



Article Title: PV Fed SEPIC Converter for Grid Tied System with Ultra Capacitor

PV Fed SEPIC Converter for Grid Tied System with Ultra Capacitor

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ABSTRACT

Recent years have seen a rise in the popularity of photovoltaic (PV) energy as a next-generation energy source that can combat both global warming and the energy fatigue brought on by rising energy demand. Due to their environmental friendliness and economical operation, renewable energy sources including photovoltaic (PV) energy are popular for home and commercial uses. This paper suggests a grid-tied system with an ultra-capacitor that uses a PV fed Sepic converter. Through a SEPIC converter, the solar system delivers voltage to the inverter. To regulate the converter by current and the DC by voltage, an energy management strategy is given. Super capacitor is attached to the bidirectional converter's output. According to many quick charge/discharge cycles, supercapacitor are used in place of long-term compact energy storage. The single phase grid is linked to the LC filter. It links to the PWM and PI controller via the sepic converter. The findings show that the suggested strategy performs better with increased efficiency and less harmonics. DSPIC30F4011 controller is used in the hardware development.

Keywords: Renewable energy sources, photovoltaic (PV) energy, Sepic converter, LC filter, Bidirectional converter.

1 Introduction

One of the cleanest forms of energy is solar energy, since it is pollution-free and favourable to the environment. India, a tropical nation, has a lot of potential to deploy technology to harvest this energy [1]. Switched reluctance motor (SRM) drives are becoming more and more



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common because of their simple construction and low cost. High efficiency across a wide speed range, the absence of any form of magnet, a winding-free rotor, and the elimination of brushes are some of the benefits of SRM over permanent magnet brushless DC motors and induction motor drives [2]. DC-DC converter setups that produce controlled output voltages in accordance with the demands of the end user at the same time, though, it has started to contribute to power supply distortion [3]. Additionally, DC microgrids outperform many AC systems' shortcomings and exhibit a number of additional benefits. Therefore, DC microgrids have potential as an alluring, beneficial, and advantageous element of contemporary smart power systems [4]. One of the most susceptible sources of renewable energy, PV microinverters, which generally have a power range of 100–300 W, are commonly classed as low-efficiency energy conversion techniques. [5]. That is due to the advantages they provide, which include higher energy collection, a lower cost of mass production, plug-and-play operation, simpler installation, and expansion [6]. The need for electrical energy has grown rapidly as a result of modernization, industrialization, and population growth. To fulfil the highest level of energy demand, it is essential to concentrate on additional sources of energy [7]. Utilising renewable energy sources (RESs) reduces reliance on fossil fuels and increases access to clean, readily available electricity. The most accessible, quietest, and cleanest renewable energy source is solar energy [8]. As manufacturing technology improves and solar cell efficiency rises, the importance of renewable energy sources like solar PV is expanding [9]. Due to the continuing depletion of conventional energy sources and their negative impacts on the environment, renewable energy sources, such as solar PV, solar thermal, and wind energy, must be taken into consideration in order to power water pumping systems [10]. The list below demonstrates how the paper is organised: Section II describes the most recent work. Section III describes the proposed work in detail. The results are presented in Section IV. Section V provides a conclusion.

2 Recent Works

Ariya Sangwongwanich *et al* (2019) [11] have proposed an innovative interharmonics mitigation technique for PV systems. Interharmonics are an increasing power quality issue in photovoltaic (PV) systems that are attached to the grid. In this way, for instance, the sample rate of the MPPT parameters has a substantial impact on the interharmonics characteristics of the photovoltaic system. However, this will definitely cause the MPPT algorithm's tracking capability to deteriorate, which might lower MPPT efficiency.

Yasmine Amara *et al* (2018) [12] have recommended a two-stage standalone solar system with an efficient design and control that uses a DC-DC boost converter as the first stage and a single-phase complete H-bridge inverter as the second stage. Perturb and Observe MPPT is used to manage the DC-DC converter in order to maximise electric power under various weather scenarios. The main disadvantage is the poor performance on overcast days.



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Naki Guler *et al* (2019) [13] have focused on the control strategy put to the test on a PV panel group's three-phase grid-connected inverter. The combined algorithm has the rapid and sensitive control skills of MPC and enables effective tracking in conditions of changing irradiance and fog. This system type can be used by low-power PVs, however mechanical observer utilisation is not a workable option for high-power systems.

Mostafa I. Marei *et al* (2022) [14] have developed the analysis of various operating modes for an integrated TPC-based PV battery system using the PSCAD/EMTDC software package. The TPC has several advantages over standalone dc-dc converters, including compactness, reduced component count, and less weight. The PV port inverter's duty cycle is modulated using the MPPT approach. It is not, however, appropriate for ESS integration into standalone applications.

Shailendra Kumar *et al* (2020) [15] have suggested the solar PV (photovoltaic) system with a single-phase grid that is interactive, versatile, and capable of smooth power transmission. That adaptable PV battery technology contributes to raising the standard of the convenience grid's power output. However, subpar synchronisation strategies result in instability, harm to delicate loads, and even the demise of the distribution network itself.

3 Proposed Work Explanation

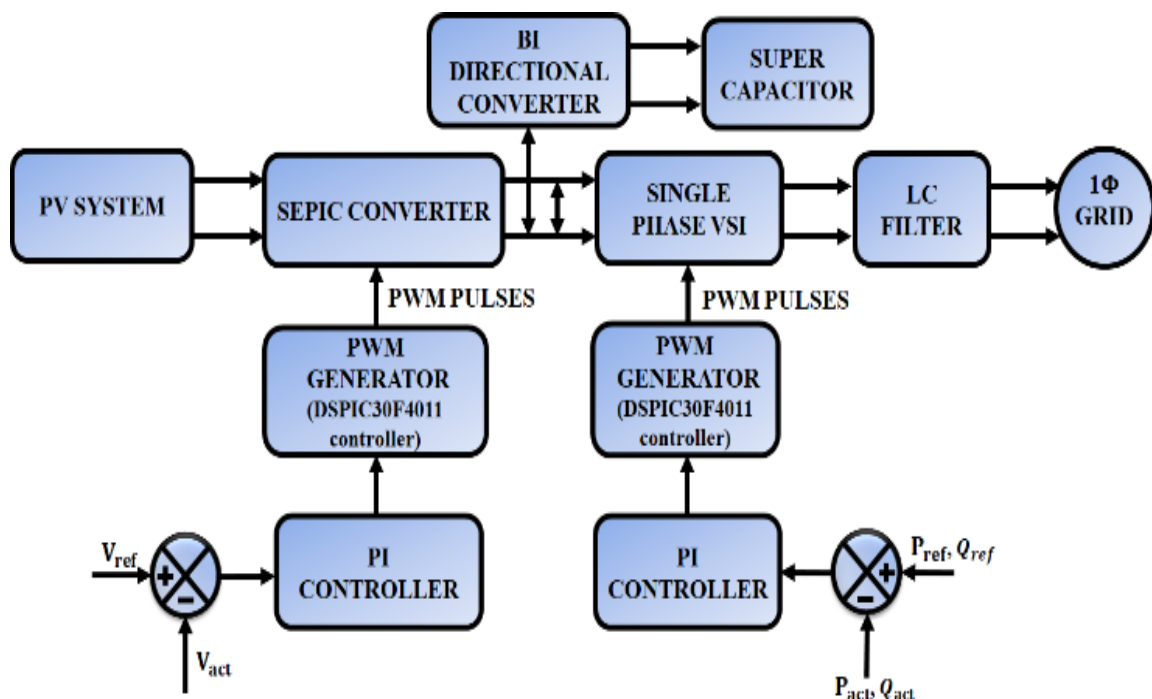


Figure 1: Block Diagram for Proposed System

The proposed approach involves implementing a PV-fed Sepic converter for a grid-connected system using an ultra-capacitor. The grid is synchronised with applications for renewable



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energy sources, such as PV sources. A SEPIC converter is used to send the solar system's voltage to the inverter. An energy management technique is advised to regulate the converter by current and the DC by voltage. One VSI, which changes the DC voltage to an AC voltage, feeds the converter's output onto the grid. A DC-DC, DC-AC, and storage unit connected to a bidirectional converter and the PV power source are seen to be powering the load. A super-capacitor is connected to the bidirectional converter's output. The battery works as a bi-directional system, guaranteeing that the DC power it stores is transmitted into the train to fuel both the system's functioning and the grid. The sepic converter receives electricity from the PV panels, boosts it, and converts it to AC through a single VSI before pumping it into the grid with the proper synchronisation. While enhancing grid performance, a PI controller is used to maintain the voltage on the DC connection.

3.1 PV System

PV materials and apparatus convert solar energy into electrical energy. A photovoltaic (PV) cell is a single PV device. Often thinner than four human hairs, these cells are made of different semiconductor materials. In order to boost their power production, PV cells are strung together to form larger units known as modules or panels.

3.2 SEPIC Converter

The duty cycle of a pulse may be adjusted by the SEPIC converter to either raise or lower an input voltage. Direct control of the Duty cycle with a potentiometer is one approach to do that. The SEPIC is a DC-DC converter that enables the yield voltage to be either not precisely, greater than, or indistinguishable from for its information.

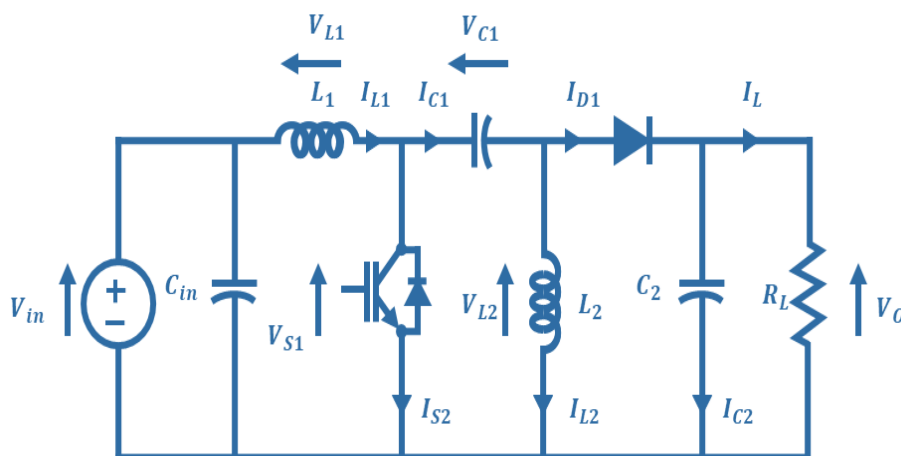


Figure 2: SEPIC Converter Block Diagram



3.3 Bi-Directional Converter

Bidirectional DC-DC converters supply the two-way power flow required for battery charging and discharging. The converter's duty cycle regulates charging and discharging according to the battery's state of charge and the flow of electricity.

3.4 Super Capacitor

A super-capacitor (SC), sometimes known as an ultra-capacitor, is a high-capacity capacitor that has reduced voltage requirements but a capacitance value that is substantially higher than that of typical capacitors. Electrolytic capacitors and rechargeable batteries left a hole that is now filled. Smaller units are used as a backup power source for static random-access memory (SRAM).

3.5 LC Filter

Low-pass filters can be replaced with LC or LCL filters, which have inductor and capacitor values that are relatively modest. Due to the two inductors, the LCL filter requires more room and is more expensive. Depending on the filter type, there are differences in the efficiency, price, losses, weight, and size. An LC filter is created in this work.

3.6 Single Phase VSI

Two-stage converters are part of an inverter system supplied by a rectifier. This study describes inverter-side control. The duty cycle may be calculated using the rectifier side control. Voltage control is necessary for the majority of inverter applications. Due to changes in the inverter source voltage and internal regulation, this control may be necessary. The three categories it may be broken down into are control of the voltage supplied to the inverter, control of the voltage within the inverter, and control of the voltage returned by the inverter.

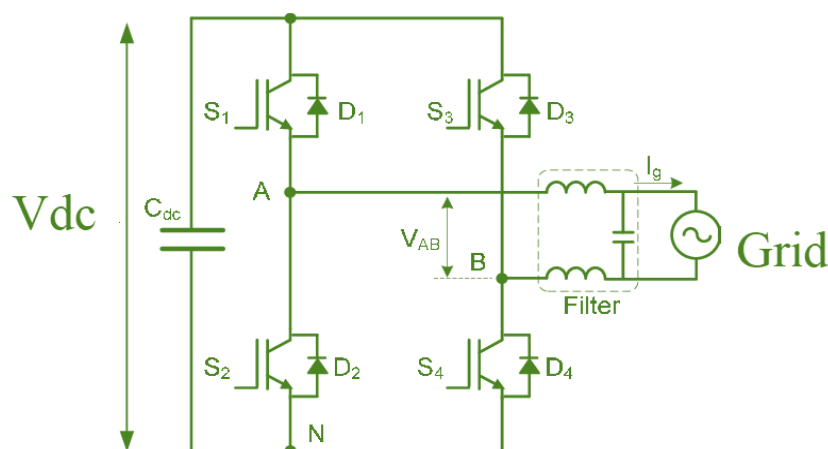


Figure 3: Block diagram of single phase inverter via grid



3.7 PWM Generator

The pulse-width-modulated signal is generated and received by the switch inside the buck-boost converter. The PWM generator genuinely divides the average power drop into separate components. The average voltage and current levels are given to the load side by keeping the switch ON for a longer amount of time than it is off. The main responsibility of the PWM generator is to produce the pulse-width-diversified gate pulse wave that is supplied to the switch of the converter.

3.8 PI Controller

One type of feedback controller is the proportional integral controller, or PI controller. It powers the plant, which is managed by a weighted sum of errors and the integral of that value. From motion control to aerospace, from slow to fast systems, PI-controllers have been employed to govern almost every process now in use. Additionally, PI-Controllers need to be returned often due to fluctuations in operating points and changes in system dynamics. This has led to in-depth research into the capabilities and prospects of the so-called adaptive PI controllers.

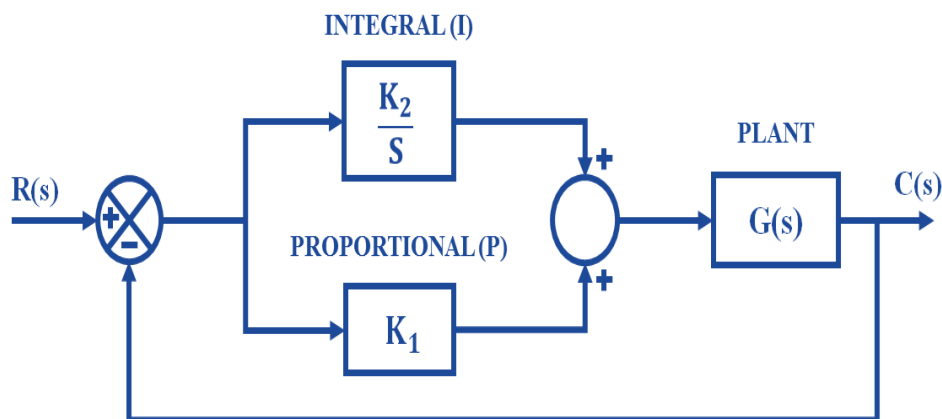


Figure 4: Basic block of PI Controller



4 Results and Discussion

4.1 Hardware View

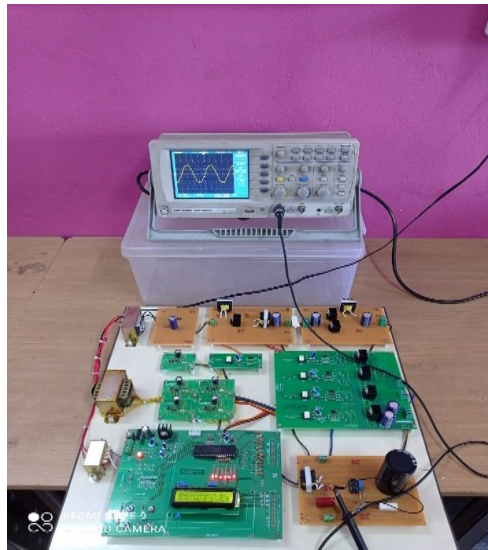


Figure 5: *Hardware View*

A grid-connected solar PV system employing the DSPIC30F4011 controller is shown with a SEPIC converter in Figure 5. The topic of this paper includes a PV system, an LC filter, a bidirectional DC-DC converter, a PWM generator, a PI controller, a single-phase VSI, and a DC-DC converter. Applications for renewable energy sources, such as PV sources, are synchronised with the grid. Using a SEPIC converter, the inverter receives voltage from the solar system. A proposed energy management system would regulate the DC by voltage and the converter by current. One VSI, which changes DC voltage to AC voltage, transmits the converter's output to the grid. The load is fed by a bidirectional converter connected to the PV power supply using a DC-DC, DC-AC, and storage unit. A super capacitor is attached to the bidirectional converter's output. Various applications use supercapacitor instead of long-term, compact energy storage.



4.2 Experimental Analysis

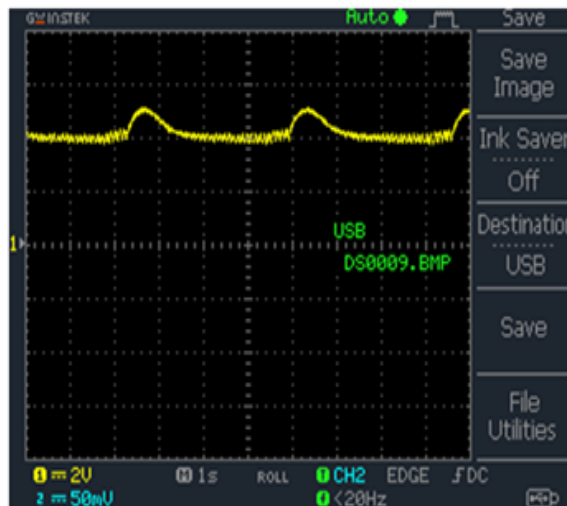


Figure 6 (a): *Input DC voltage supply Waveform*

Figure 6(a) displays the waveform of the input DC voltage supply. A DC power supply is a power source that delivers direct current (DC) voltage to power a device. Another term for a DC power supply that is widely used on an engineer's or technician's bench for various power testing procedures is a bench power supply.

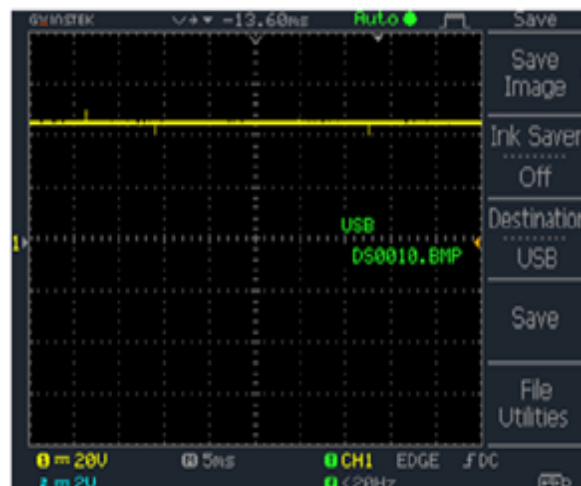


Figure 6 (b): *Converter Output DC Voltage Waveform*

Figure 6(b) shows that converter output DC voltage waveform. In contrast to V_g , the converter's output voltage V is controlled and has a different magnitude and perhaps polarity.



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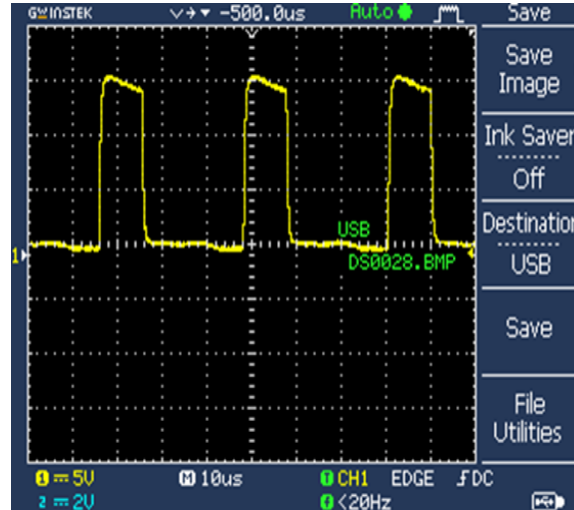


Figure 7: Pulse Waveform for Converter

Pulse waveform for converter is shown in Figure 7. The quantity of pulses in the dc output voltage that occur within a single interval of the ac source voltage is known as the pulse number.

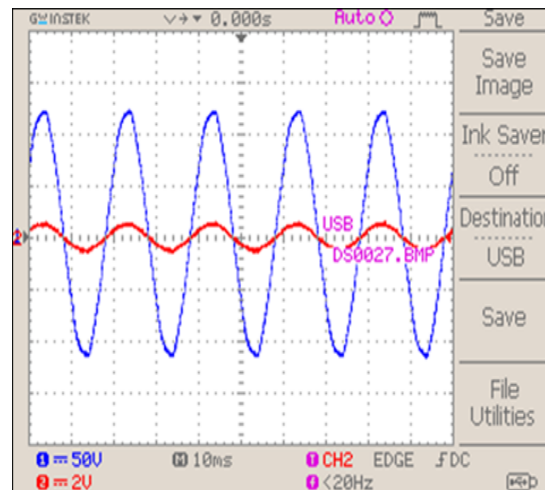


Figure 8: Grid Synchronization Output

This grid synchronization output is shown in Figure 8. In an alternating current (AC) electric power system, synchronization is the process of matching the frequency, phase, and voltage of a generator or other source to an electrical grid.



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5 Conclusion

The control of a bidirectional converter is shown. The inverter receives voltage from the solar system through a SEPIC converter. An energy management approach is provided to control the DC by voltage and the converter by current. Single-phase VSI, a device that transforms DC voltage into AC voltage, is used to send the converter's output to the grid. A storage device, a DC-DC and DC-AC converter, as well as a PV power supply through a bidirectional converter, are all seen to be feeding the load. The bidirectional converter's output is connected to a super capacitor. Supercapacitor are employed in multiple quick charge and discharge cycles in place of long-term compact energy storage. Connected to the LC filter is the single-phase grid. This combines the SEPIC converter and PWM.

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