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A Review of Converter Topology Used as MPPT in Electric Vehicle Application

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Abstract – *The environment have to be keep clean and pure then only the lives becomes possible for subsequent decade. For this, the use of Renewable energy handle a serious role. The solar energy has to be track and it fed to the electrical system. For this purpose, we need to incorporate a converter with PV module, and it act as MPPT. Here conducting a review to find the efficient converter act as MPPT. It is often handled by the various sorts of converters like Buck, Boost, Cuk, Zeta, Buck-Boost, SEPIC converters...etc. The review administered on different types of dc-dc converters supported different parameters like cost, components used, ripple in current and efficiency. Finally, we prove SEPIC Converter is best suited and efficient converter for PV fed systems.*

Key Words: Electric Vehicle, Motor Drive, Renewable Energy, DC-DC converters, SEPIC Converter, MPPT

1. INTRODUCTION

The rapid increase in the demand for electricity and the recent change in the environmental conditions such as global warming led to a need for a new source of energy that is cheaper and sustainable with less carbon emissions. Solar energy has offered promising results in the quest of finding the solution to the problem. The harnessing of solar energy using PV modules comes with its own problems that arise from the change in insulation conditions. These changes in insulation conditions severely affect the efficiency and output power of the PV modules [22-25].A great deal of research has been done to improve the efficiency of the PV modules. A number of methods of how to track the maximum power point of a PV module have been proposed to solve the problem of efficiency and products using these methods have been manufactured and are now commercially available for consumers [30]. As the market is now flooded with varieties of these MPPT that are meant to improve the efficiency of PV modules under various insolation conditions it is not known how many of these can really deliver on their promise under a variety of field conditions. This research then looks at how a different type of converter affects the output power of the module and also investigates if the MPPT that are said to be highly efficient and do track the true maximum power point under the various conditions [22].

A MPPT is used for extracting the maximum power from the solar PV module and transferring that power to the load [25, 26]. A dc/dc converter (step up/ step down) serves the purpose of transferring maximum power from the solar PV module to the load. A dc/dc converter acts as an interface between the load and the module. By changing the duty cycle, the load impedance as seen by the source is varied and matched at the point of the peak power with the source to transfer the maximum power [26]. Therefore, MPPT techniques are needed to maintain the PV array is operating at its MPPT. Many MPPT techniques have been proposed in the literature; example are the Perturb and Observe (P&O) methods, Incremental Conductance (IC) methods, Fuzzy Logic Method, etc. In this paper two most popular of MPPT technique (Perturb and Observe (P&O) methods and Incremental Conductance methods) and three different DC-DC converter (Buck and Boost converter) will involve in comparative study [30].

2. DC – DC CONVERTER

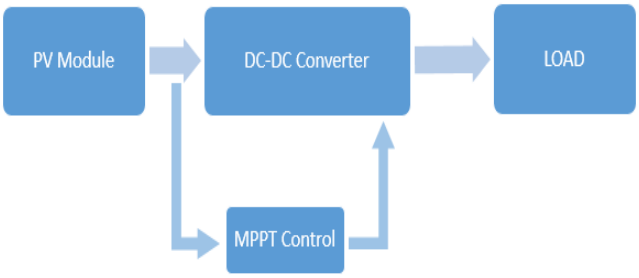

Fig -1: Block diagram

The Maximum Power Point Tracker is used to extract the maximum power from solar power module. The module produce a power according to the sunlight available, but the sunlight varies time to time. It makes the output of solar module varying. The MPPT helps to set a working point which produce maximum power. For this purpose we have to introduce a converter as MPPT module. Commonly there are different types of converters used as MPPT. They are Boost converter, Buck converter, Cuk converter, Zeta converter, Buck-Boost converter, and SEPIC converter.

2.1 Boost Converter

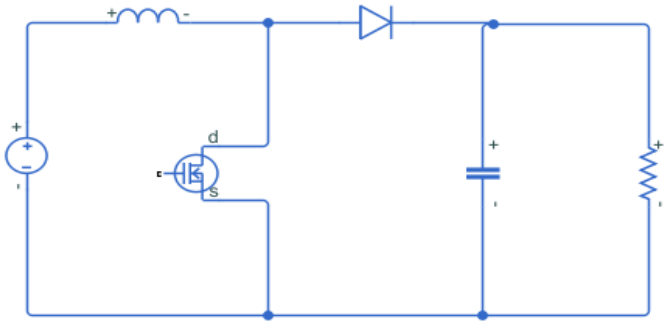

Fig -2: Boost Converter

Provides a better insight to three novel DC-DC converters used in electric vehicle applications called Zeta converter super lift Luo and cascaded boost converter, which step up or step down input voltage and feeds the BLDC motor with constant voltage. These types of converters are readily invoked in electric vehicles as it can produce high voltage from low voltage. The operating frequency of the converter is fixed at 80 KHz. The proposed Zeta converter has two mode of operation labeled as ON and OFF depending on the charging and discharging phase of inductor. Cascaded boost converters are preferred over other DC-DC converters when high voltage gain is needed [2].

In [3] Dhumal et al considers a solar PV array fed water-pumping system using Switched Reluctance Motor (SRM) drive. The visible benefits of using the proposed motor drive includes low cost, improved efficiency and high reliability, which mainly comes from its simple construction. The usage of DC-DC boost converter under Continuous Conductance Mode (CCM) reduces stress on the converter while providing balanced voltage to Asymmetrical Power Converter (APC). Oscillation occurring at MPPT is avoided by incorporating Incremental Conductance (InC) MPPT techniques. The MATLAB simulation results shows that the efficiency of the introduced water pumping system is far better compared to other systems based on either DC or induction motors.

Authors in [4] formulates a cost effective method of utilizing solar power for driving and speed control of BLDC motor which are commonly used in solar powered electric vehicle. The speed control is carried out by feeding the DC bus rated voltage the motor windings. Furthermore a boost converter is used to boost the input voltage to a high voltage that is required by the motor. A PI controller is integrated in the system to regulate the motor speed. The simulation results validates that the proposed system has high accuracy and robust operation from zero to high speed levels.

BUCK CONVERTER

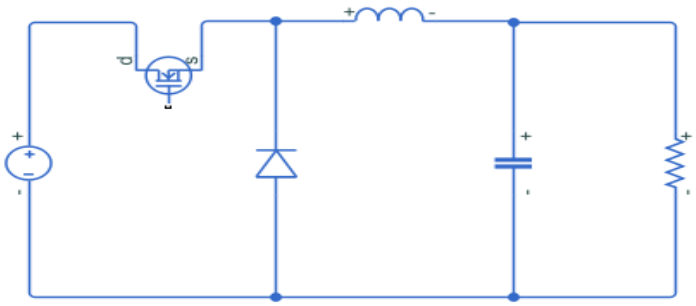

Fig -3: Buck Converter

A novel type of converter called integrated synchronous buck converter for EV application is explored in [11]. The converter provides benefits like improved efficiency, better dynamic behavior, minimized cross regulation problem, decreased switching losses and less complex control strategy at reduced cost by lowering the number of switching elements. Proposed converter is integrated with solar PV array, PI controller and battery by using MPPT method to form the final structure. The analytical results proves that apart from EV application the prototype can be satisfactorily used in Mp3 players, digital cameras etc., Panel efficiency can be improved by adopting incremental conductance with MPPT so that the system can extract Maximum power from panel.

2.2 Cuk Converter

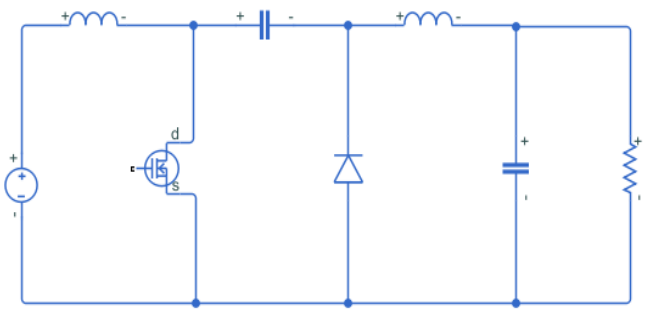

Fig -4: Cuk Converter

Gives attention to a solar photovoltaic (SPV) energized BLDC drive for water pumping system. It is worth pointing out that here the speed of the motor is controlled by adjusting DC bus voltage of a Voltage Source Inverter (VSI) by completely eliminating current sensors of BLDC motor. The SPV array is made to operate at its maximum power without any ripples by using a DC-DC cuk converter. Apart from enhancing the efficiency of system, VSI minimizes the switching losses by adopting a fundamental switching frequency. As the speed control does not require an

additional circuitry, it helps in the soft starting of motor and the method is cost effective. The performance of the proposed work is validated by simulation results and it shows that the system shows far better performance compared to other conventional water pumping systems [6].

A battery operated EV system which shows better operating performance under different driving conditions is explored in [8]. The motor drive is made to operate on two different modes, acceleration and braking mode and found to have ripple free and stable performance compared to parallel switch based boost converter technique. Although the proposed system improves the efficiency of vehicle without using the large capacitive filters it has a drawback of increased complexity and cost. Thus, it introduces a novel but less complex method of using cuk converter without a bidirectional converter.

A low cost SPV array fed Switched Reluctance Motor (SRM) drive for water pumping system is devised in [10]. Incremental Conductance (INC) algorithm with MPPT technique is adopted to enhance the efficiency of pumping system. Voltage pulses for phase wind excitation are provided with the help of a mid-point converter having two split capacitors. Furthermore, PI based controller is used as the control system for four phase SRM drive for minimal torque ripples and speed control. A DC-DC cuk converter is made to operate in CCM mode to reduce stress level on converter elements by lowering the ringing effect and thus improves the efficiency of overall pumping system.

2.3 Buck Boost Converter

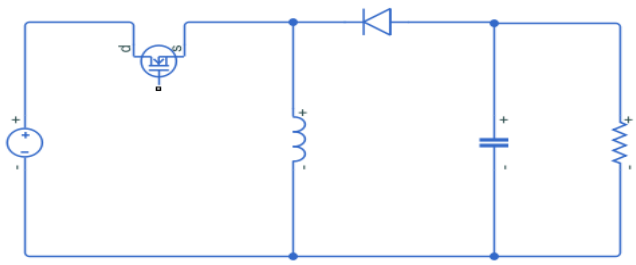

Fig -5: Buck – Boost Converter

Have explored an eco-friendly solar PV powered electric vehicle, which can effectively overcome the key issues of fuel, noisy operation and pollution. The battery is charged from solar PV modules and thus it completely builds a green environment. MPPT controller is used to transverse the maximum power point in the solar panel. In addition, Buck-Boost converters are used to boost up the DC voltage coming from battery whose output is then directly applied to an inverter .Inverter convert DC power to AC power, which can track the BLDC motor in an electric vehicle application. The key benefit of the projected system includes higher efficiency, power density and various speed levels [5].

2.4 ZETA Converter

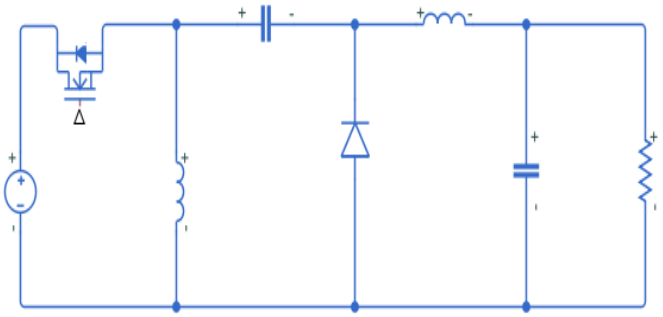

Fig -6: Zeta Converter

In [7] authors examined a PV array powered BLDC motor controlled by Zeta converter. The converter is fed by photovoltaic array and carries many potential benefits as low current, low ripple input and output currents compared with the conventional Buck-Boost, cuk converter. The major characteristics of the Zeta converter is that it can amplify or reduce input voltage levels without inverting its polarities. The effectiveness of the topology of BLDC motor with zeta converter is examined using MATLAB and the results shows its applicability for fan load.

Studied solar PV array fed BLDC motor combined with Fuzzy logic and Zeta converter. INC-MPPT algorithm is integrated for the purpose of tracking and controlling the Zeta converter. The Fuzzy Logic Controller (FLC) helps in smooth functioning of the inverter while enhancing the efficiency. The visible benefits of the system include soft starting of BLDC motor, minimized switching losses, stable operation and reduction in stress level on MOSFET. The proposed system is found to be highly competitive with other technologies even under reduced solar irradiance level [9].

2.5 SEPIC Converter

Proposes a architecture for single phase induction motor electric vehicle combined with buck/boost converter. The architecture is an integration of MPPT SEPIC converter, bidirectional buck/boost converter and an induction motor. SEPIC converter used for power extraction from solar PV also ensures a safe battery recharge. It is noteworthy that for high power processing the single phase induction motor can

be replaced by three phase motor without changing other driver setup. The analytical results show that the system has enhanced efficiency through regenerative breaking and is highly eco-friendly [1].

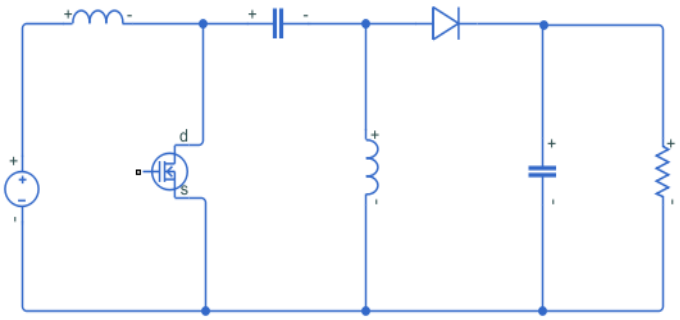

Fig -7: SEPIC Converter

3. RESULT ANALYSIS

Table -1: Comparison Between of Different Types of Converters

Converters / Parameter	Buck	Boost	Buck-Boost	Cuk	Zeta	SEPIC
Components	5	5	5	2	2	4
Cost	4	4	4	2	2	4
Ripple	3.5	3.5	4	2	2	4.5
Efficiency	3	3	3	3.5	4	4
Total	**15.5**	**15.5**	**16**	**9.5**	**10**	**16.5**

From the detailed study, we conclude it into a Table. It gives the clear idea about the DC- DC Converters used as MPPT. In the table, the highest value means it is favorable to us. The converter analyze based on different parameters, like cost, efficiency, ripple and components used. If the components used is increases the converter size also increases. Each parameter evaluated and give a measure within 5 points. Zeta converter has high efficiency but it has more components thus size will large. From these analysis we can say that the SEPIC Converter has more advantages over the other converters.

4. CONCLUSION

In this work, a review is carried out based on different types of DC to DC Converters used as MPPT. Here presented a discussion based on a detailed study of the Operation, Working principles, other features and drawbacks of different converters available. Finally, because of study carried out it can be concluded, as the SEPIC Converter becomes the most efficient and suitable for MPPT Application. This converter has noted with high efficiency, less components and performance. Due to these characteristics, this converter is popularly used as MPPT in the PV fed applications.

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