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A New High Gain DC-DC Converter with Model Predictive-Control Based MPPT Technique for Photovoltaic Systems

Mr V. Suresh[1], S.Joycemary[2], V.Vasuki[3], S.Sridhar[4]
[1]*Assistant Professor, Department of electrical and electronics, Loyola institute of technology Chennai, India*
[2,3,4]*B.E, Department of electrical and electronics, Loyola institute of technology Chennai, India*

Abstract-High gain DC-DC converters are increasingly being used in solar PV and other renewable generation systems. Satisfactory steady-state and dynamic performance, along with higher efficiency, is a pre-requirement for selecting the converter for these applications. In this paper, a non-inverting high gain DC-DC Step up converter has been proposed. The proposed converter has only one switch with continuous input current and reduced voltage stress across switching devices. The operating range of the duty cycle is wider, and it obtains a higher gain at a lower value of the duty cycle. Moreover, the converter has higher efficiency at a lower duty cycle while drawing a continuous input current. The continuous input current is a desirable feature of the dc-dc converter making it suitable for solar photovoltaic applications. The converter's operation has been discussed in detail and extended to include the real circuit parameters for a practical performance evaluation. The proposed converter has been compared with other similar recently proposed converters on various performance parameters. The loss analysis for the proposed converter has also been carried out. Finally, the simulation has been validated with results from the experimental prototype.

INTRODUCTION

For sustainable development, renewable energy is going to play a significant role in energy generation. The generation of electricity by solar PV system for grid-connected and off-grid application has already proven to be the game-changer in the energy market scenario. While the transportation system is also seeing a shift, with electric vehicles promising to be the future's commutation system. Fuel cells are increasingly being used for electric transportation system. However, both solar PV and fuel cells produce low voltage which is required to be boosted up for practical applications. Therefore, a high voltage gain DC-DC converter is an integral part of the solar PV generation and electric vehicle system. Boost DC-DC converters are also used high-intensity headlamps in automobiles, uninterruptible power supply motor drives, and many others. The conventional boost converter (CBC) is reduced significantly at higher duty ratios because of voltage drops across diodes, switches, and equivalent series resistance of capacitors and inductors. The converter's efficiency depends on the number of the components present in the circuit, their conduction time as well as on switching frequency Several topologies of DC-DC converter with isolation using high-frequency transformer are proposed in the literature. High voltage gain is achieved by raising the transformer's turn ratio but due to the transformer the cost, size, and weight of the converter increases. Moreover, transformers also introduce non-idealities in the system. Sometimes the leakage inductance of coupled inductor can also create a problem of current transients through the switch. High voltage gain could be achieved using coupled inductors, but a clamp circuit needs to be designed. The traditional DC-DC converters, such as boost, buck, and buck-boost converters, have been used in PV systems. However, they suffer from low efficiency and limited voltage gain, which restricts their application in low-voltage PV modules. Therefore, the development of a new high-gain. DC-DC converter is necessary to enhance the performance and efficiency of PV systems. This project report presents the development of a new high-gain DC-DC converter with Model Predictive Control (MPC)-based Maximum Power Point Tracking (MPPT) technique for photovoltaic (PV) systems. The proposed converter is designed to improve the efficiency and performance of PV systems, which can provide a sustainable and clean energy source.The proposed converter is designed based Step up dc -dc converter topology, with additional components such as a coupled inductor, a switch, and a diode. The MPC-based MPPT technique is employed to track the maximum power point of the PV array. The MPC algorithm considers the variations in the solar irradiation and temperature, which are considered as disturbances, and adjust the duty cycle of the converter to achieve the maximum power output. Ismail propose a converter has a single switch with two inductors, and that has extended from the relief circuit. The converter has a high voltage gain but also has high voltage stress on the switches. In authors have proposed a single switch quadratic voltage gain converter is proposed, but inductor counts are more, and voltage stress on the switch is the same as output voltage. A schematic diagram that shows the application of DC-DC converter in DC Microgrid.

LITERATURE SURVEY

According to Mansour et al., (2022), proposed A new design of a non-isolated high-voltage gain DC/DC converter that operates at a reasonable duty cycle, by merging the dual boost converter with the switched inductor structure, is presented as a solution for the high-conversion ratio requirement. The proposed converter operates in discontinuous-current mode (DCM) with zero current switching for all switches and diodes. Wide duty cycle range operation, high output voltage gain, low switching stress, small switching losses, and high efficiency are achieved efficiently. Operating the converter in DCM can support a wide range of the duty cycle operation, maintain lower voltage stress of all devices, ensure the same current sharing among inductors, make it easy to control, provide more stability, and require a smaller inductor which reduces size and weight of the proposed converter. Moreover, the converter operates with a continuous input current. These features make the converter a good choice for many applications such as photovoltaic, x-ray, fuel cells, etc. To prove the converter's effectiveness, theoretical analysis, project specifications, and operation principles are presented and studied. Experimental results in an open and closed-loop, and a comparison with other recent converters are also introduced to confirm the validity of the proposed converter. While Ahmad et al., (2021)introduced a new high-gain DC-DC converter was proposed in this paper to improve voltage gain and reduce voltage stress across switching devices. This converter utilizes two switched inductors, two capacitors, and two switches to achieve quadratic voltage gain. Loss analysis was done using the Piecewise Linear Electrical Circuit Simulation (PLCES), and the experimental and theoretical analyses agreed with each other. This converter was compared with other topologies in terms of stress, passive components, and voltage stress. On the other hand Sujatha et al., (2021) compared between Fuzzy Logic Control (FLC) and Fuzzy Optimal Fuzzy Logic Control (FOFLC) techniques for Maximum Power Point Tracking (MPPT) and Charge Controller (CC) of a Photovoltaic (PV) system. The authors have developed a mathematical model of the PV system in MATLAB/Simulink and used it to analyze the performance of the FLC and FOFLC techniques. The FLC technique is based on a fuzzy logic approach, while the FOFLC technique is based on an optimization approach. The authors have also used the model to compare the performances of the FLC and FOFLC techniques in terms of convergence time, steady-state error, and efficiency. The authors report that the FOFLC technique is superior to the FLC technique in terms of convergence time, steady-state error, and efficiency. The FOFLC technique has a shorter convergence time, a lower steady-state error, and a higher efficiency than the FLC technique. The authors also provide a detailed comparison of the two techniques in terms of their performance metrics. Furthermore, they discuss the potential applications of the FLC and FOFLC techniques in other areas such as power.

EXISTING SYSTEM

The converter can be operated with a wide range of duty ratios avoiding operation at extreme duty ratio, and hence there is no problem related to reverse recovery time for diodes in the proposed converter. This converter has comparatively more components, but its voltage gain is high and input current is continuous. The circuits of the conventional boost converter and twice the quadratic boost converter are shown in Figure3.1. respectively. It can be seen that these converters utilize two and three inductors respectively but still their voltage gain is less than the proposed topology. The absence of common ground is one of the disadvantages of the converter. However, the proposed converter can be interfaced with solar PV by removing the voltage multiplier circuit used in the converter as by adding other existing multipliers with common ground.

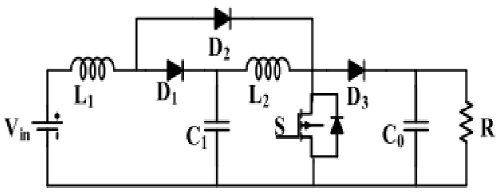

Fig 1 Existing system

PROPOSED SYSTEM

The conventional quadratic boost is with two inductors. Proposed converter uses a voltage multiplier to boost the voltage to achieve voltage gain of twice the quadratic boost converter with three inductors. The proposed converter consists of two inductors but with an advantage greater than the aforementioned converters. The presented converter in includes single switch S1, two inductors L1 and L2, five capacitors named C1, C2, C3, C4 and C0 and six diodes specified as D1, D2, D3, D4, D5, and D6 and load R. All capacitances and inductances are taken as large for analysis so that voltage across capacitors and current through inductors are constant. The converter has two operating states within one switching Period Ts. All analysis is done in CCM mode; therefore, a continuous input current is assumed.

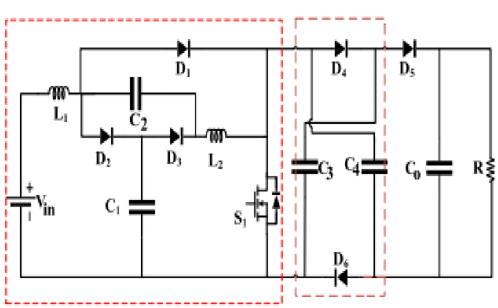

Fig 2 Proposed System

RESULTS AND DISCUSSION

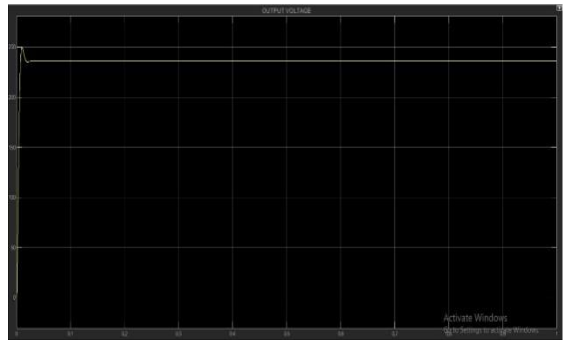

Fig 3 Output Voltage

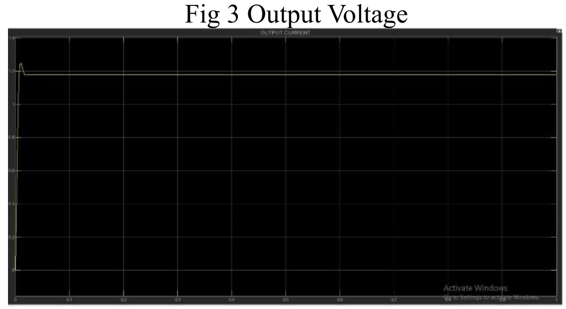

Fig 4Output Current

The a new high gain dc-dc converter with model predictive-control based technique for photovoltaic systems to use an high step up converter and gain a high amount of Voltage and Current at the result.

CONCLUSION

A new non-inverting DC-DC High step up converter is proposed in this paper. The proposed converter has high gain and utilizes only one switch to operate the converter, and therefore, control is easy. The voltage stress on the switch and diodes is low, and therefore low voltage-rated switch can be chosen which increases the efficiency and reduces the cost. The converter has draws continuous input current and thus the need for an input filter does not arise. Hence, it can be used in microgrid applications as the voltage of the converter at a low duty ratio is high compared to the conventional boost converter and other high gain converters. To verify the analysis practically, a 200W hardware prototype has been prepared for the converter. The peak of the efficiency of the proposed converter is observed to be greater than 95% but the efficiency decreases at high output power on account of losses. Thus, the proposed converter is suitable for medium power range suitably up to 300W. The merits of the converter make it suitable to be used in solar PV applications, automobiles, fuel cells and electric vehicles.

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