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Design of DC To DC Converter for Hybrid Wind Solar Energy System

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ABSTRACT: Environmentally friendly solutions are becoming more prominent than ever as a result of concern regarding the state of our deteriorating planet. This project presents a new system configuration of the front-end converter stage for a hybrid wind/photovoltaic energy system. The Aim of this project is to implement the converter and inverter for the wind and solar hybrid system. For the hybrid system, extracting energy from wind and solar as possible and feeding the load with high quality electricity are the two main targets. This strategy makes hybrid DG system work properly when a voltage disturbance occurs in distribution system, and it stays connected to the main grid. Boosting the DC voltage to enough level using the converter and obtaining pure AC voltage from the inverter are the keys to realize the above targets. This configuration allows the two sources to supply the load separately or simultaneously depending on the availability of the energy sources. The inherent nature of this cuk-SEPIC fused converter, additional input filters are not necessary to filter out high frequency harmonics. This project describes about the closed loop mechanism of cuk and SEPIC converter and simulated results are presented.

KEYWORDS: Hybrid System, Converters, Wind Generators, Photo Voltaic, Solar Voltage Sag, PI Controller.

1. 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. Hybrids renewable energy system utilizes two are more energy production methods, usually solar and wind power. The major advantage of solar / wind hybrid system is that when solar and wind powers production is used together, the reliability of the system is enhanced. The additionally the size of the battery storage can be reduced slightly as there is less reliance on one method of power production. Often, there is no sun, there is plenty of wind. 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 for the difference. Several hybrid wind/PV power systems with MPPT control have been proposed and discussed in works [1]-[5]. Mostof the systems in literature use a separate DC/DC boost converter connected in parallel in the rectifier stage to perform the MPPT control for each of the renewable energy power sources [1]-[4]. A simpler multi-input structure has been suggested by [5] that combine the sources from the DC-end while still achieving MPPT for each renewable source. The structure proposed by [5] is afusion of buck and buck boost converter. The system in literature requires passive input filters to remove the high frequency current harmonics injected in to wind turbinegenerators [6]. The harmonic content in the generator current decreases its life span and increases the power loss due to heating [6].

In this paper an alternative multi-input rectifier structure is proposed for hybrid wind/solar energy systems. The proposed design is a fusion of the cuk and SEPIC converter. The inherent nature of these two converters eliminates the

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need for separate input filters. These fused converters are compared with separate parallel operation of cuk and SEPIC converters. The circuit operating principles will be discussed in this paper. Simulation results are provided to verify with the feasibility of the proposed system.

II. PROPOSED SYSTEM BLOCK DIAGRAM

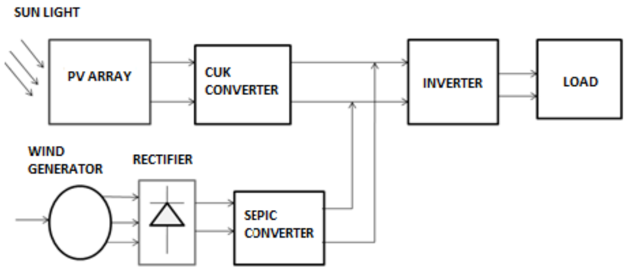

Figure 1: Block diagram of hybrid system

An alternative multi-input rectifier structure is proposed for hybrid wind/solar energy system. The proposed block diagram is a fusion of the cuk and SEPIC convertersis shown in figure 1, where one of the inputs is connected to the output of the PV array and the other input connected to the output of a generator [1]. The fusion of the two converters output is combined and it is given to the rectifier block. The rectified AC voltage is given to the load. This configuration block diagram shown, allows each converter to operate normally individually in the event that one source is unavailable [2].

III. DESIGN OF CONVERTERS

The proposed circuit diagram was shown in Figure 2.The converters have designed for the resistive load of 100W power,using the basic formulae, with the maximum duty ratio to achieve a output voltage of 270V [3]. The input output relationship for cuk is given by (1) and for the SEPIC is given by (2)

$V_{dc}/V_{pv}= d_1/ 1-d_1$ (1)

$V_{dc} /V_w = d_2/ 1-d_2$ (2)

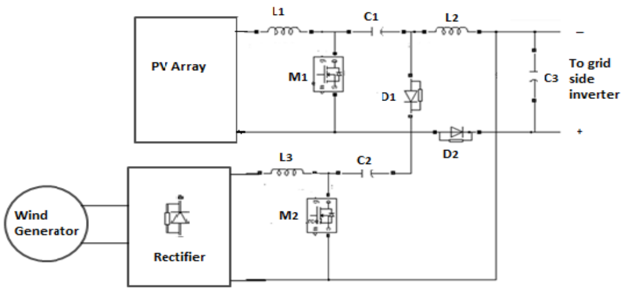

Figure 2: Basic circuit diagram of hybrid system

The inductor L1 and L2 for cukare given by using the equation (3) and (4) and the capacitance for the converter is given by using equation (5) and (6).

$L_1 = (1-d_1)^2 R/2d_1f$ (3)

$L_2 = (1-d_1)R/2f$ (4)

$C_1 = d_1/2fR$ (5)

$C_2 = 1/8fR$ (6)

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The inductance and capacitance for SEPIC converter is given by equations (7) and (8).This converter allows each converter to operate normally individually in the event that one source is unavailable .In this case, D_1 turns off and D_2 turns on the proposed circuit becomes SEPIC converter only when wind sources is available and the other hand, if only the PV source is available, then D_2 turns off and D_1will be on and the circuit becomes a Cuk converter.

$$L_1 = L_2 = ½ * V_{in} * d_{2(max)} / \Delta I_L f \quad (7)$$

$$C_1 = C_2 = I_{out} * d_{2(max)} / \Delta V f \quad (8)$$

IV. HYBRID SYSTEM WITH SEPARATE CONVERTERS CIRCUIT

The hybrid system with separate circuit is shown in Figure 3.In this, the converter are not fused, separate circuit is connected in parallel and the combined output is given to the inverter and output of inverter is given to the load .In this circuit the input to the cuk is from solar, the three solar panel of 24V is connected in series to get the input voltage of 72V. The switch is operated at a frequency of 25 KHZ .By varying the duty ratio converter output was boosted to 270V.The output from the wind generator is given as a input to the SEPIC converter. The rectified output of wind generator is46V DC is given for SEPIC converter and the output is boosted to a voltage of 260V by varying the duty ratio.

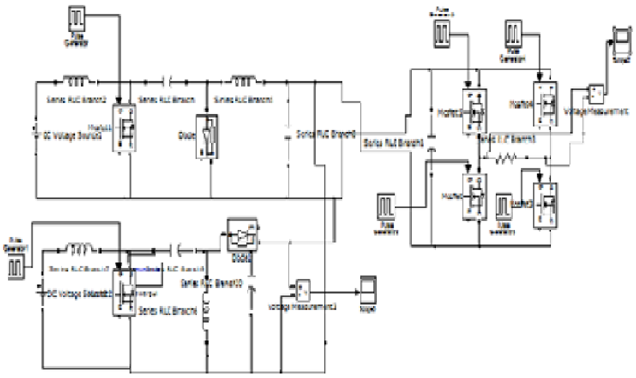

Figure 3: Hybrid system with separate converters in parallel

The both converters are combined in parallel to get the output voltage of 270V.The DC output voltage is given as input to a single phase inverter and rectified to a voltage of 230V

The hybrid system is simulated for both open and closed loop and the closed loop circuit was shown in Figure 4.

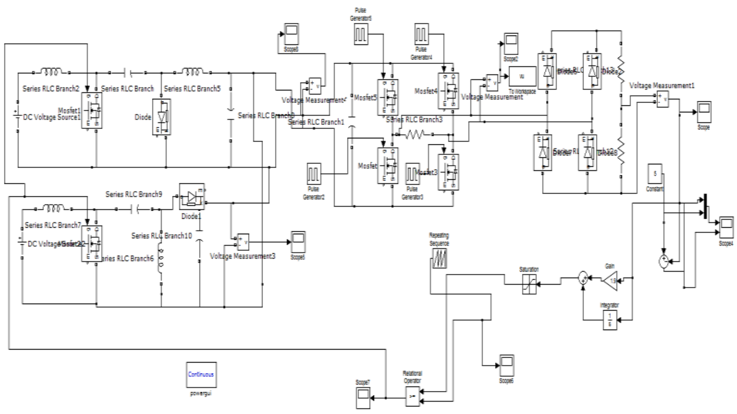

Figure 4: Closed loop control of hybrid system

The simulated output for open loop hybrid system is shown in Figure 5 and the closed loop output for the system was shown in Figure 6. The output was connected to a resistive load of 100W

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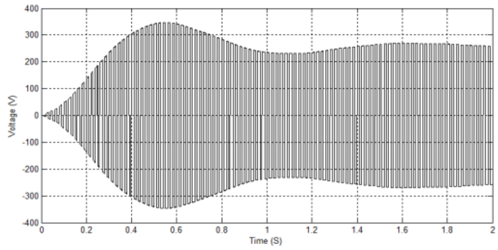

Figure 5: Open loop output of hybrid system

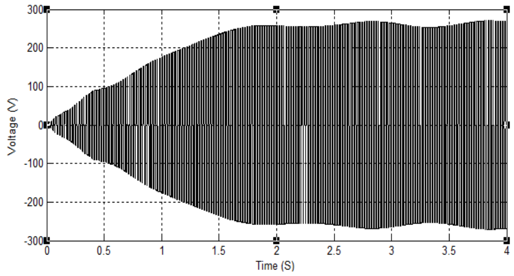

Figure 6: Closed loop output of hybrid system

V. HYBRID SYSTEM WITH FUSED/COMBINED CONVERTERS CIRCUIT WITH R LOAD

A system diagram with fused converters is shown in Figure 7, where one of the inputs is connected to the output of the PV array of 72V (Three solar panel of 24V connected in series) and the other input is connected of a generator of 46V DC [4].

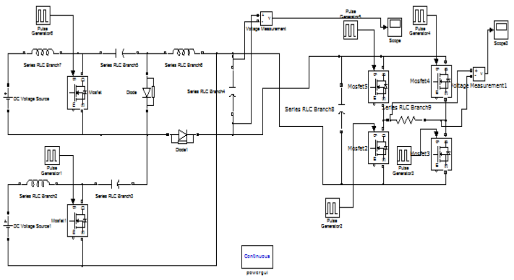

Figure 7: Fused hybrid system with open loop control

The fusion of two converters is achieved by reconfiguring the two existing diodes from each converter and shared utilization of the Cuk output inductor by the SEPIC converter [5]. This configuration allows each converter to operate normally individually in the event that one source is unavailable. The circuit is simulated for both open and closed loop and closed loop circuit was shown in Figure 8.

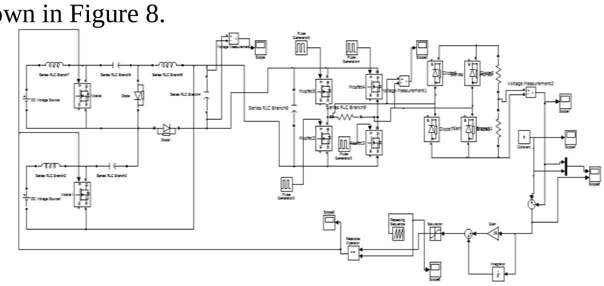

Figure 8: Fused hybrid system with closed loop control

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A. SOURCEAND LOAD SIDEDISTURBANCE FOROPEN AND CLOSED LOOP SYSTEM WITH R LOAD

The hybrid system with source and load disturbance is also performed for both open and closed loop system.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 [6]. Due to this drawback the output voltage of the solar will vary is referred as a source disturbance. Even with this disturbance we can able to achieve the required output voltage in the closed loop system [7].

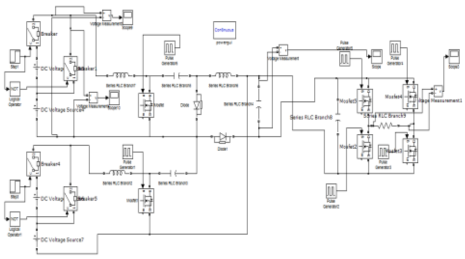

Figure 9: System with open loop source disturbance with R load

The circuit for open loop hybrid system with resistive loadis shown in Figure 9 and for closed loop is shown in Figure 10.

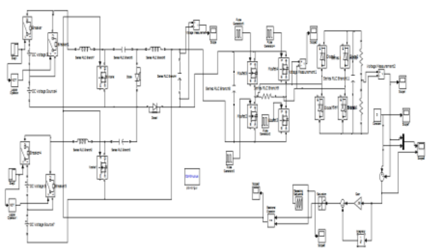

Figure 10: System with closed loop source disturbance with R Load

The load disturbance circuit for open and closed loop for is shown in Figure11 and Figure 12.

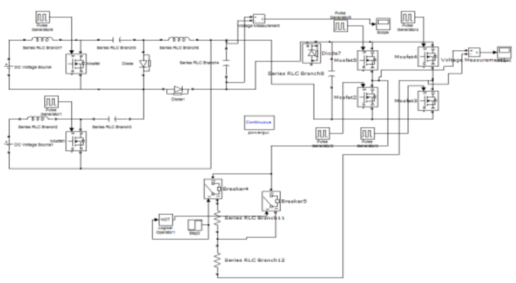

Figure 11: System with open loop load disturbance with R load

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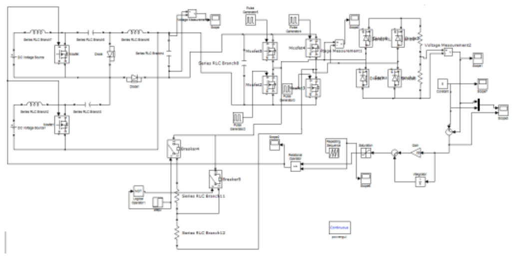

Figure 12: System with closed loop load disturbance with R load

The simulation output for the open loop of proposed system is shown inFigure 13 and output of closed loop system is shown in Figure 14.PI controller is used for the closed loop control.

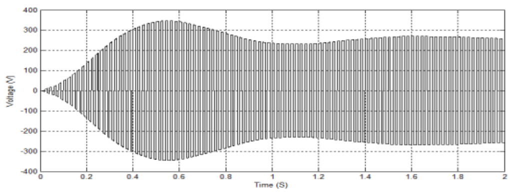

Figure 13: Open loop output of hybrid system

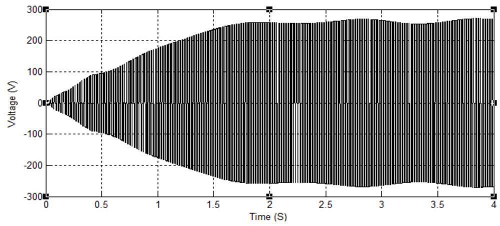

Figure 14: Closed loop output of hybrid system

The source disturbances output for open loop system is shown in Figure15 and for closed loop system is shown in Figure16. The disturbance was given at step 4 for open loo and closed loop and the change in voltage at step 4 is observed

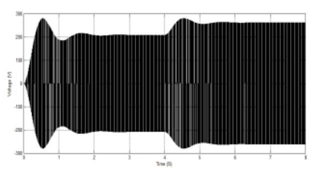

Figure:15 Open loop source disturbed output

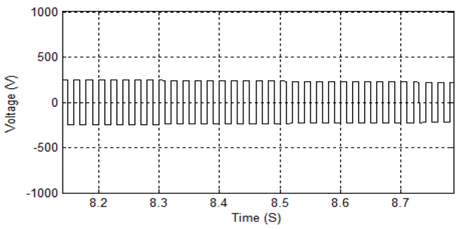

Figure:16Closed loop source disturbed output

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The fused converter circuit, when compared with the separate circuit, it is found that with reduced duty ratio the same output can be able to achieve and also the number components has reduced [8]. With this reduced inductance circuit if any change in input voltage can be boosted to a required output voltage.

VI. HYBRID SYSTEM WITH FUSED/COMBINED CONVERTERS CIRCUIT WITH RL LOAD

The hybrid system with Inductive load is also analysed and the simulation circuit was given in Figure 17.The same system with the inductive load the output is boosted to a voltage of 230V [9]. The input of the cuk is the 72V from solar panel and forSEPIC is the 46V DC from wind generator. The combined output of both the converter is boosted to a voltage of 270V.The 270V DC was rectified to a voltage of 230V AC by a single phase rectifier and this output is given to inductive load. This system is used to compensate for the voltage sag condition [10].

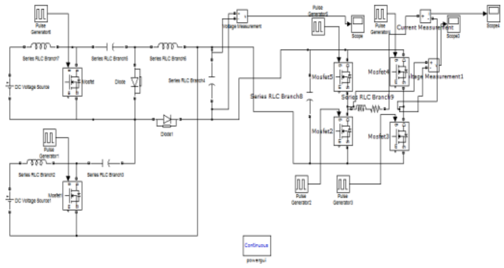

Figure 17: Open loop hybrid system with RL load

The hybrid system with inductive load was simulated for both the open and closed loop and the closed loop system was shown in Figure 18. PI controller is used for a closed loop voltage control [11]. The load disturbance was given for both open and closed loopsystem. The open loop load disturbance circuit for inductive load was shown in Figure 19.

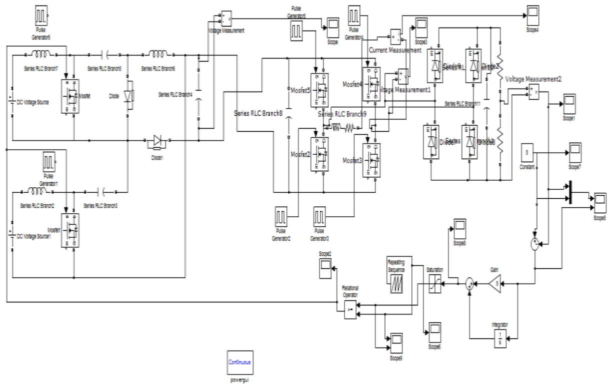

Figure 18: Closed loop hybrid system with RL load

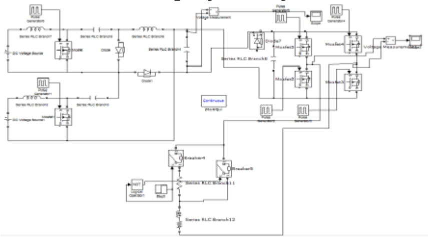

Figure 19: open loop hybrid system with RL load disturbance

The closed loop load disturbance circuit for inductive load was shown in Figure 20. The system is able to produce the same output voltage of 230V in open and closed loop control [12].

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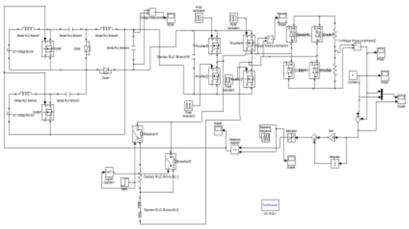

Figure 20: Closed loop hybrid system RL load disturbance

The simulation output for both the open and closed loop system was given in the Figure 21 and Figure 22 [13]. It is seen that the output voltage is 230V given for inductiveload, the open and closed loop load disturbance output is also shown in Figure 23 and Figure 24.

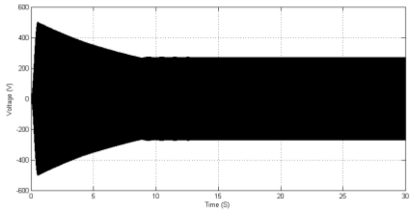

Figure 21: Open loop voltage of the hybrid system with RL load

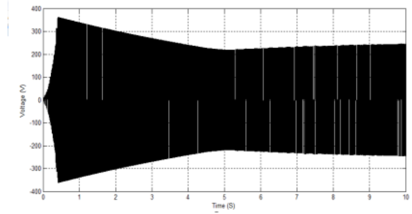

Figure 22: Closed loop voltage of the hybrid system with RL load

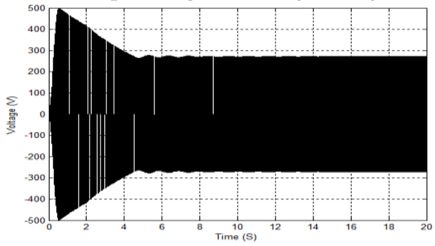

Figure 23: Open loop voltage of the RL load with load disturbance

Is is seen that the output is controlled to maintain the same voltage during the load disturbance. So the proposed system is able to meet the unbalance voltage sag condition [14].

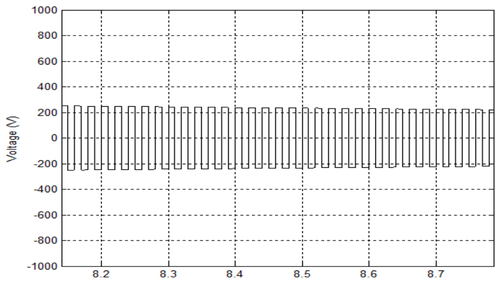

Figure 24: Closed loop voltage of RL load with load disturbance

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VII CONCLUSION

The complete model oftheproposed system is presented and designed using cuk and SEPIC converters for various load condition and also with source and load side disturbances.The controlstrategy of hybrid system is discussed for under unbalance voltage sag condition. The simulation resultsshown, it is seen that the closed loop performance is better when compared with the open loop system, whichis able to tolerate under various voltage sags condition.

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BIOGRAPHY

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