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IMPLEMENTATION OF EMBEDDED CONTROLLER TECHNIQUE FOR HYBRID RENEWABLE ENERGY SYSTEM

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ABSTRACT

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. This project presents a new system configuration of the front-end rectifier stage for a hybrid wind/photovoltaic/fuel cell energy system.Hybridizing solar and wind power sources provide a realistic form of power generation. The topology uses a fusion of 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. The fused multi input rectifier stage also allows Maximum Power Point Tracking (MPPT) to be used to extract maximum power from the wind and sun when it is available. An adaptive MPPT algorithm will be used for the wind system and a standard incremental conductance method will be used for the PV system. The cuk converter used for solar and sepic converter used for wind energy. The closed loop embedded controller method is using this project and it gives the feedback signal and getting desired output. Simulation is carried out in MATLAB/ SIMULINK software.

Keywords-Renewable energy, Cukconverter, SEPIC converter,MPPT Algorithm

1. 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. 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. The Cuk-SEPIC fused converters have the capability to eliminate the HF current harmonics in the wind generator. This eliminates the need of passive input filters in the system. These converters can support step up and step down operations for each renewable energy sources.

They can also support individual and simultaneous operations. Solar energy source is the input to the Cuk converter and wind energy source is the input to the SEPIC converter. The average output voltage produced by the system will be the sum of the inputs of these two systems. All these advantages of the proposed hybrid system make it highly efficient and reliable.

2. DC – DC CONVERTERS

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

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.

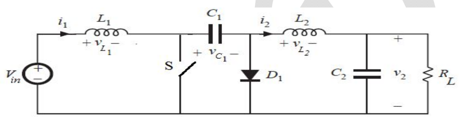


Figure:1 Cuk Converter

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 Cuk converter operates via capacitive energy transfer. When M1 is turned on, the diode D1 is reverse biased, the current in both L1 and L2 increases, and the power is delivered to the load. When M1 is turned off, D1 becomes forward biased and the capacitor C1 is recharged [10]. The voltage conversion ratio MCUK of the Cuk converter is given by:

$$M_{CUK} = \frac{V_{out}}{V_{in}} = \frac{-t_{on}}{t_{sw}-t_{on}} = \frac{-D}{1-D}$$

SEPIC Converter

Single-ended primary-inductor converter (SEPIC) is a type of DC-DC converter allowing the voltage at its output to be greater than, less than, or equal to that at its input. It is similar to a buck boost converter. It has the capability for both step up and step down operation. The output polarity of the converter is positive with respect to the common terminal.

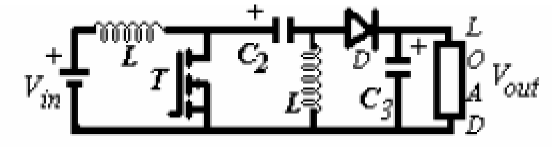


Fig ure.2 Sepic Converter

The capacitor C1 blocks any DC current path between the input and the output. The anode of the diode D1 is connected to a defined potential. When the switch M1 is turned on, the input voltage, Vin appears across the inductor L1 and the current IL1 increases. Energy is also stored in the inductor L2 as soon as the voltage across the capacitor C1 appears across L2. The diode D1 is reverse biased during this period. But when M1 turns off, D1 conducts. The energy stored in L1 and L2 is delivered to the output, and C1 is recharged by L1 for the next period. The voltageconversion ratio MSEPIC of the SEPIC converter is given by:

$$M_{SEPIC} = \frac{V_{out}}{V_{in}} = \frac{t_{on}}{t_{sw}-t_{on}} = \frac{D}{1-D}$$

3. PROPOSED HYBRID SYSTEM

PV array is the input to the Cuk converter and wind source is the input to the SEPIC converter. The converters are fused together by reconfiguring the two existing diodes from each converter and the sharing the Cuk output inductor by the SEPIC converter. This configuration allows each converter to operate normally individually in the event that one source is unavailable. When only wind source is available, the circuit operates as a SEPIC converter and the voltage conversion relationship is given by:

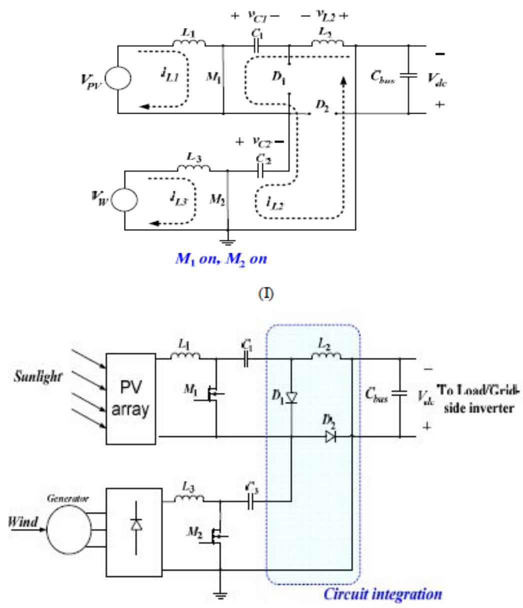
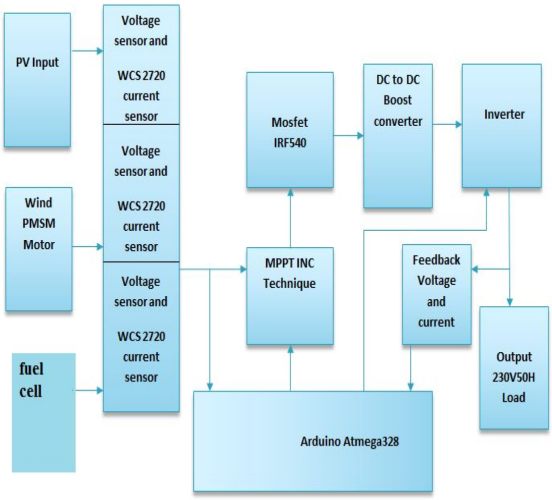


Figure. 3 Proposed rectifier stage for a Hybrid wind/PV system



Figie.4 Proposed block diagram of Hybrid wind/PV system

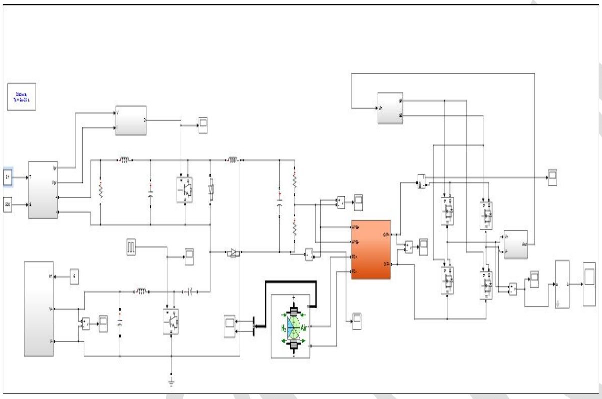


Figure.5 simulink diagram of proposed system

$$\frac{V_{dc}}{V_W}=\frac{d_1}{1-d_1}$$

When only PV source is available, the circuit acts as a Cuk converter and the voltage conversion is given by:

$$\frac{V_{dc}}{V_{PV}}=\frac{d_1}{1-d_1}$$

Figure I shows the various switching states of the proposed converter. If the turn on duration of M1 is longer than M2, then the converter operates in state I, III and IV and if the turn on duration of M2 is longer than M1, then the converter operates in state I, II and IV.

$$I=I_{ph}-I_0\left[\exp\left(\frac{q(V+R_sI)}{Ak_BT}\right)-1\right]-\frac{V+R_sI}{R_{sh}}$$

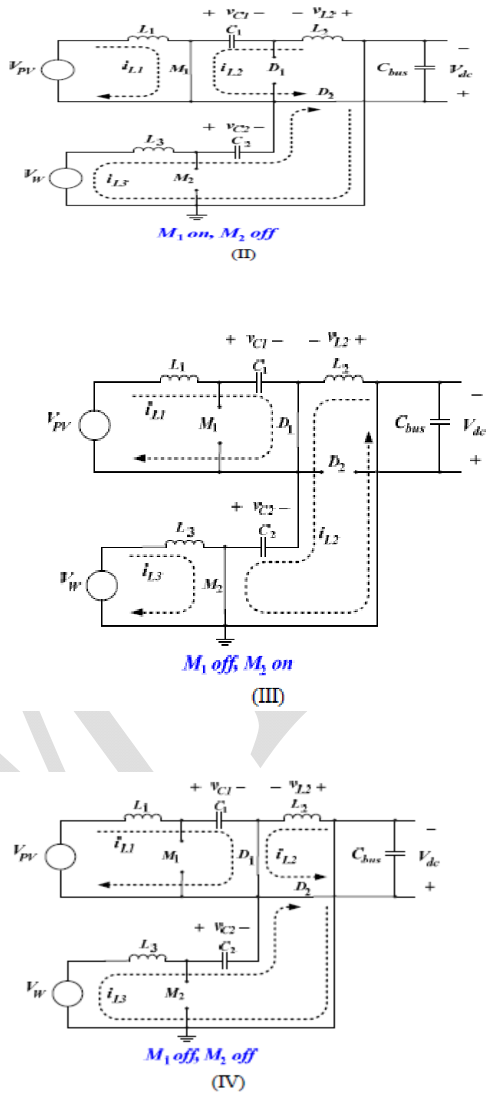


Figure 6(I-IV): Proposed rectifier stage for a Hybrid wind/PV system

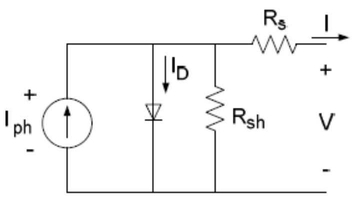


Figure.7 PV cell voltage-current characteristic

Where,

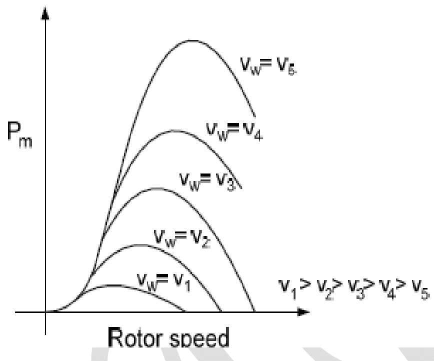
Vw = wind speed
ρ = air density,
A = rotor swept area,
Cp (λ, β) = power coefficient function
λ =tip speed ratio,

β = pitch angle,

4. MPPT CONTROL OF PROPOSED CIRCUIT

A common inherent drawback of wind and PV systems is the intermittent nature of their energy sources. 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. 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. These drawbacks tend to make these renewable systems inefficient. However, by incorporating maximum power point tracking (MPPT) algorithms, the systems' power transfer efficiency can be improved significantly.

To describe a wind turbines power characteristic equation describes the Mechanical power that is generated by the Wind.



$$p_m = 0.5 \rho A C_p(\lambda, \beta) v_w^3$$

Figure.8 Power Curves for a typical wind turbine

The power coefficient (Cp) is a nonlinear function that represents the efficiency of the wind turbine to Convert wind energy into mechanical energy. It is dependent on twovariables, the tip speed ratio (TSR) and the pitch angle. The TSR, λ, refers to a ratio of the turbine angular speed over the wind speed. The mathematical representation of the TSR is given by (8). The pitch angle, β, refers to the angle in which the turbine blades are aligned with respect to its longitudinal axis.

5. RESULTS AND DISCUSSION

Simulation Result of Wind Turbine:

The simulation of SEPIC converter with Wind turbine fed as input is done separately and the output current and voltage waveforms obtained are shown in Figure12, 13.

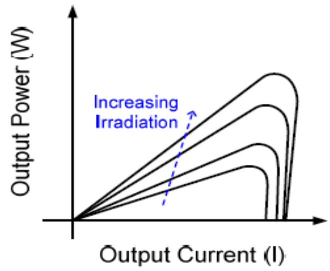
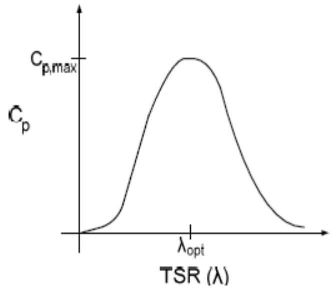


Figure. 9. PV cell equivalent circuit



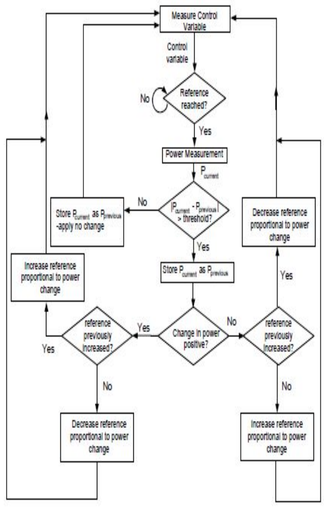


Figure.10 General MPPT Flow Chart for wind and PV

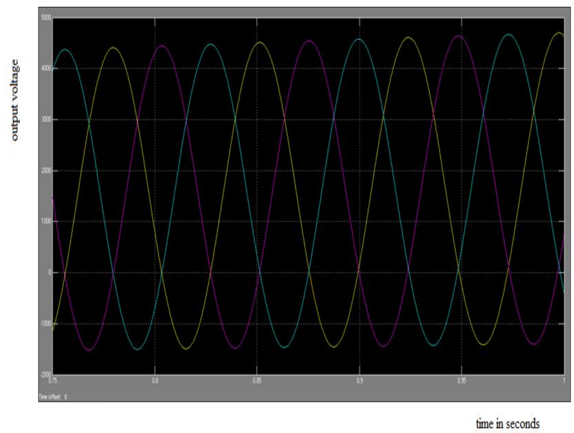


Figure.12 Voltage curve for wind

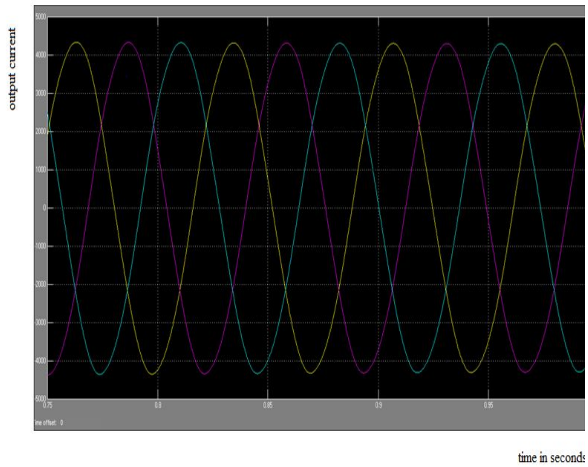


Figure.13.Current curve for wind

Simulation Result of PV Cell

The simulation of Cuk converter with PV cell fed as input is done separately and the output current and voltage waveforms obtained are shown in Figure14, 15

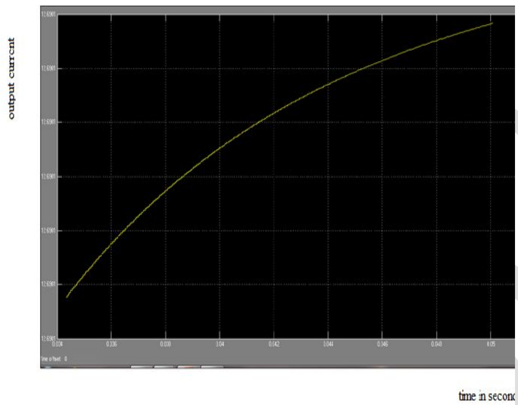


Figure.14 solar current output

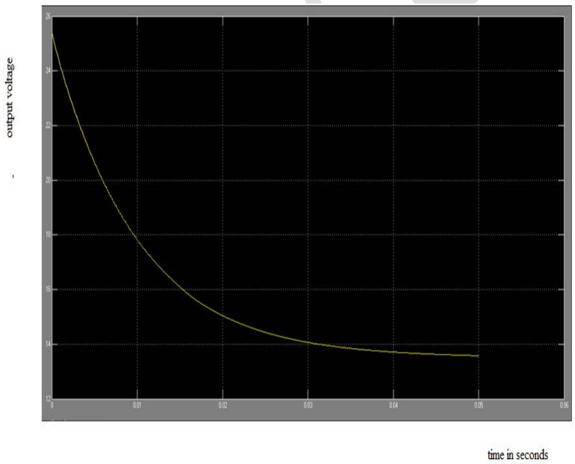
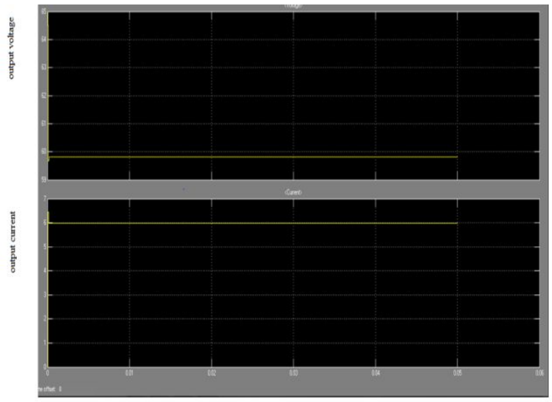


Fig ure.15 solar voltage output

Simulation Result of Fuel Cell

The simulation of fuel cell fed as input is done separately and the output current and voltage waveforms obtained are shown in Figure16



Time in seconds

Figure.16 fuel cell voltage, current output

5.4 Simulation Result of Proposed Hybrid System

The combined wind, solar, fuel cell hybrid overall output simulation result is given in figure17

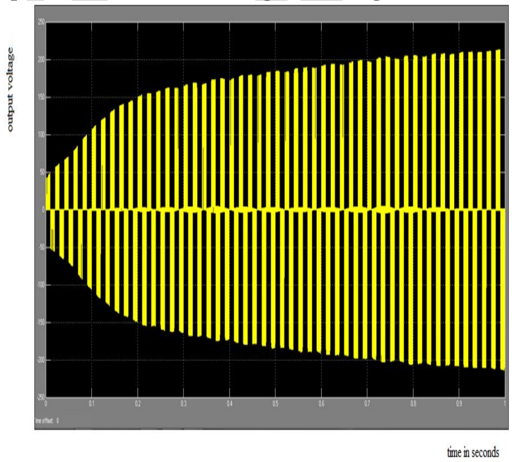


Figure.17 overall output voltage

6. CONCLUSION

In this project a new multi-input Cuk-SEPIC rectifier stage for hybrid wind/solar energy/fuel cell 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. Simulation results have been presented to verify the features of the proposed topology.

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