one is the best solution (fitness) it has achieved so far. (The fitness value is also stored.) This value is called pbest. Another "best" value that is tracked by the particle swarm optimizer is the best value, obtained so far by any particle in the population. This best value is a global best and called gbest. When a particle takes part of the population as its topological neighbors, the best value is a local best and is called lbest. After finding the two best values, the particle updates its velocity and positions with following equation. The pseudo code of the procedure is as follows

```

For
eachparticle
Initializeparticle
END
Do
    For each particle. Calculate fitness value
    If the fitness value is better than the best fitness value (pBest) in history
    set current value as the new pBest
    End
    Choose the particle with the best fitness value of all the
    particles as the gBest
    For each particle Calculate particle velocity Update
    particleposition
    End
    While maximum iterations or minimum error criteria is not
    attained
    
```

Particles' velocities on each dimension are clamped to a maximum velocity  $V_{max}$ . If the sum of accelerations would cause the velocity on that dimension to exceed  $V_{max}$ , which is a parameter specified by the user. Then the velocity on that dimension is limited to  $V_{max}$ .

## VI.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.

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