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Article Title: Design of High Gain Zeta Based DC-DC Converter for EV Applications

Design of High Gain Zeta Based DC-DC Converter for EV Applications

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ABSTRACT

Electric vehicles (EVs), which assist sustainable transportation while minimising carbon emissions, have recently attracted a lot of interest. The use of EVs powered by photovoltaic (PV) technology significantly reduces the quantity of carbon dioxide discharged into the increase in dc voltage while input and output currents are constant, minimal switching loss, and non-inverting production. The ZETA converter is operated under an adaptive PI controller. To attain Maximum Power Point and the proper duty ratio of the gate pulse for the Zeta converter switch, a controlled method is necessary (MPP) Because there is an inductor on the output side, the output current can be constant and absent of ripples.

Keywords: Photovoltaic (PV), Electric Vehicle (EV), Zeta converter, Adaptive Proportional Integral Controller

1 Introduction

There are numerous factors today driving the development of electric automobiles. The biggest influences are higher fuel prices a scarcity of energy supplies, and a reduced carbon footprint [1]. As a result, the implementation of PV-powered electric vehicles (EVs) is essential to offering a workable alternative to combat climate change. The electric vehicles (EVs) are a more efficient, zero-emission form of transportation. In contrast, the PVs are a source of clean and sustainable energy that are produced anywhere, including in urban centers, to facilitate EV technologies [2]. A broad range, high level of voltage gain, bidirectional dc-dc converter is needed to complement the low voltage (LV) of the rechargeable batteries and high voltage (HV) of the power supply due to the relatively low voltage of the EV's battery [3]. A positive output voltage is produced through ZETA converter interpretation with an input power that fluctuates above and below the output value. A series capacitor, often known as a flying capacitor, and dual inductors are also necessary components of the ZETA converter [4].The gain parameters of a Proportional-Integral controller, which is commonly used in industries, have been tuned using a model technique described in this research. [5-6]. each region is sequentially given the planned fuzzy system so that it can choose its own appropriate gain values. It is preferable in multiarea power networks that each area be able to support its own load, contributing as little as possible to the disturbances of other areas [7].Because of variations in duty cycle, there is a negligible alteration in output voltage at the electrical connections. PV voltage and current can be altered by adjusting the solar irradiance [8]. The converter is a switch mode of DC to DC converter with the ability to change the DC output voltage to be lower or greater than the DC input voltage. The duty cycle of the converter's switch determines the output voltage's parameter [9]. The adaptable and detachable FLC characteristics and the rapid response properties of the PI controllers are combined to create adaptive PI controllers. As a result, system will change caused by the device's reliance on a variable can be mitigated [10].

This work suggests a PV-based Electric vehicle charging system in which the energy needed to run the capacity of the Electric vehicle is supplied from the PV using a ZETA converter. An adaptive PI controller is used to regulate the ZETA converter.

2 Recent Work

M. S. BHASKAR et al [2021] [11] have suggested a novel hybrid converter with high voltage gain is dependent on the zeta converter. These devices are low voltage/current rating devices, high voltage gain without multiplication circuits. Combining traditional converter topologies with capacitor-diode voltage multiplier cells is a handy way to boost voltage gain while also improving effectiveness and reliability. Poor voltage regulation and pulsing input current are faults of switched capacitor converters.

K. SURESH et al [2021] [12] have suggested the non-isolated four-port (two input and two output ports) customized topology of intersection for power electronics which can be applied to electric vehicle (EV) technologies. The versatility of such a converter up to tolerate renewable resources of various voltage and current characteristics. The suggested converter is capable of generating an output greater than or lower than the minimal input voltage. By lowering switching losses, the suggested converter's efficiency is raised. The circuit structure and control complexity are then increased since the amount of components active in this design is equal to the amount of source systems.

R. EMAMALIPOUR et al [2020] [13] have introduced a multiple string inverter/rectifier resonant bidirectional DC-DC converter for purposes of energy storage. The suggested converter has an unbiased point which makes assured the voltage is distributed evenly over through the switching devices while ensuring that any variations in the snubber capacitors' levels have no bearing on the voltage forces exerted on the switching devices. Although it is straightforward and capable of power converters, its value drops in slightly elevated operations.

R. KUSHWAHA et al [2021] [14] have suggested a novel electric vehicle (EV) charger with built-in power factor preregulation at the source .It is designed on some kind of bridgeless (BL) isolated zeta converter. Over the duration of a switching cycle, it is observed that the current is conducted through fewer parts and devices, improving the overall efficiency. The popularity

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of an external charger layout is due to the vehicle's lighter weight, which gives designers more freedom to create a charger with a high rated power. Similar to a traditional proposed converter, the input rectifier has no effect on how rapidly the components are used.
M. R. BANAEI et al [2020] [15] have suggested a brand-new transformer-free converter based on ZETA converter. Because there is only one fundamental switch employed throughout this converter, losses are minimized and efficiency is boosted. Low active switch voltage stress allows for the use of switches with minimal on-state resistance. The converter's voltage gain is three times as large as the traditional converter's. Voltage gain is high, minimal diode and switch stresses, minimal fluctuation, and performance also high are some benefits of the converter. Voltage stress on the switches is really the main concern with switched-capacitor cells. Additionally, high voltage systems produce significant conduction losses.

3 Proposed Work Explanation

Because of the ongoing uncertainty surrounding the quantity of fossil fuels and the requirement to address anthropogenic global warming, the globe is currently concentrating on the creation of an environmentally friendly and decarbonized transportation and energy generation system. Therefore the abovementioned issues are recommended to be solved by a PV-based EV charging system.

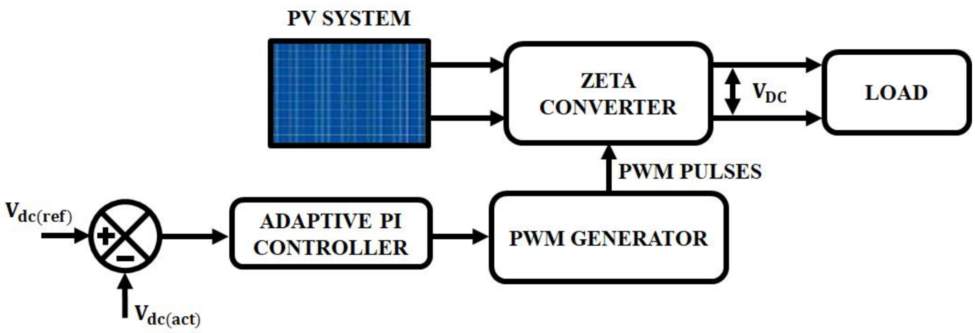

Figure 1: *Block diagram for proposed system*

3.1 PV system

The sun generates solar energy in the form of heat or light. The solar panel is exposed to light in the form of photons, which are energy packets. Through the photovoltaic effect, the solar panel turns light into electrical energy. A feature of electricity that changes when exposed to light is called the photovoltaic effect.
A solar panel is made up of solar cells, which are essentially P-N junction diodes with semiconductor qualities. The most effective cell type is a monocrystalline one, followed by polycrystalline, thin and economical. The Figure 2 shows to represent the equivalent configuration of solar cell.

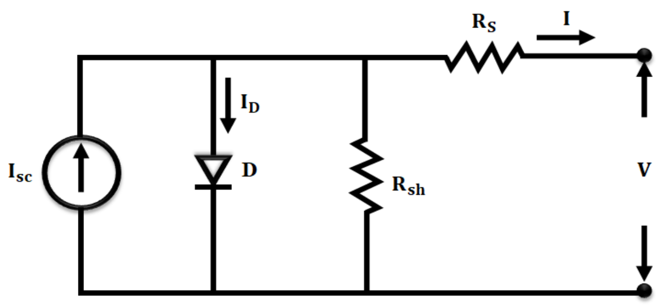

Figure 2: *Equivalent circuit of solar cell*

A solar cell is an electrical device that uses the natural and chemical photovoltaic effect to actively transform electricity from light energy.

3.2 ZETA Converter

Zeta converter is a fourth order DC-DC converter as shown in Figure 3, it consists of a switch, a diode, two inductors, two capacitors and a load. ZETA has continuous output current and minimal ripple to the load. ZETA converter can be operated by two modes one is ON condition another one is OFF condition.

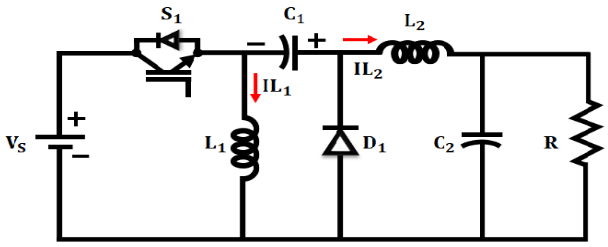

Figure 3: *Circuit diagram of ZETA Converter*

If the condition is ON when switch S1 is turned-on and diode D1 is reverse biased, while the condition is OFF when switch S1 is turned-off and diode D1 is forward biased. The Figure 3(a) shows ON condition of the ZETA converter, when the switch S1 is turned-on and the diode D1 is open-circuited. Both inductors L1 and L2 are in the charging state during this condition. The input voltage source is charging the first inductor, L1. While, the second inductor L2 is charging from the capacitor C1. In this condition, both inductor currents increase linearly Figure 3(b) illustrates the OFF condition, which occurs when the switch S1 is turned-off and the diode D1 is forward biased. In this condition, the inductors L1 and L2 are discharging through the capacitor C1 and the load, respectively. When a result, as the two inductors discharge, their current is reducing.

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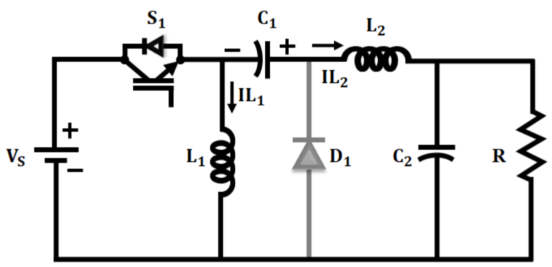

Figure 3(a): *ON condition*

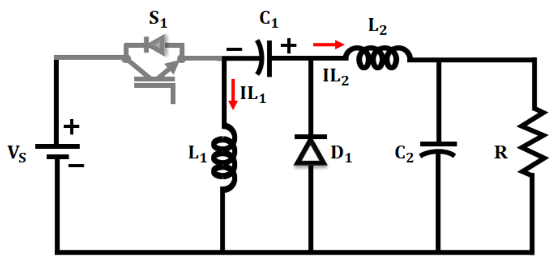

Figure 3(b): *OFF condition*

3.3 Adaptive PI Controller

The load frequency control situation under consideration here is made up of intermittent, brief, random variations that periodically interfere with a power system's ability to function normally. As a result, it is necessary to control the frequency and tieline power variations of every integration site. A PI controller's adaptive proportional gain KP and integral-gain KI sequencing is depicted in Figure 4 The adaptive PI controller continuously specifies the proportional (KP) and integral (KI) gains of the PI controller depending on system's selected location in PI controller.

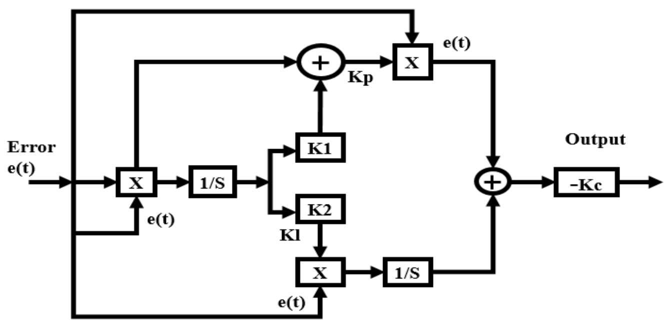

Figure 4: *Adaptive PI controller*

4 Result and Discussion

The proposed system of zeta dc-dc converter and an adaptive PI controller algorithm is used to operate the system. The solar irradiance is fed into the PV module's input, but the panel's output voltage is insufficient to fully charge the battery being used. The load is given the necessary amount of voltage using a ZETA converter. The maximal functioning range of the Photovoltaic modules has been determined using the Maximum Power Point Tracker. The figure 5 (a) and figure 5(b) shows the solar panel input voltage and input current.

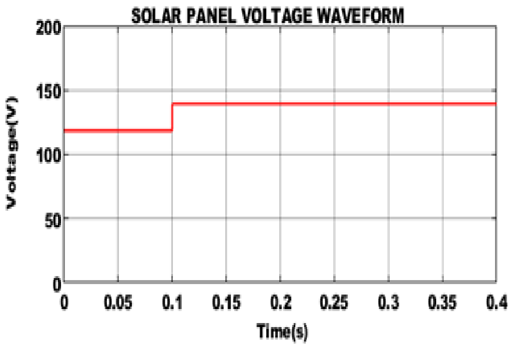

Figure 5 (a): *Solar panel Voltage*

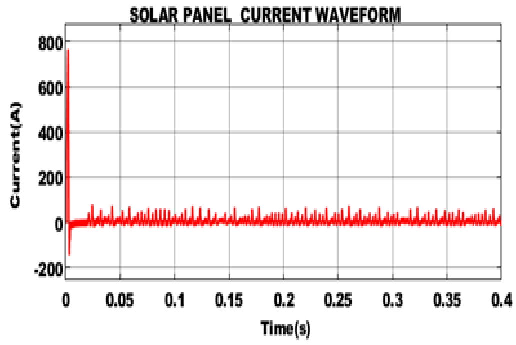

Figure 5 (b): *Solar panel Voltage*

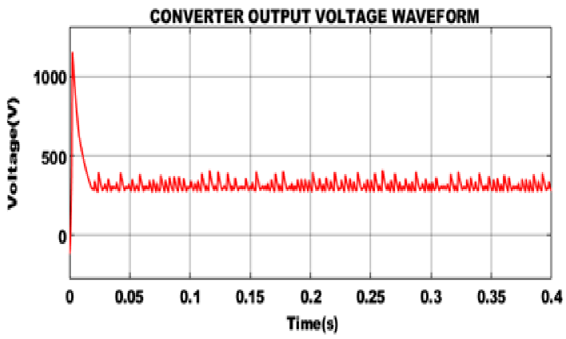

Figure 5 (c): *Converter Output Voltage*

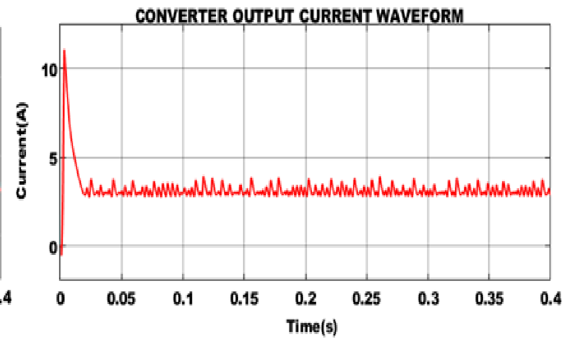

Figure 5 (d): *Converter Output Current*

Figure 5(c) and 5 (d) depicts the Zeta converter's behaviour. During ON and OFF conditions, both inductors are concurrently working in the charging and discharging modes. Variations in sun irradiation have modified the inductors' currents. By using the technique of adaptive PI controller the values of parameters to be changed in mode of operations. When the high gain voltage of the zeta converter is given to the load in EV applications.

5 Conclusion

Zeta dc-dc converters may produce high gain voltages over a broad range. This converter has strong step-down and step-up voltage gains, high efficiency switches with low ratings, common ground, and the ability to operate in both directions. The adaptive PI controller technique is used to produce the duty cycle for the Zeta converter in order to preserve the photovoltaic system's maximum power point. The suggested converter, which assures accurate and seamless current management in both orientations of working.

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