A Novel Approach for Power Quality Improvement of Grid Connected Renewable Energy Using CUK and SEPIC Converter Topology

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Abstract -- **This paper proposes Hybrid Renewable energy resources integrating using CUK and SEPIC converter. Among the available renewable energy resources, the wind and photo voltaic energy is being widely utilized because of their abundance and sustainability to generate electricity, in wind and PV based power conditioning system interfacing converters system acts as the major components which is responsible in order to make the output compatible to the load. The proposed system can boost and conditions the desired output voltage efficiently when a low voltage is introduced. SEPIC inverters have been recently attracted by the researchers due to the unique quality of the converter topology and it is successfully proposed for alternative power conversion concept as they have both voltage buck and boost capabilities. It has economical power conversion, high performance, minimal components count, increased efficiency, improved power factor and reduced cost.**

Keywords— **CUK Converter; SEPIC Converter; hybrid system; renewable energy.**

I. INTRODUCTION

With increasing concern 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, wind and photovoltaic energy holds the most potential to meet our energy demands. Alone, wind energy is capable of supplying large amounts of power but its presence is highly unpredictable as it can be here one moment and gone in another. Similarly, solar energy is present throughout the day but the solar irradiation levels vary due to sun intensity and unpredictable shadows cast by clouds, birds, trees, etc. The common inherent drawback of wind and photovoltaic systems are their intermittent natures that make them unreliable. However, by combining these two intermittent sources and by incorporating the system's power transfer efficiency and reliability can be improved significantly
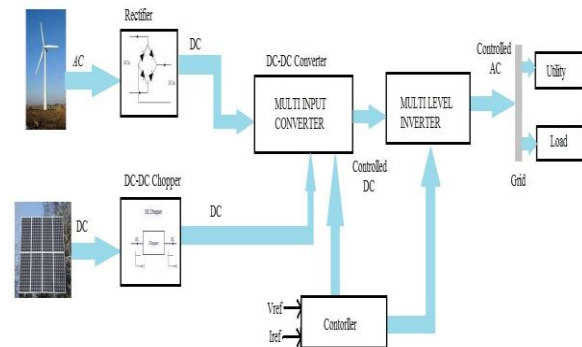
Virtually all regions of the world have renewable resources of one type or another. By this point of view studies on renewable energies focuses more and more attention. Solar energy and wind energy are the two renewable energy sources most common in use. Wind Energy has become the least expensive renewable energy technology in existence and has peaked the interest of scientists and educators over the world. Photovoltaic cells convert the energy from sunlight into DC electricity. PVs offer added advantages over other renewable energy sources in

that they give off no noise and require practically no maintenance. Hybridizing solar and wind power sources provide a realistic form of power generation. Many studies have been carried out on the use of renewable energy sources for power generation and many papers were presented earlier. The wind and solar energy systems are highly unreliable due to their unpredictable nature. In a PV panel was incorporated with a diesel electric power system to analyze the reduction in the fuel consumed. It was seen that the incorporation of an additional renewable source can further reduce the fuel consumption. When a source is unavailable or insufficient in meeting the load demands, the other energy source can compensate for the difference. Several hybrid wind/PV power systems with Maximum Power Point Tracking (MPPT) control have been proposed earlier. They used a separate DC/DC buck and buck- boost converter connected in fusion in the rectifier stage to perform the MPPT control for each of the renewable energy power sources. These systems have a problem that, due to the environmental factors influencing the wind turbine generator, high frequency current harmonics are injected into it. Buck and buck-boost converters do not have the capability to eliminate these harmonics. So the system requires passive input filters to remove it, making the system more bulky and expensive.

II.SCHEMATIC REPRESENTATION

The Schematic representation is shown in figure which describes the Grid Connected Renewable Energy Using Cuk and Sepic Converter Topology.

A.PV ARRAY

The PV array is constructed by many series or parallel connected solar cells [8]. Each solar cell is form by a PN junction semiconductor, which can produce currents by the photovoltaic effect. Typical output power characteristics curves for the PV array under different insolation are shown in Fig.2.It can be seen that a maximum power point exists on each power characteristic curve. Therefore, to utilize the maximum output power from the PV array.

B.WIND TURBINE

Among various types of wind turbines, the permanent- magnet synchronous wind turbine, which has higher reliability and efficiency, is preferred [13]–[16].

The power P_{wind} of the wind can be derived as

$$P_{\mathrm{wind}} \qquad = \frac{1}{2}\rho A V_{\mathrm{wind}}^3 \qquad (1)$$

where ρ is the air density (kg/m), A is the area (m) swept by wind blades, and V_{wind} is the wind speed (m/s). It had been proven that the energy conversion efficiency,C_P, of the wind turbine is a function of the tip speed ratio, λ_{tip}, which is defined as

$$\lambda_{tip}= \omega r/V_{wind} \qquad (2)$$

where ωr is the rotational speed (rad/sec) of wind turbine blades, is the radius of the area swept by wind turbine blades. A typical curve of the C_P versus λ_{tip} is shown in Fig, where the maximum value of C_P is only achieved at a particular tip speed ratio. Since the speed of the wind is not constant, the rotational speed of the wind turbine must be adjustable to ensure a constant tip speed ratio to gain the maximum C_P. The output current change of the wind turbine will cause of the rotational speed as well as λ_{tip} to change. Since C_P is a function of λ_{tip}, the output power of the wind turbine will change, too. Therefore, by controlling the output current of the wind turbine, the rotational speed of the wind turbine blades can be adjusted to achieve the appropriate tip speed ratio. Eventually, the maximum value of C_P can be obtained and the maximum power can be transferred from the airstream to the wind turbine to produce the maximum electrical power.

C.CONVERTER TOPOLOGY

1.CUK converter :

The Cuk converter is a type of DC-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude. Cuk converter is actually the cascade combination of a boost and a buck converter. The voltage gain is given by equation
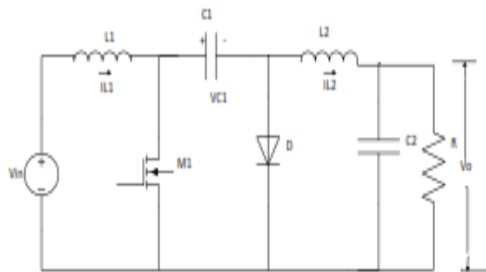
$$Vo= - Vin(D/(1-D))$$

Fig 1 Equivalent circuit of Cuk converter

A non-isolated Cuk converter comprises two inductors, two capacitors, a switch (usually a transistor), and a diode. Its schematic can be seen in fig1. It is an inverting converter, so the output voltage is negative with respect to the input voltage.

The capacitor C is used to transfer energy and is connected alternately to the input and to the output of the converter *via* the commutation of the transistor and the diode .

The two inductors L_1 and L_2 are used to convert respectively the input voltage source (V_i) and the output voltage source (C_o) into current sources. Indeed, at a short time scale an inductor can be considered as a current source as it maintains a constant current. This conversion is necessary because if the capacitor were connected directly to the voltage source, the current would be limited only by (parasitic) resistance, resulting in high energy loss. Charging a capacitor with a current source (the inductor) prevents resistive current limiting and its associated energy loss.

2. SEPIC Converter:

Single-Ended   Primary-Inductor Converter (SEPIC)   is   a   type   of DC-DC converter allowing the electrical potential (voltage) at its output to be greater than, less than, or equal to that at its input; the output of the SEPIC is controlled by the duty cycle of the control transistor.

A SEPIC is similar to a traditional buck-boost converter, but has advantages of having non-inverted output (the output has the same voltage polarity as the input), using a series capacitor to couple energy from the input to the output (and thus can respond more gracefully to a short-circuit output), and being capable of true shutdown: when the switch is turned off, its output drops to 0 V, following a fairly hefty transient dump of charge.
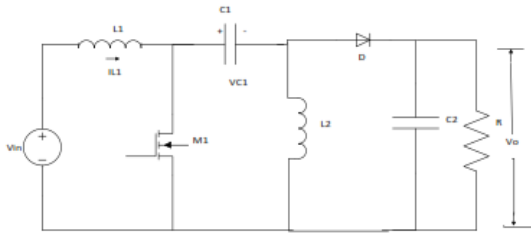
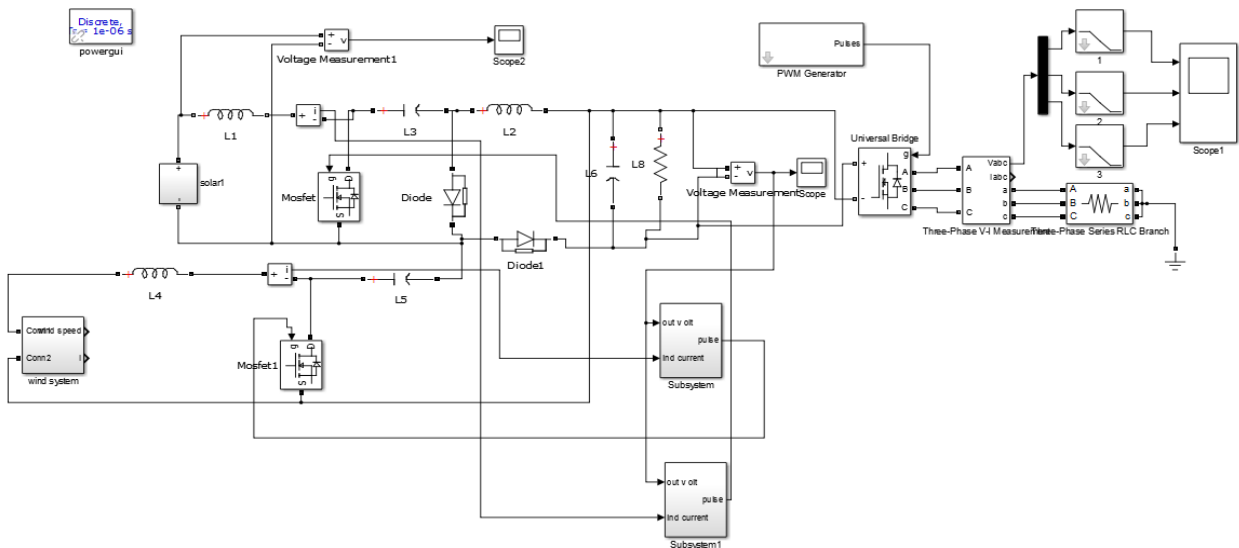Fig 2 Equivalent circuit of SEPIC converter

The schematic diagram for a basic SEPIC is shown in Fig2. As with other switched mode power supplies (specifically DC-to-DC converters), the SEPIC exchanges energy between the capacitors and inductors in order to convert from one voltage to another. The amount of energy exchanged

is controlled by switch S1, which is typically a transistor such as a MOSFET; MOSFETs offer much higher input impedance and lower voltage drop than bipolar junction transistors (BJTs), and do not require biasing resistors (as MOSFET switching is controlled by differences in voltage rather than a current, as with BJTs).

III.RESULT AND DISCUSSION

In this section, simulation results from given to verify that the proposed cuk and SEPIC output stage it can support individual as well as simultaneous operation. Here we get output of integrated wind and PV circuit maximum of 500V DC.
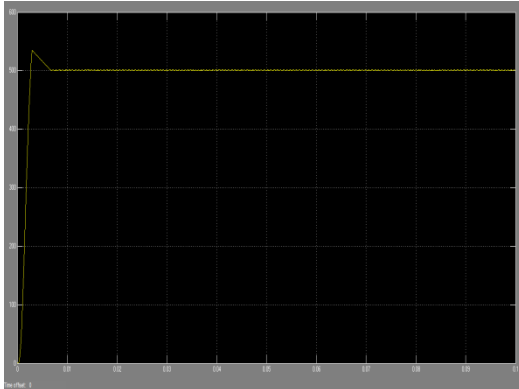
SIMULATION DIAGRAM:

Fig.3 CUK and SEPIC converter output.

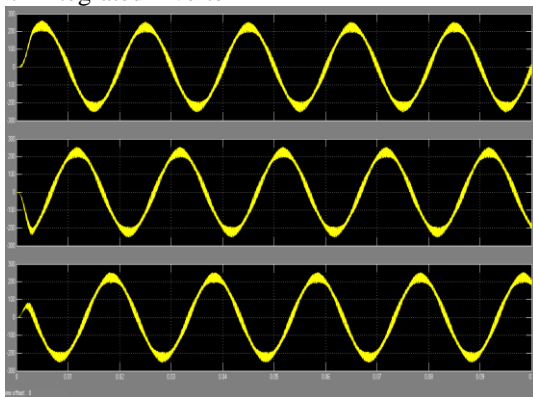Here we get output of CUK and SEPIC converter with integrated inverter

Fig. 4 CUK and SEPIC converter with integrated inverter

IV.CONCLUSION

In this paper a new multi-input CUK-SEPIC rectifier stage for hybrid wind/solar energy systems has been presented.
The features of this circuit are:
1) Additional input filters are not necessary to filter out high frequency harmonics;
2) Both renewable sources can be stepped up/down (supports wide ranges of PV and wind input);
3) MPPT can be realized for each source;

4) Individual and simultaneous operation is supported.

In this paper, the operation principle of the proposed inverter has been verified by using been introduced. Simulation results have been presented to verify the features of the proposed topology.

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