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Fused Converter Based Hybrid System Using Three State Switching Cell for High Power Applications

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ABSTRACT: Renewable energies are derived from natural processes that are replenished constantly and have various forms. This paper presents a new converter configuration for a hybrid fuel cell and photovoltaic systems with maximum power point tracking (MPPT) technique. This configuration allows the two sources to supply the load separately or simultaneously depending on availability. The converter is a combination of CUK and SEPIC converter. This paper also presents a step up and step down dc to dc converter based on the three state switching cell. It can be used for high power applications. The circuit consists of two switches two diodes and two coupled inductors. This topology has 3 switching stages, thus the name given as three state switching cell. General advantages of 3SSC circuits over conventional topologies are, the inductor is designed for twice the switching frequency, with consequent reduction of size and the current through the switches is half of the input current .Hybrid system transfer the energy to 3SSC through fused converter which is then fed to the drives for high power application .The two converters both 3SSC and fused are closed loop controlled using PI controllers, hence stability is obtained. It implemented using MATLAB.

KEYWORDS: Fused Converter, 3SSC-Three State Switching Cell, High Power Application.

I.INTRODUCTION

The proposed system consists of a hybrid system comprising solar and fuel cell where solar power is MPPT controlled and fuel cell is closed looped to get controlled output voltage. The output of which is given to 3SSC boost converter which is also closed looped using PI controller whose output is then fed to inverter then to motor used for high power applications.

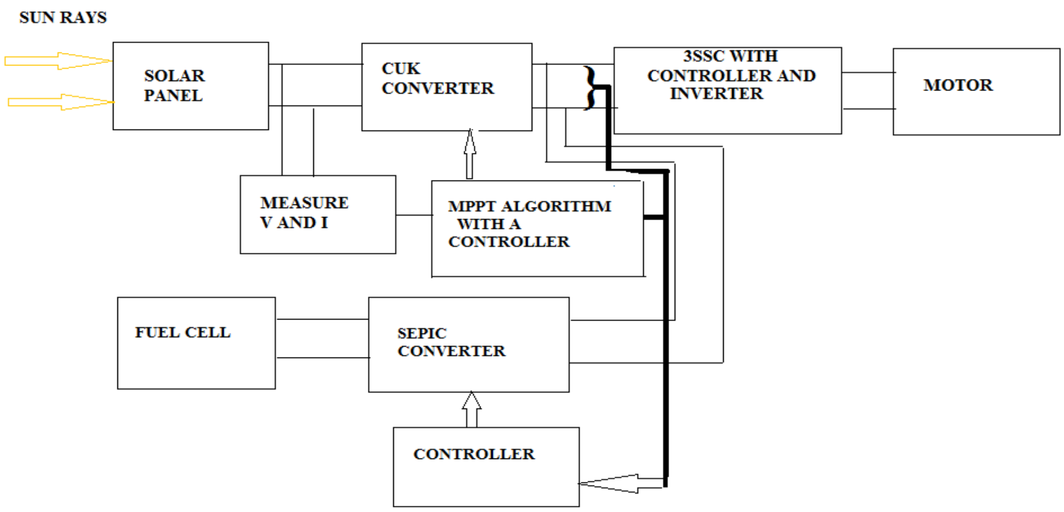

Fig 1.Proposed system block diagram

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With the increasing threat of global warming and the depletion of fossil fuel reserves, many are looking at sustainable energy solutions to preserve the earth for the future generations. Other than hydro power and wind, photovoltaic energy and fuel cell hold the most potential to meet our energy .Solar energy is present throughout the day, but the solar irradiation levels vary, due to the sun's intensity and unpredictable shadows cast by clouds, birds, trees, etc. The common inherent drawback of wind and photovoltaic system, are their intermittent natures that make them unreliable. Hybrids renewable energy system utilizes two or more energy sources, usually solar and wind power but here we use PV and fuel cell combination. The major advantage of a hybrid system is that, when solar and fuel cell power production is used together, the reliability of the system is enhanced. However, by combining these two intermittent sources and the system's power transfer efficiency and reliability can be improved significantly. When a source is unavailable or insufficient in meeting the load demands, the other energy source can compensate the deficit. Several hybrid wind and PV power systems with MPPT technique are discussed. Most of the hybrid systems require separate DC/DC converters and passive filter at the input side which increase the cost and makes circuit as bulky. The proposed circuit operates in 4 modes. The circuit operates as CUK converter when only PV source is available. It acts as a SEPIC converter when only wind source is available. When both the sources are available the switches will turn ON. When both sources are unavailable the switches will turn OFF. The CUK-SEPIC fused converters have the capability to eliminate the high frequency current harmonics in the wind generator. This eliminates the need of passive input filters in the system. This design produces power at all times by efficiently using freely available renewable resources. They can also support individual and simultaneous operations by providing constant output at the load.

Pulse-width modulated (PWM) converters are currently used in the majority of DC-DC conversion applications. Widespread applications of DC-DC converters include UPS, variety of electronic systems, energy systems for telecommunications, systems for utilization of solar energy, DC motor drivers and energy systems for satellites. Also DC-DC converters are often found as basic building blocks for other types of power converters. This paper introduces a new family of PWM DC-DC non-isolated converters. The new converters are generated using three-state commutation cells. Comprising two active switches, two diodes and coupled inductors. The main advantages over the classical converters are low conduction and commutation losses, and low input and output current ripple. Due to these features, the new converters are suitable for high voltage and high current applications. Earlier days, conventional dc-dc converters are used single switch and hard switching technique. It have low power density and large switching losses. To avoid these limitation, we use soft switching, so it reduces overlap between voltage and current. By using snubber circuit switching losses can be reduced .This circuit integrates the advantage of reduced voltage across the switches using three level commutation cell, and decreased switching losses obtained from a soft switching technique. By using interleaving technique in high current applications, output ripples can be reduced. This paper presents the method to obtain the three-state switching cells. The obtained cells are subsequently used to synthesize a new family of DC-DC three-state switching converters. In the last few years, many converters based on the 3SSC have been proposed. The cell can be obtained by the association of two 2-state PWM cells (2SSC) interconnected to a center tap autotransformer, from which novel converters can be derived. General advantages of 3SSC circuits over conventional topologies are, the inductor is designed for twice the switching frequency, with consequent reduction of size and the current through the switches is half of the input current. In the 3SSC circuits, part of the input power is delivered to the load by the transformer instead of the main switches, thus reducing conduction and commutation losses and lower cost switches can be used. Here we describe non overlapping mode and continuous conduction period. When duty ration is less than 0.5, non-overlapping mode can attained.

II. PROPOSED SYSTEM

A hybrid wind-solar energy system is shown in Fig 2, where one of the inputs is connected to the output of the PV array and the other input connected to the output of a fuel cell . The fusion of the two converters is achieved by reconfiguring the two existing diode from each converter and the shared utilization of the CUK output inductor by the SEPIC converter. Here we are using P&O algorithm since which is the most simplest one available .Fused converter operates in four modes:

1)When both sources are available 2)When both sources are not available 3) When only solar energy is available 4) When only fuel cell energy is available.

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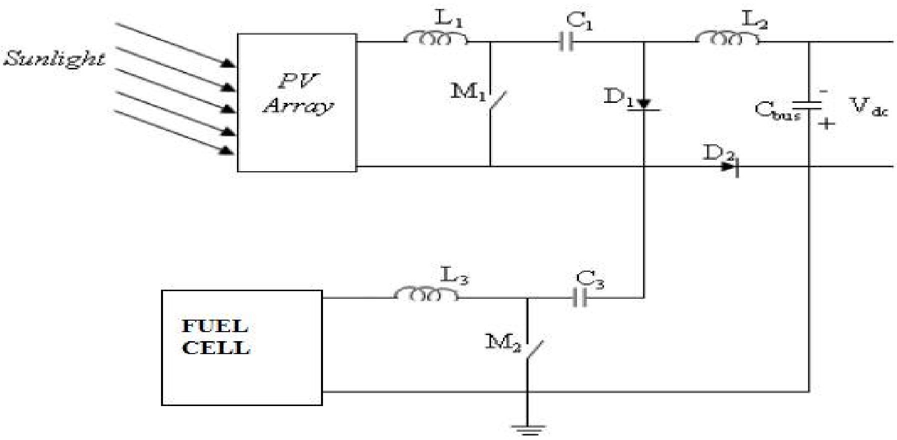

Fig 2. Fused converter

3SSC converters are actually evolved from conventional push pull converters. In order to make 3SSC boost circuits, we can replace high frequency transformer into coupled inductors. For this we can assume the turns ratio of central tap autotransformer is unity and ideal. Also connect the negative pole of the output voltage stage to the input negative pole. Thus we can achieve a converter with less switching losses. Characteristics of the 3SSC converters are[1]:Reduced size, and volume of magnetics, which are designed for twice the switching frequency analogous to the interleaved converter. The current stress through each main switch is equal to half of the total output current, allowing the use of semiconductors with lower current ratings. Losses are distributed among the semiconductors, leading to better heat distribution and consequently more efficient use of the heat sinks. Part of the input power, i.e., 50%, is directly transferred to the load through the diodes and the coupled inductors(autotransformers), and not through the main switches. As a consequence, conduction and switching losses are reduced. The use of the 3SSC allows the parallel connection of switches and, therefore, inexpensive power devices and drives can be used. Energy is transferred from the source to the load during most part of the switching period, which is a distinct characteristic of the proposed converter, since in other type converters, it only occurs during half of the switching period. As a consequence, reduction of current peaks and also conduction losses are expected. The drive circuit of the main switches becomes less complex because they are connected to the same reference node, what does not occur in the interleaved boost converter. Several assumptions have to considered for the analysis of new 3SSC converters

1) Converters are operates in steady state.
2) Switching frequency is constant and PWM is employed to drive the switches.
3) The gating signals of the switches are 1800 displaced.
4) The turns ratio of the autotransformer is unity.
5) The magnetizing current is much lower than the load current.
6) All semiconductor and passive elements are ideal.

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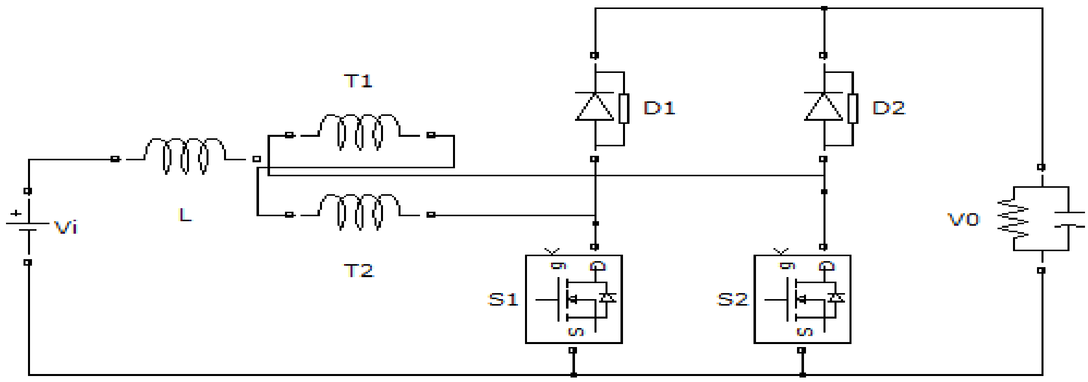

Fig 3.Three State Switching Cell Converter

III. SIMULATION RESULTS

For simulating Fused converter, in which SEPIC for fuel cell consists of a 1.9926 mH inductor and a 1.69µF capacitor , CUK for solar consists of a 2.516 mH inductor and a 6.77 µ F capacitor and fused portion consists of a 4.5086 mH inductor .Output voltage is obtained as 28V. For pulse generation we use PWM generation and a controlled circuit is used to control output voltage. The repeating sequence being utilized in the model has an operating frequency of 20 KHz.

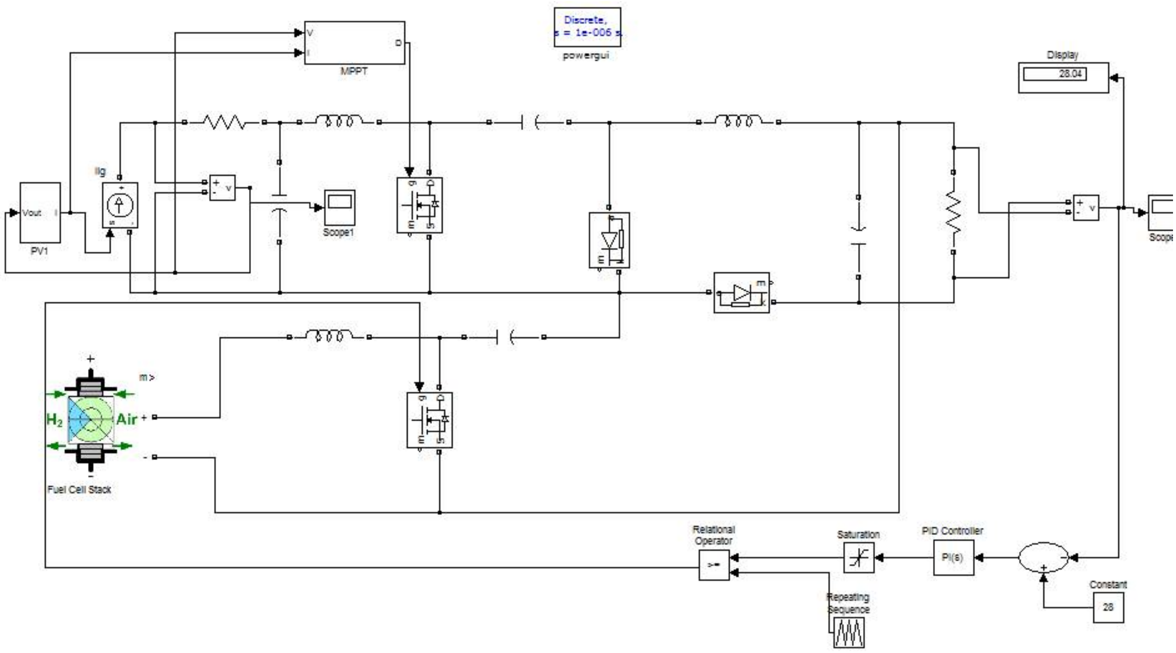

Fig 4: Simulink model of Fused converter

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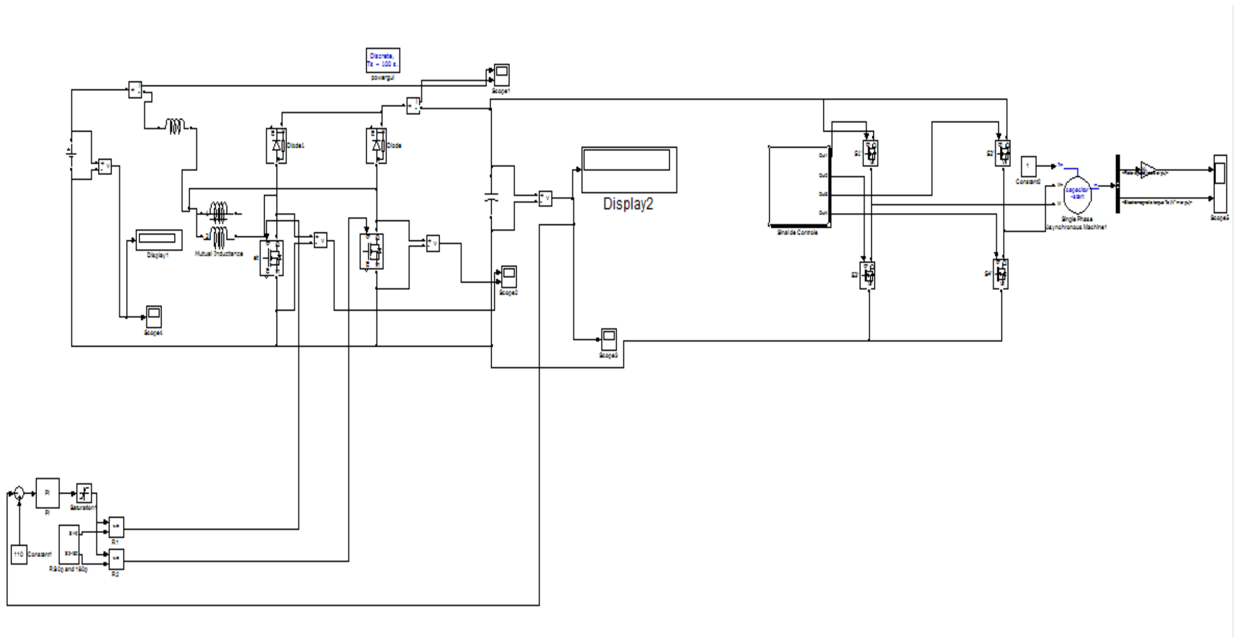

Fig 5: Simulink model of 3SSC boost converter,inverter and motor

Observing the simulation results, gate pulses given to two switches are complementary in action. Analysing the inductor current, the switching frequency is half of the ripple current frequency, it leads to the reduction of magnetic elements.28V of boost converter is step upped as 110V at duty ratio 0.3.

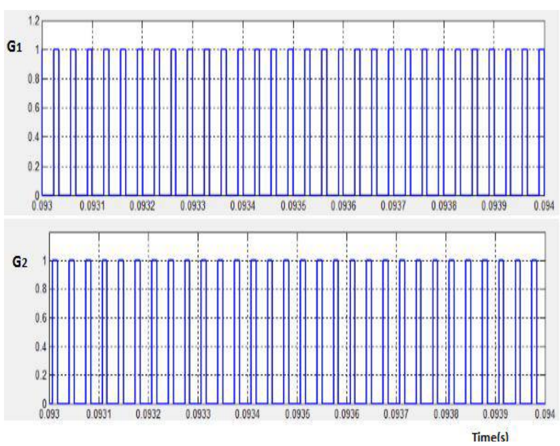

Fig. 6 Gate pulses for switches of 3SSC

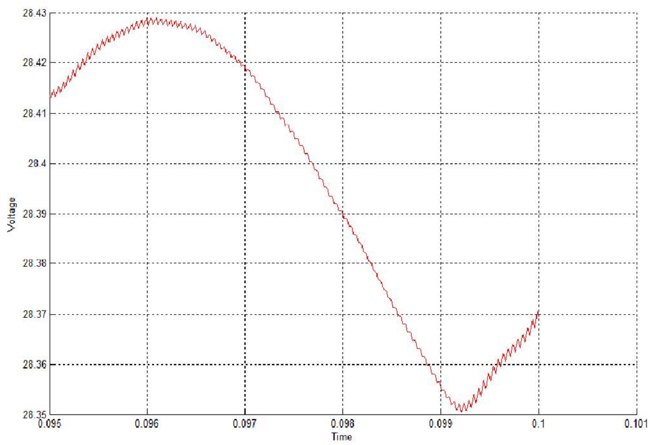

Fig 7: Simulation waveform of fused converter

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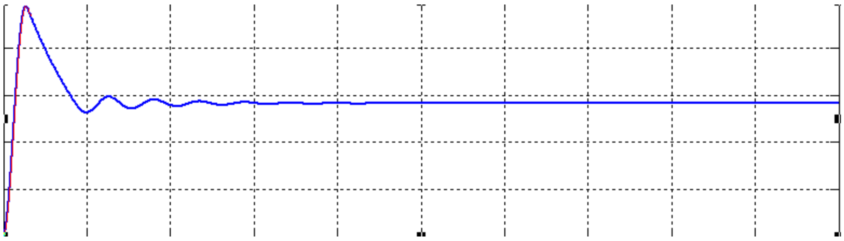

Fig 8**:** Simulation waveform of 3SSC boost converter

IV. CONCLUSION

In this paper the CUK-SEPIC converter has been proposed for hybrid system instead of conventional multiple boost converters. The system has following advantages compared to traditional approach:
1) Two boost converters are replaced by single CUK-SEPIC fused converter. 2) Additional input filters are not required to filter out high frequency harmonics because of inherent input filter. 3) Energy storage and transfer depends on capacitors of converter. 4) Both renewable energy sources can be stepped up/down by using converter and which supports wide range of PV and wind input variation. 5) It supports both individual and simultaneous operation of sources.

Fused coverer and boost converter based on three state switching cell for high application were simulated and results are noted. In Step up converter an input voltage 28 V is given and got 110 V as output. Relationship between input-output voltages and duty ratio is observed in boost 3SSC converter as V0/Vi= 1/ (1-D).Simulations are done in SIMULINK/MATLAB R2010a. From the simulation results high output power is obtained and less amount of ripples were observed.

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