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Modified Converter Topology for Hybrid Wind and PV Systems

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ABSTRACT: Renewable energy sources also called non-conventional type of energy are continuously replenished by natural processes. Hybrid systems are the right solution for a clean energy production. Hybridizing solar and wind power sources provide a realistic form of power generation. Here, a hybrid wind and solar energy system with a converter topology is proposed which makes use of Cuk and SEPIC converters in the design. This configuration permits the sources to provide the load singly or at the same time reckoning on the provision of the energy sources. The proposed hybrid topology is designed and verified by using MATLAB/ SIMULINK. Furthermore, the high percentage of energy efficient conversion ratio is obtained.

KEYWORDS: Renewable energy, wind turbine, Cuk converter, Hybrid converters, SEPIC Converter, MPPT.

I.INTRODUCTION

Recent developments and trends in the electric power consumption indicate an increasing use of renewable energy. 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 [9]. 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 [15]. 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 [17], 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 1 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 [4]. 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 [4].

In this paper, a brand new device topology for hybridization the wind and solar power sources has been planned. During this topology, each wind and solar power sources are incorporated along employing a combination of Cuk and SEPIC converters, so if one among them is unprocurable, then the opposite supply will atone for it. The Cuk-SEPIC coalesced converters have the potential to eliminate the HF current harmonics within the generator. This eliminates the necessity of passive input filters within the system. These converters will support intensify and step down operations for every renewable energy sources. They'll additionally support individual and co-occurring operations. Solar power supply is that the input to the Cuk device and wind energy supply is that the input to the SEPIC device.

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The average output voltages created by the system are going to be adding of the inputs of those two systems. This consent of the planned hybrid system creates it extremely economical and reliable.

II.DC –DC CONVERTERS

DC-DC converters can be used as switching mode regulators to convert an unregulated dc voltage to a regulated dc output voltage. The regulation is normally achieved by PWM at a fixed frequency and the switching device is generally BJT, MOSFET or IGBT.

A. 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.

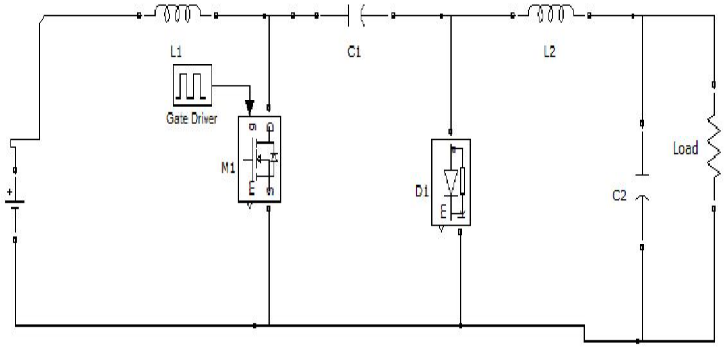

Figure1: CUK Converter

It has the capability for both step up and step down operation. The output polarity of the converter is negative with respect to the common terminal. This converter always works in the continuous conduction mode. The Ćuk converter operates via capacitive energy transfer. When M_1 is turned on, the diode D_1 is reverse biased, the current in both L_1 and L_2 increases, and the power is delivered to the load. When M_1 is turned off, D_1 becomes forward biased and the capacitor C_1 is recharged [10].

B. SEPIC CONVERTER

Single-ended primary-inductor device (SEPIC) could be a style of DC-DC device permitting the voltage at its output to be larger than, less than, or adequate that at its input. it is the same as a buck boost device. it has the aptitude for each accelerate and step down operation. The output polarity of the device is positive with relation to the common terminal.The electrical device C_1 blocks any DC current path between the input and also the output. The anode of the diode D_1 is connected to an outlined potential. Once the switch M_1 is turned on, the input voltage, V_{in} seems across the electrical device L_1 and also the current I_{L1} will increase [6].Energy is additionally kept within the electrical device L_2 as before long because the voltage across the electrical device C_1 seems across L_2. The diode D_1 is reverse biased throughout this era. However once M_1 turns off, D_1 conducts. The energy keep in $L_1$and L_2 is delivered to the output, and C_1 is recharged by L_1 for consecutive amount [9].

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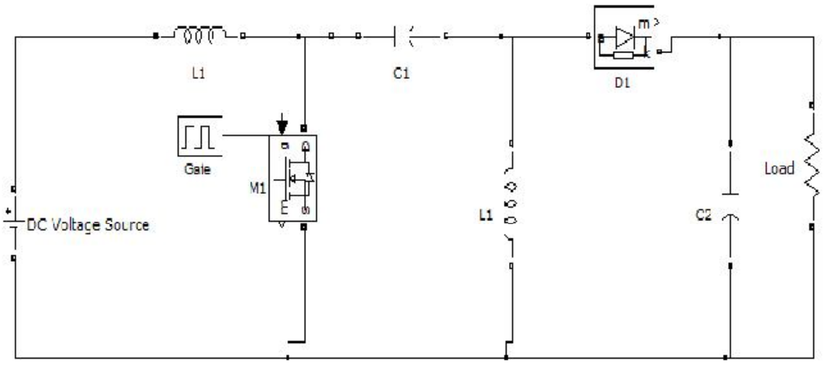

Figure 2 : SEPIC Converter

III. PROPOSED HYBRID SYSTEM

A system diagram of the projected rectifier stage of a hybrid energy system is shown in Figure 3, wherever one amongst the inputs is connected to the output of the PV array and also the different input connected to the output of a generator [7]

The fusion of the two devices is achieved by reconfiguring the two existing diodes from every converter and also the shared utilization of the Cuk output electrical device by the SEPIC converter. This configuration permits every device to control commonly separately within the event that one supply is unobtainable. Figure 3.1 illustrates the case once solely the wind supply is offered. During this case, D_1 turns off and D2 turns on; the projected output voltage relationship is given by (1). On the opposite hand, if solely the PV supply is offered, Figure 3.2 then D_2 turns off and D_1 can forever get on and therefore the circuit becomes a Cuk device as shown in the input to output voltage relationship is given by (2). In each case, each converter has step I up/down capabilities, which give additional style flexibility within the system if duty quantitative relation management is employed to perform MPPT management [7].

The output dc bus voltage is

$$V_{dc} = (d_1 / 1 - d_1)V_{pv} + (d_2 \ / \ 1 - d_2)V_w \qquad (1)$$

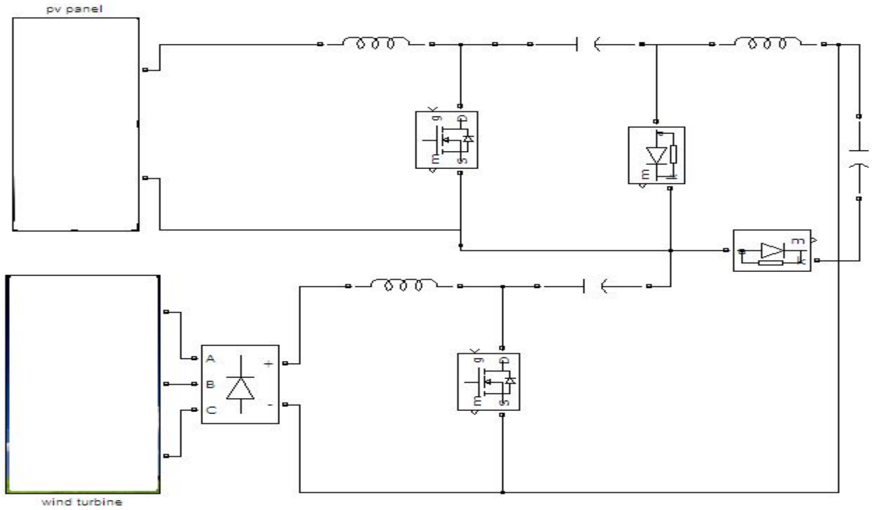

Figure 3: Hybrid System

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IV. MODELING OF PV PANEL

A cell is comprised of a p-n junction semiconductor material like silicon that produces currents via the electrical phenomenon impact. Once light-weight energy strikes the photovoltaic cell, electrons area unit knocked loose from the atoms within the semiconductor material. If electrical conductors are connected to the positive and negative sides, forming associate electrical device, the electrons will be captured within the kind of

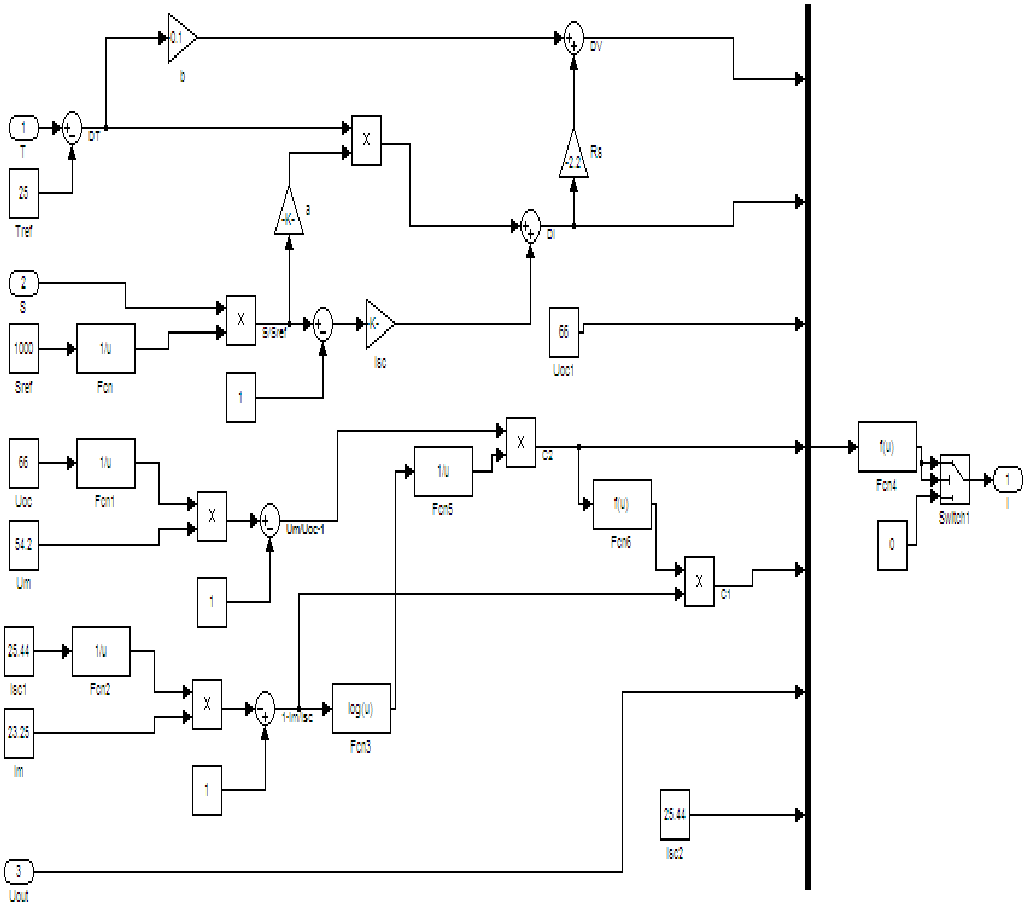

Figure 4:Simulink model of PV Array

an electrical current. This electricity will then be wont to power a load. The low voltage is generated during a PV cell (around zero.5V), many PV cells are connected nonparallel (for high voltage) and in parallel (for high current) to make a PV module for desired output [8].

A PV cell may be delineated by a current supply connected in parallel with a diode, since it generates current once it's well-lighted and acts as a diode once it is not. The equivalent circuit model additionally includes a shunt and series internal resistance. R_S is that the intrinsic series resistance. Whose worth is very small. R_P is the equivalent shunt resistancewhich has a very high value.

The current voltage equation of a PV cell is given by

$I = n_p I_{ph} - n_p I_{rs}(\exp(\frac{qv}{KTA_n}) - 1)$ (2)

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V. MODELING OF WIND TURBINE

The turbine is that the 1st and foremost part of wind generation systems. Wind turbines capture the facility from the wind by means that of aerodynamically designed blades and convert it to rotating mechanical power. This mechanical power is delivered to the rotor of an electrical generator wherever this energy is reborn to electricity. Electrical generator used is also associate degree induction generator or synchronous generator [2], [6].The mechanical power generated by the wind is given by

$$p_w = \frac{\rho}{2c_p}.(\delta,\theta).A_r v_w^3 \qquad (3)$$

Where

ρ - Air density, A - Rotor swept area, Cp (δ, β) - power coefficient function, λ - Tip speed ratio β - Pitch angle,v_w^3wind speed.

The turbine model is connected to a cage asynchronous generator. The energy obtained from the turbine is fed to the generator that converts it to the electricity [2].

VI. SIMULATION MODEL

PV array, Wind turbine, and the proposed hybrid system is modelled using MATLAB/ SIMULINK software.

A. Simulink Model of PV Array

The Simulink wave of PV array is shown in Figure 4 and the VI characteristics curve of the PV modelling is shown in Figure 5. This explains the details about the each PV cells characteristic for every variation of sun light directions with respect to the time [7].

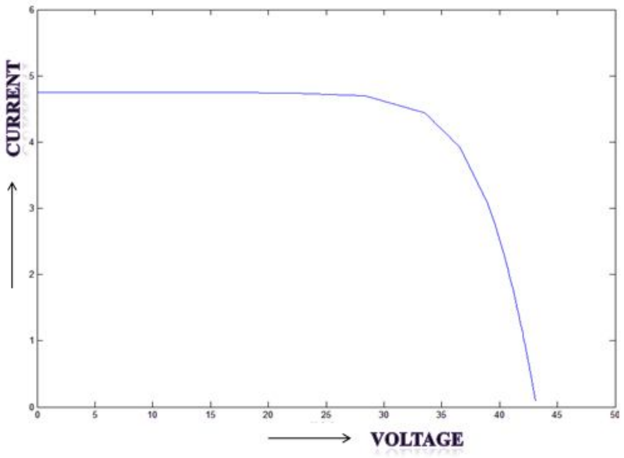

Figure 5: VI curve characteristics

B. Simulink Model of Wind Turbine

The Simulink model of wind turbine shown in Figure 6is the wind turbine modelling with asynchronous generator. This simulation explains the details about the three phase AC output current and output voltage characteristic for the wind speed of 10 m/sec which is shown in figure 7.

The generated three phase AC waveform from wind generator is fed to the hybrid combination of cuk and SEPIC converter which is inverted and supplied to three phase RLC load connected at the load side.

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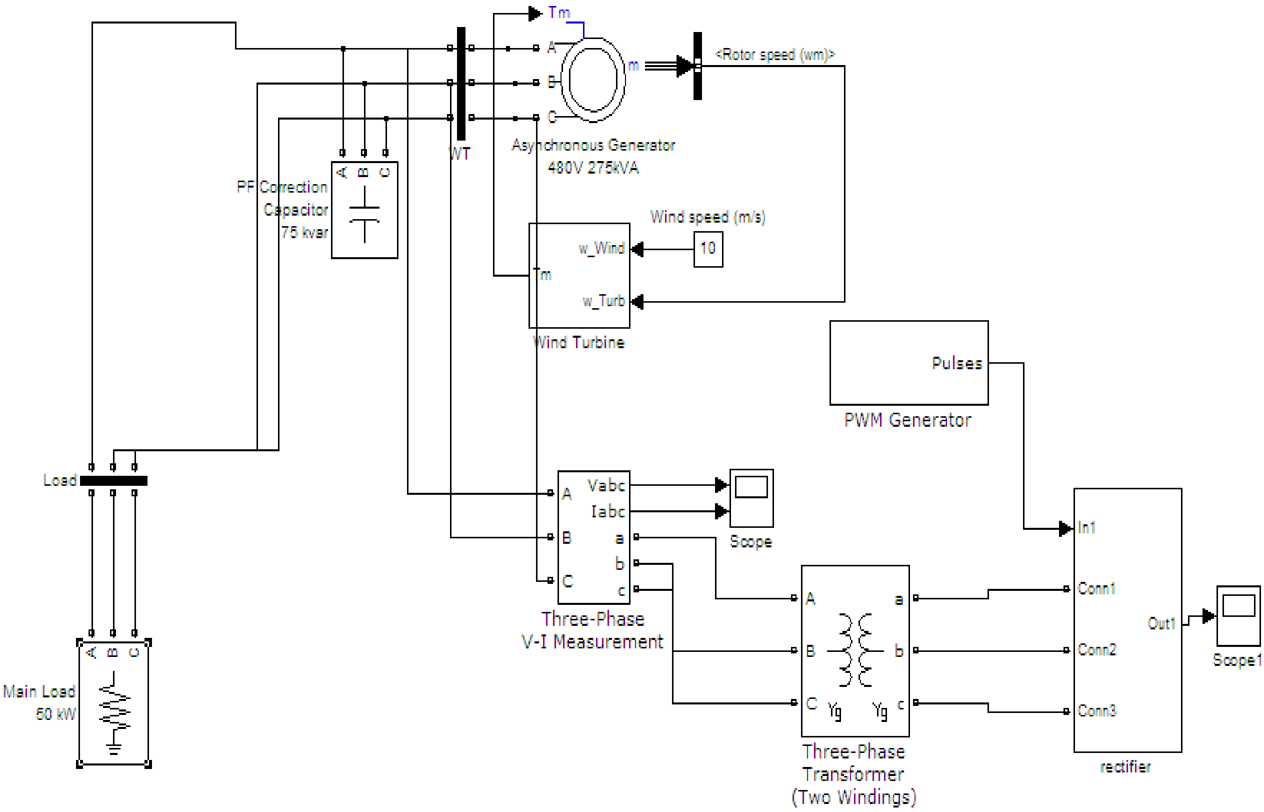

Figure 6: Simulink model of wind turbine

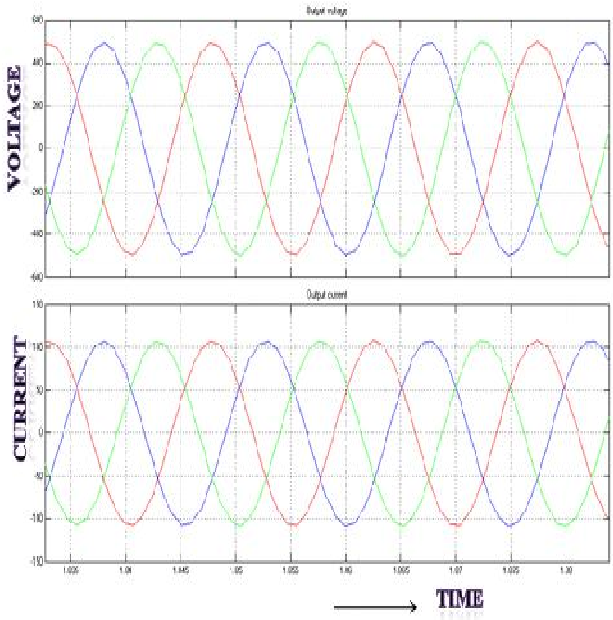

Figure 7: Output wave form of wind turbine

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C. Simulink model of proposed hybrid system

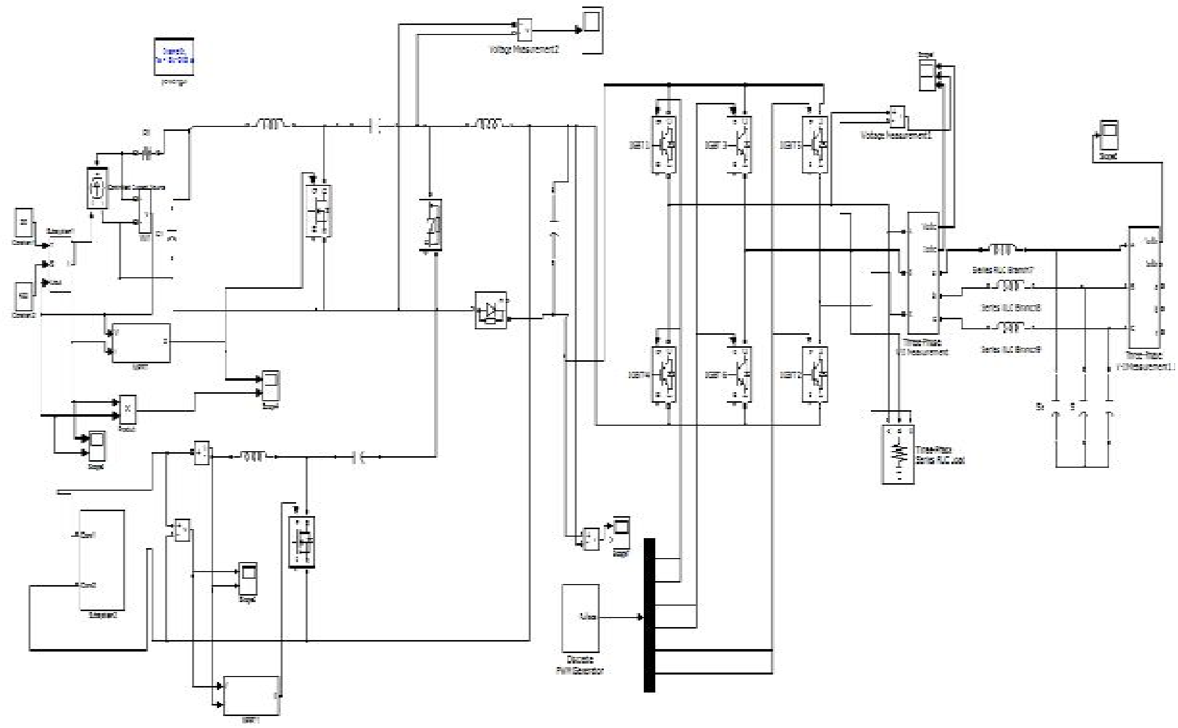

Figure 8: Simulink model of hybrid system

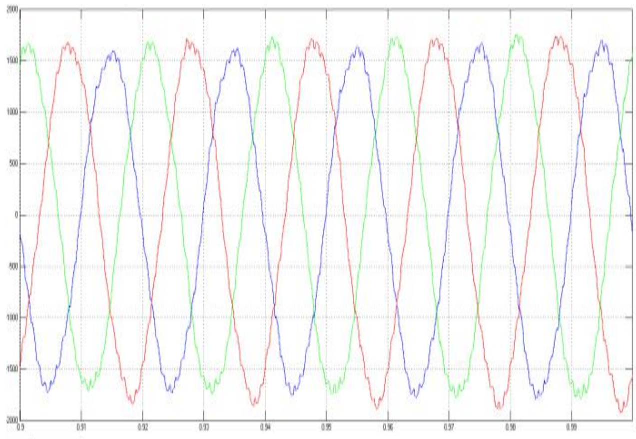

Figure 9: Output Wave form of hybrid system

VII. CONCLUSION

Renewable energy technologies offers clean, abundant energy gathered from self-renewing resources such as the sun, wind etc. As the power demand increases, power failure also increases. So, renewable energy sources can be used to provide constant loads. A new converter topology for hybrid wind/photovoltaic energy system is proposed. Hybridizing solar and wind power sources provide a realistic form of power generation. The topology uses a fusion of

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Cuk and SEPIC converters. This configuration allows the two sources to supply the load separately or simultaneously depending on the availability of the energy sources. This technique has lower overhead and find applications in remote space power generation, constant speed and variable speed energy conversion systems and rural electrification. The proposed system is employed by using MATLAB/ SIMULINK to model the PV panel, turbine, DC-DC converters and therefore the planned hybrid system.

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BIOGRAPHY

N.Kavitha received her UG degree in Electrical and Electronics Engineering and PG degree in Applied Electronics. She has presented her papers in 3 international conferences and 3 national conferences. Her research interest includes Power quality issues, Power Converters, Renewable energy sources, Electrical Drives. She is currently working at Dr Mahalingam College of Engineering as an Assistant Professor in EEE Department. She is a life member of ISTE.

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B.Kishore received his UG degree in Electronics and Instrumentation Engineering and PG degree in Applied Electronics. Currently he is working as an Assistant Professor in the department of Electrical and Electronics, Dr Mahalingam College of Engineering & Technology, Pollachi. He has 13 years of academic experience and 1 year of industrial experience. He has presented papers in 8 international conferences and 5 national conferences. He has three books to his credit and is a life member of ISTE, IAENG, ACM.