IJSEAT International Journal of Science Engineering and Advance Technology

A Noval Converter For Integrated Wind – Pv Energy System

Devika[1], D.Srilatha[2],

[1]PG Scholar; [2]Assoc. Prof. Dept. Of EEE, Prakasam Engineering College , JNTUK,India,

Achyuthuni.devika@gmail.com; Srilatha.dande@gmail.com

Abstract

This paper proposes a novel dc/dc converter topology that interfaces the non-conventional energy sources. It consists of four power ports: two sources (namely solar and wind), one bidirectional storage port, and one isolated load port. The proposed four-port dc/dc converter is derived by simply adding two switches and two diodes to the traditional half-bridge topology. Zero-voltage switching is realized for all four main switches. This paper proposes a new four-port-integrated dc/dc topology, which is suitable for various renewable energy harvesting applications. An application interfacing hybrid photovoltaic (PV) and wind sources, one bidirectional battery port, and an isolated output port is given as a design example. It can achieve maximum power-point tracking (MPPT) for both PV and wind power simultaneously or individually, while maintaining a regulated output voltage.

Simulation results are provided to verify with the feasibility of the proposed system.

I. Introduction

As interest in renewable energy systems with various sources becomes greater than before, there is a supreme need for integrated power converters that are capable of interfacing, and concurrently, controlling several power terminals with low cost and compact structure. This paper proposes a new four-port-integrated dc/dc topology, which is suitable for various renewable energy harvesting applications. Three of the four ports can be tightly regulated by adjusting their independent duty-cycle values, while the fourth port is left unregulated to maintain the power balance for the system. Compared to the effort spent on the traditional two- port converter, less work has been done on the multiport converter Circuit analysis and design considerations are presented. Four-port dc/dc converter has bidirectional capability.

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 buck and SEPIC converters. The features of the proposed topology are: 1) the inherent nature of these two converters eliminates the need for separate input filters for PFC 2) it can support step up/down operations for each renewable source (can support wide ranges of PV and wind input); 3) MPPT can be realized for each source; 4) individual and simultaneous operation is supported. The circuit operating principles will be discussed in this paper.

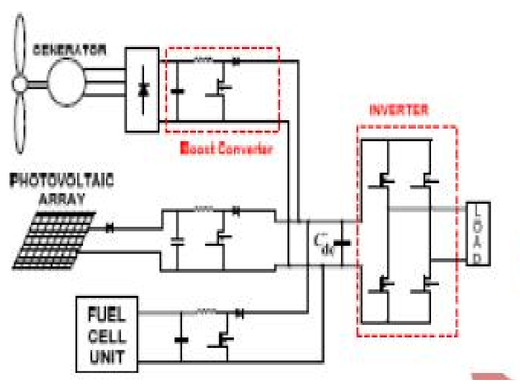


Fig 1: Hybrid system with multi-connected boost converter

II. Proposed Multi-Input Rectifier Stage

A system diagram of the proposed rectifier stage of a hybrid energy system is shown in Figure 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 generator. The fusion of the two converters is achieved by reconfiguring the two existing diodes from each converter and the shared utilization of the buck output inductor by the converter. This configuration allows each converter to operate normally individually in the event that one source is unavailable. Figure3 illustrates the case when only the wind source is available. In this case, D1 turns off and D2 turns on; the proposed circuit becomes a CUK converter and the input to output voltage relationship is given by (1). On the other hand, if only the PV source is available, then D2 turns off and D1 will always be on and the circuit becomes a buck converter as shown in Figure 4.The input to output voltage relationship is given by (2). In both cases, both converters have step-up/down capability, which provide more design flexibility in the system if duty ratio control is utilized to perform MPPT control.

$$\frac{V_{dc}}{V_W} = \frac{d_2}{1-d_2} \qquad \frac{V_{dc}}{V_{PV}} = \frac{d_1}{1-d_1}$$

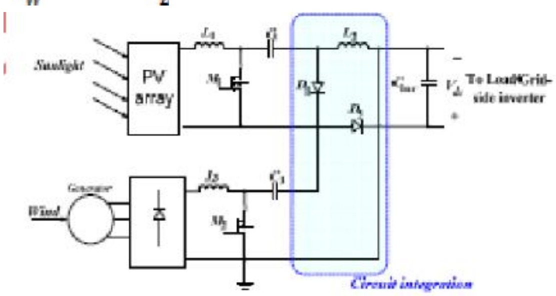


Fig 2: Proposed rectifier stage for a Hybrid wind/PV system

III. Analysis Of Proposed Circuit

To find an expression for the output DC bus voltage, V_{dc}, the volt-balance of the output inductor, L_2, is examined according to Figure 6 with $d_2 > d_1$. Since the net change in the voltage of L_2 is zero, applying volt-balance to L_2 results in (3).The expression that relates the average output DC voltage(V_{dc}) to the capacitor voltages (v_{c1} and v_{c2}) is then obtained as shown in (4), where v_{c1} and v_{c2} can then be obtained by applying volt-balance to L_1 and L_3. The final expression that relates the average output voltage and the two input sources (V_W and V_{PV}) is then given by (5). It is observed that V_{dc} is simply the sum of the two output voltages of the Cuk and SEPIC converter. This further implies that V_{dc} can be controlled by d_1 and d_2 individually or simultaneously.

$$V_{dc} = \left(\frac{d_1}{1-d_2}\right)V_{c1} + \left(\frac{d_2}{1-d_2}\right)V_{c2}$$

$$V_{dc} = \left(\frac{d_1}{1-d_1}\right)V_{PV} + \left(\frac{d_2}{1-d_2}\right)V_w$$

The switches voltage and current characteristics are also provided in this section. The voltage stress is given by equations respectively. As for the current stress, it is observed from Figure 6 that the peak current always occurs at the end of the on-time of the MOSFET. Both the Cuk MOSFET current consists of both the input current and the capacitors(C_1 or C_2) current. The peak current stress of M_1 and M_2 are given by equations respectively. Leq1 and Leq2 represent the equivalent inductance of Cuk and CUK converter respectively.

$$V_{ds1} = V_{PV}\left(1 + \frac{d_1}{1-d_2}\right)$$

$$V_{ds2} = V_w\left(1 + \frac{d_2}{1-d_2}\right)$$

$$I_{ds1,pk} = I_{i,PV} + I_{dc.org} + \frac{V_{PV} d_1 T_s}{2L_{eq1}}$$

$$L_{eq1} = \frac{L_1 L_2}{L_1 + L_2}$$

$$I_{ds2,pk} = I_{i,PV} + I_{dc.org} + \frac{V_w d_2 T_s}{2L_{eq2}}$$

$$L_{eq2} = \frac{L_3 L_2}{L_3 + L_2}$$

$$I_{i,PV} = \frac{P_o}{V_{dc}} \frac{d_1}{1-d_1}$$

IV. 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 system sinefficient. However, by incorporating maximum power point tracking (MPPT) algorithms, the systems' power transfer efficiency can be improved significantly. To describe a wind turbine's power characteristic, equation describes the mechanical power that is generated by the wind.

$$P_m = 0.5 \rho A C_p(\lambda, \beta) V_w^3$$

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 two variables, 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 equation. The pitch angle, β, refers to the angle in which the turbine blades are aligned with respect to its longitudinal axis.

$$\lambda = \frac{RW_b}{V_w}$$

Figure 3 are illustrations of a power coefficient curveand power curve for a typical fixed pitch (β =0) horizontal axis wind turbine. It can be seen from figure 3 that the power curves for each wind speed has a shape similar to that of the power coefficient curve. Because the TSR is a ratio between the turbine rotational speed and the wind speed, it follows that each wind speed would have a different corresponding optimal rotational speed that gives the optimal TSR. For each turbine there is an optimal TSR value that corresponds to a maximum value of the power coefficient(C_p, max) and therefore the maximum power. Therefore by controlling rotational speed, (by means of adjusting the electrical loading of the turbine generator) maximum powercan be obtained for different wind speeds.

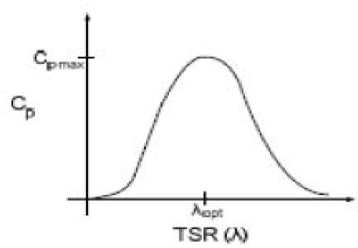


Fig 3: Power Coefficient Curve for a typical wind turbine

A solar cell is comprised of a P-N junction semiconductor that produces currents via the photovoltaic effect. PV array sare constructed by placing numerous solar cells connected in series and in parallel. A PV cell is a diode of a large-are forward bias with a photo voltage and the equivalent circuit is shown by Figure 4. The current-voltage characteristic of a solar cell is derived as follows:

$$I = I_{ph}$$

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

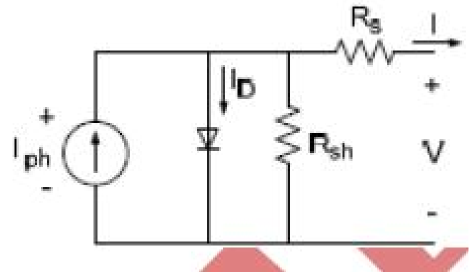


Fig 4: PV cell equivalent circuit

Typically, the shunt resistance (R_{sh}) is very large and the series resistance (R_s) is very small. Therefore, it is common to neglect these resistances in order to simplify the solar cell model. The resultant ideal voltage-current characteristic of a photovoltaic cell is given by and illustrated by Fig 5.

$$I = I_{ph} - I_0 \left[\exp\left(\frac{qV}{kT}\right) - 1\right]$$

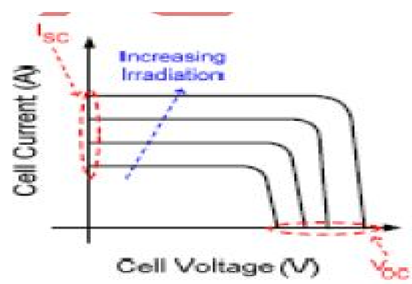


Fig 5: PV cell voltage-current characteristic

Due to the similarities of the shape of the wind and PV array power curves, a similar maximum power point tracking scheme known as the hill climb search (HCS) strategy is often applied to these energy sources to extract maximum power. The HCS strategy perturbs the operating point of the system and observes the output. If the direction of the perturbation (e.g an increase or decrease in the output voltage of a PV array) results in a positive change in the out put power, then the control algorithm will continue in the direction of the previous perturbation. Conversely, if a negative change in the output power is observed, then the control algorithm will reverse the direction of the pervious perturbation step. In the case that the change in power isc lose to zero (within a specified range) then the algorithm will invoke no changes to the system operating point since it corresponds to the maximum power point (the peak of the power curves).

The MPPT scheme employed in this paper is a version of the HCS strategy. Figure 6 is the flow chart that illustrates the implemented MPPT scheme.

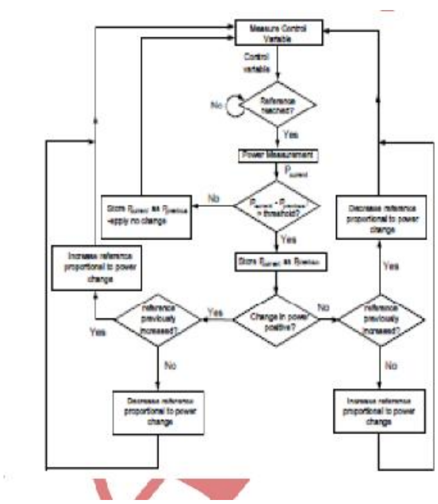


Fig 6: General MPPT Flow Chart for wind and PV

IV. Simulation Results

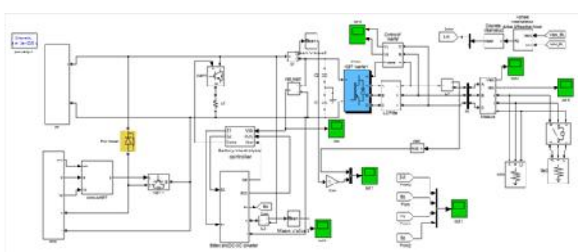


Fig7:Praposed Model

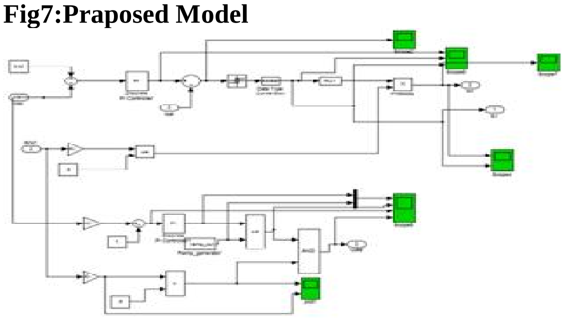
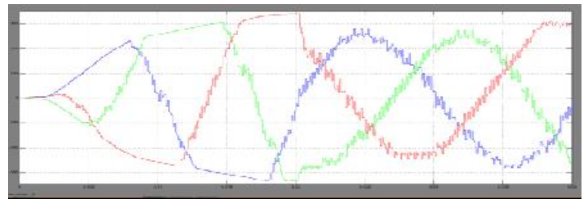
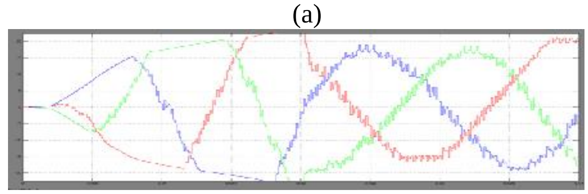


Fig.8:Control Scheme

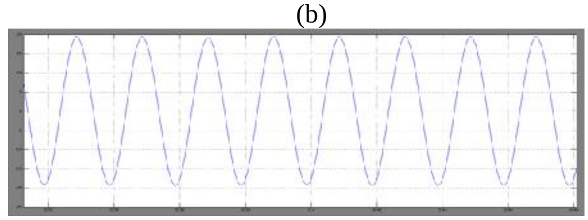
The out put voltages and currents are as shown in fig .



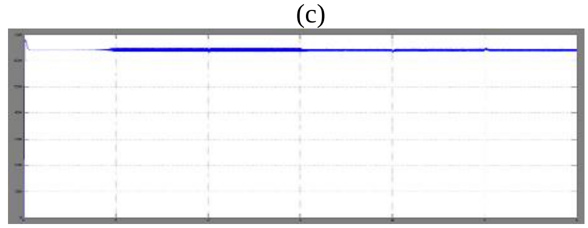
(a)



(b)



(c)



(d)

Fig.9 (a)load voltages (b) load currents (c)load current with fiter (d) battery voltage

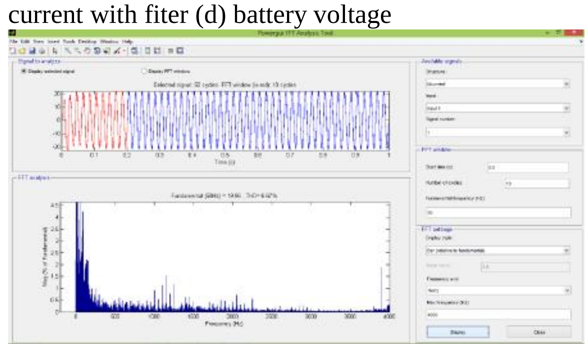


Fig.10:Load current without filter %THD = 39.42%

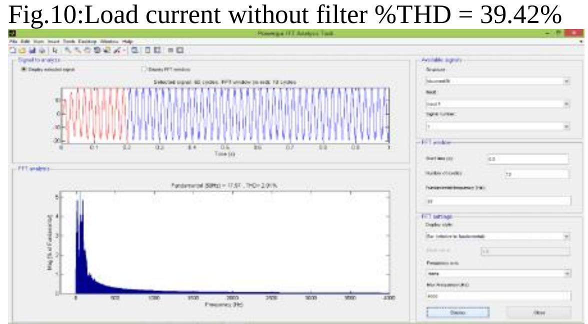


Fig.11:Load current without filter %THD = 6.67%

VI. Conclusion

In the thesis load demand is met from the combination of PV array, wind turbine and the battery. An inverter is used to convert output from solar & wind systems into AC power output. Circuit Breaker is used to connect an additional load of 5 KW in the given time. This hybrid system is controlled to give maximum output power under all operating conditions to meet the load. Either wind or solar system is supported by the battery to meet the load. Also, simultaneous operation of wind and solar system is supported by battery for the same load.

References

[1] Joanne Hui*, AlirezaBakhshai, and Praveen K. Jain, “A Hybrid Wind-Solar Energy System: A New Rectifier Stage Topology “, in Applied Power Electronics Conference and Exposition (APEC), 2010 Twenty-Fifth Annual IEEE, pp 156-161, 21-25 Feb. 2010

[2] S.K. Kim, J.H Jeon, C.H. Cho, J.B. Ahn, and S.H. Kwon, “Dynamic Modeling and Control of a Grid-Connected Hybrid Generation System with Versatile Power Transfer,” IEEE Transactions on Industrial Electronics, vol. 55, pp. 1677-1688, April 2008.

[3] N. A. Ahmed, M. Miyatake, and A. K. Al-Othman, “Power fluctuations suppression of stand-alone hybrid generation combining solar photovoltaic/wind turbine and fuel cell systems,” in Proc. Of Energy Conversion and Management, Vol. 49, pp. 2711-2719, October 2008.

[4] Wind and Solar Power Systems Design Analysis and Operation Second Edition, by Mukund R. Patel, Taylor & Francis Group Publishing Co.

[5] Y.M. Chen, Y.C. Liu, S.C. Hung, and C.S. Cheng, “Multi-Input Inverter for Grid-Connected Hybrid PV/Wind Power System,” IEEE Transactions on Power Electronics, vol. 22, May 2007.

[6] S. Jain, and V. Agarwal, “An Integrated Hybrid Power Supply for Distributed Generation Applications Fed by Nonconventional Energy Sources,” IEEE Transactions on Energy Conversion, vol. 23, June 2008.

[7] D. Das, R. Esmaili, L. Xu, D. Nichols, “An Optimal Design of a Grid Connected Hybrid Wind/Photovoltaic/Fuel Cell System for Distributed Energy Production,” in Proc. IEEE Industrial Electronics Conference, pp. 2499-2504, Nov. 2005.

[8] Dos Reis, F.S., Tan, K. and Islam, S., “Using PFC for harmonic mitigation in wind turbine energy conversion systems” in Proc. of the IECON 2004 Conference, pp. 3100- 3105, Nov. 2004

[9] R. W. Erickson, “Some Topologies of High Quality Rectifiers” in the Proc. of the First International Conference on Energy, Power, and Motion Control, May 1997.

[10] D.S.L. Simonetti, J.Sebasti´an, and J.Uceda, “The Discontinuous Conduction Mode".