Grid connected PV Wind Battery coupled bidirectional DC-DC Luo converter for household applications

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ABSTRACT

In this Paper, a strategy for power flow management of a grid-connected hybrid electrical phenomenon (PV)–wind battery primarily based system coupled dc–dc Luo converter is bestowed. The main objective of this proposed system is to provide an uninterrupted power supply. The effectiveness of the topology and also the effectiveness of the projected management strategy square measure valid projected system aims to satisfy the load demand, manage the facility result totally different sources, inject the excess power into the grid, and charge the battery from the grid as and once needed. Luo device is employed to harness power from wind, whereas a bidirectional Luo device is employed to harness power from PV at the side of battery charging/discharging management. A single-phase full-bridge electrical converter is employed for feeding ac hundreds and interaction with the grid. The projected device design has reduced variety of power conversion stages with less part count and reduced losses compared with existing grid-connected hybrid systems. This improves the potency and also the dependableness of the system. Simulation results obtained mistreatment MATLAB/Simulink show the through elaborate experimental studies to demonstrate the potential of the system operation in numerous modes.

1. INTRODUCTION

Rapid depletion of fuel reserves, ever increasing energy demand and considerations over temperature change encourage power generation from renewable energy sources. star electrical phenomenon (PV) and wind have emerged as in style energy sources because of their eco friendly nature and value effectiveness. However, these sources ar intermittent in nature. Hence, it's a challenge to provide stable and continuous power mistreatment these sources. this will be addressed by with efficiency integration with energy storage parts. The fascinating complementary behavior of star insolation and wind speed pattern not to mention the preceding blessings has light-emitting diode to the analysis on their integration leading to the hybrid PV–wind systems. For achieving the mixing of multiple renewable sources, the standard approach involves mistreatment dedicated single-input converters one for every supply, that ar connected to a typical dc-bus. However, these converters don't seem to be effectively used, because of the intermittent nature of the renewable sources. additionally,

there are multiple power conversion stages that cut back the potency of the system. a big quantity of the literature exists on the mixing of star and wind energy, as a hybrid energy generation system in the main focuses on its filler and improvement. In the filler of generators in an exceedingly hybrid system is investigated. during this system, the sources and storage ar interfaced at the dc-link through their dedicated converters. alternative contributions ar created on their modeling aspects and management techniques for a complete hybrid energy system in. Dynamic performance of a complete hybrid PV–wind system with battery storage is analyzed in. a passivity/sliding mode management is given that controls the operation of wind energy system to enrich the solar power generating system. Not several tries ar created to optimize the circuit configuration of those systems that would cut back the value and increase the potency and reliableness. Integrated converters for PV and wind energy systems ar given. PV–wind hybrid system, encompasses a straightforward power topology, however it's appropriate for complete applications. associate degree integrated four-port topology supported hybrid PV–wind system but, despite straightforward topology, the management theme used is complicated. To feed the dc masses, a coffee capability multiport device for a hybrid system is given. Hybrid PV–wind-based generation of electricity and its interface with the ability grid ar the necessary analysis areas. this technique is principally targeted on rising the dc-link voltage regulation. within the six-arm device topology the outputs of a PV array and wind generators ar fed to a Luo device to match the dc-bus voltage. The steady-state performance of a grid-connected hybrid PV and wind system with battery storage is analyzed. This project focuses on system engineering, like energy production, system reliableness, unit filler, and value analysis. a hybrid PV–wind system at the side of electric battery is given, within which each sources ar connected to a typical dc-bus through individual power Luo converters. additionally, the dc-bus is connected to the utility grid through associate degree electrical converter. the utilization of multi-input device for hybrid power systems is attracting increasing attention due to reduced part count, increased power density, compactness, and centralized management. because of these blessings, several topologies ar planned, and that they will be classified into 3 teams, namely, nonisolated, totally isolated, and partly isolated multiport topologies.

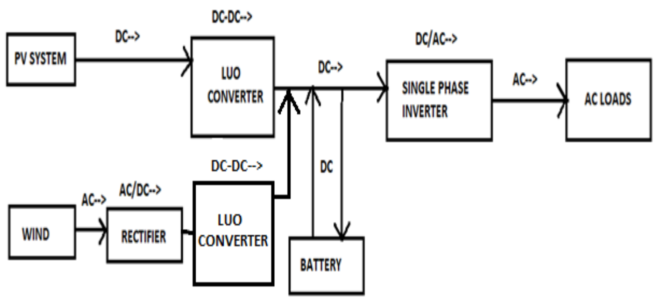


FIGURE 1.1 - BLOCK DIAGRAM

In the above block diagram of the hybrid system, it states that the PV output is in low dc and the wind output is in ac so as to convert the ac to dc rectifier circuit is used . Luo converter is used to harness the power and boost it in a ratio of 1:7. The boosted voltage is used to charge the battery as well as to supply the load. Before supplying to the load the dc is converted into ac using single phase inverter.

2. PROPOSED DIAGRAM

The circuit diagram consist of a PV source , wind source and a battery as a power bank. There are two luo converters for PV as well as wind separately. Mosfets are used as a triggering switch. Inductors and capacitors are used for charging and discharging purpose. To convert dc to ac single phase full bridge inverter is used to supply power to the ac load. The input of photovoltaic cell is sun light and the output current and voltage is 1A and 69.9V. The input of wind is mechanical energy which is converted into electrical energy. The output voltage of wind energy is around 145V and converter output is 390V. Asynchronous generator is used to convert mechanical energy into electrical energy. The load which we are using is resistive load.

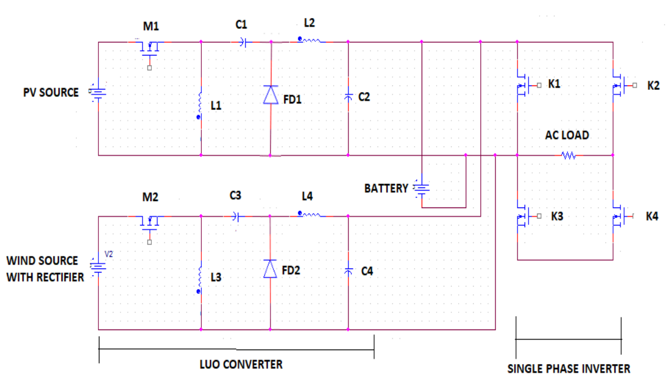


FIGURE 2.1 CIRCUIT DIAGRAM

In the paper, when the switch is on then the transformer convert 230V ac supply to 12V ac supply which on further convert into 12V dc using full wave bridge rectifier. The 12V dc supply passes through the voltage regulator 7805 to convert into 5V dc which is the threshold voltage to run the dsPIC microprocessor. The dsPIC30F2010 is a controller microprocessor which provide 5V square wave pulse to the driver circuit TLP250. The optocoupler driver circuit converts the 5V pulse to 12V pulse so as to satisfy the mosfet pulse. There are 5 mosfet used, 4 on single phase inverter and 1 on luo converter.

For the further output the transformer provides 12V supply to the luo converter which boost the dc voltage upto 40V and current 1.43V with a power rating of 57W.

3. MODES OF OPERATION AND MODELLING OF ELEMENTARY LUO CONVERTER

3.1 MODES OF OPERATION

MODE-1

- when the switch is ON.
- The inductor L1 is charged by the supply voltage E.
- At the same time, the inductor L2 absorbs the energy from source and the capacitor C1.
- The load is supplied by the capacitor C2.

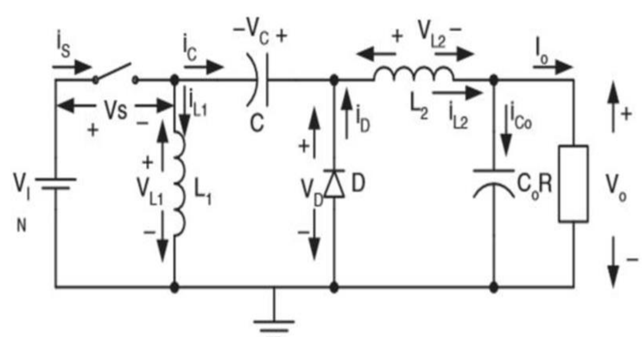


FIGURE 3.1.1 LUO CONVERTER WHEN SWITCH IS ON

MODE-2

- When switch is in OFF state.
- the current is drawn from the source becomes zero.
- Current IL1 flows through the freewheeling diode to charge the capacitor C1.
- Current IL2 flows through C2 –R circuit and the freewheeling diode FD.

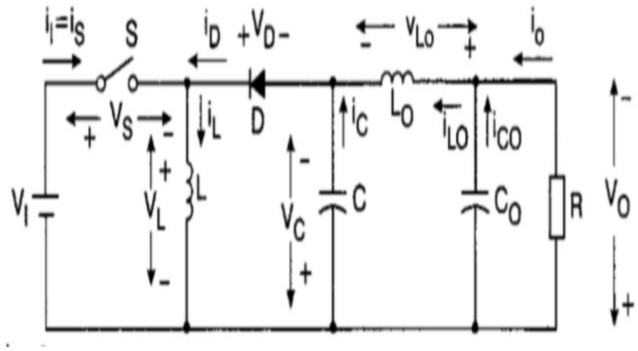


FIGURE 3.2.2 LUO CONVERTER WHEN SWITCH IS OFF

3.2 ELEMENTARY MODELLING OF LUO CONVERTER

There are two modes in Luo converter i.e ON mode and OFF mode. The equation of both the modes are as follows:-

$$x' = A_1x + B_1V_d \quad during\, dT_s$$

$$x' = A_2x + B_2V_d \quad \text{during}(1-d)T_s$$

For turn on:

$$\begin{pmatrix} x_1^1 \\ x_2^1 \\ x_3 \end{pmatrix} = \begin{pmatrix} 0 & \frac{1}{L} & 0 \\ \frac{-1}{C_1} & \frac{-1}{(R_1C_1)} & 0 \\ 0 & 0 & \frac{-1}{RC_2} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} + \begin{pmatrix} 0 \\ \frac{1}{(R_1C_1} \\ 0 \end{pmatrix} V_d$$

For turn off:

$$\begin{pmatrix} x_1^1 \\ x_2^1 \\ x_3^1 \end{pmatrix} = \begin{pmatrix} 0 & \frac{1}{L} & \frac{-1}{L} \\ \frac{-1}{C_1} & 0 & 0 \\ \frac{-1}{C_2} & 0 & \frac{-1}{RC_2} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} + \begin{pmatrix} \frac{1}{L} \\ 0 \\ 0 \end{pmatrix} V_d$$

$$A = \begin{pmatrix} 0 & \frac{1}{L} & \frac{-(1-D)}{L} \\ \frac{-1}{C_1} & \frac{-D}{(R_1C_1)} & 0 \\ \frac{(1-D)}{C_2} & 0 & \frac{-1}{RC_2} \end{pmatrix} B = \begin{bmatrix} \frac{(1-D)}{L} \\ \frac{D}{R_1C_1} \\ 0 \end{bmatrix} C = (0\,0\,1)$$

Using Laplace transformation:

$$S\hat{x}(s) = A\hat{x}(s) + [(A_1 - A_2)\times + (B_1 - B_2)V]\hat{d}(s)$$
$$\hat{x}(s) = [SI - A]^{-1}[(A_1 - A_2)\times + (B_1 - B_2)V]\hat{d}(s)$$

$$\frac{\hat{v}_0(s)}{\hat{d}(s)} = C[SI - A]^{-1}[(A_1 - A_2)\times + (B_1 - B_2)V_d] + (C_1 - C_2)X$$

The above result states the converter output of the luo converter.

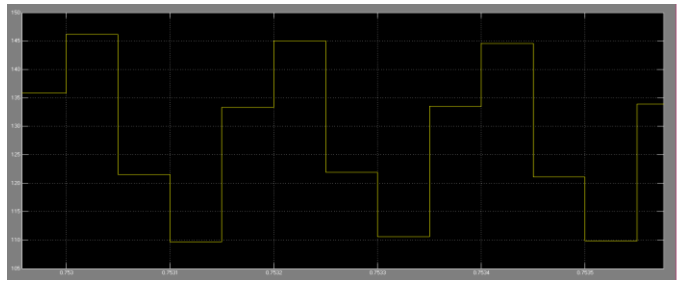


FIGURE 3.2.1OUTPUT OF WIND MODELLING

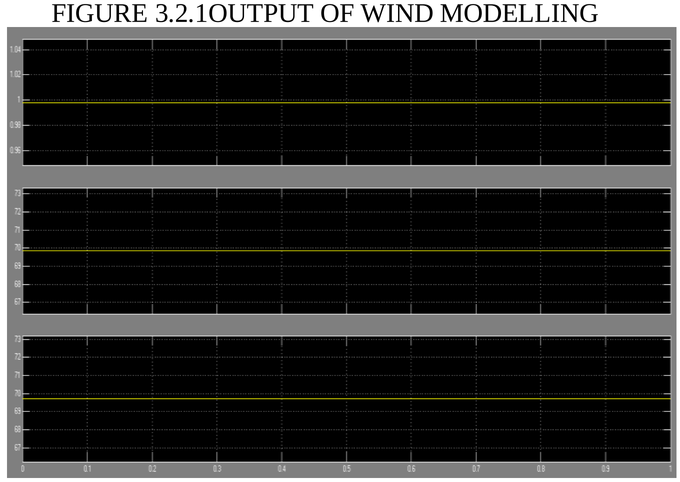


FIGURE 3.2.2 OUTPUT OF SOLAR PANEL

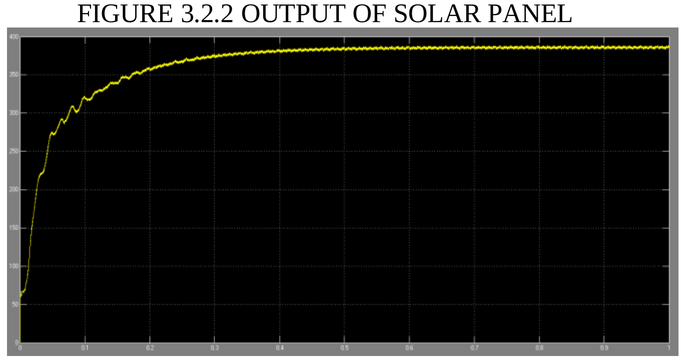
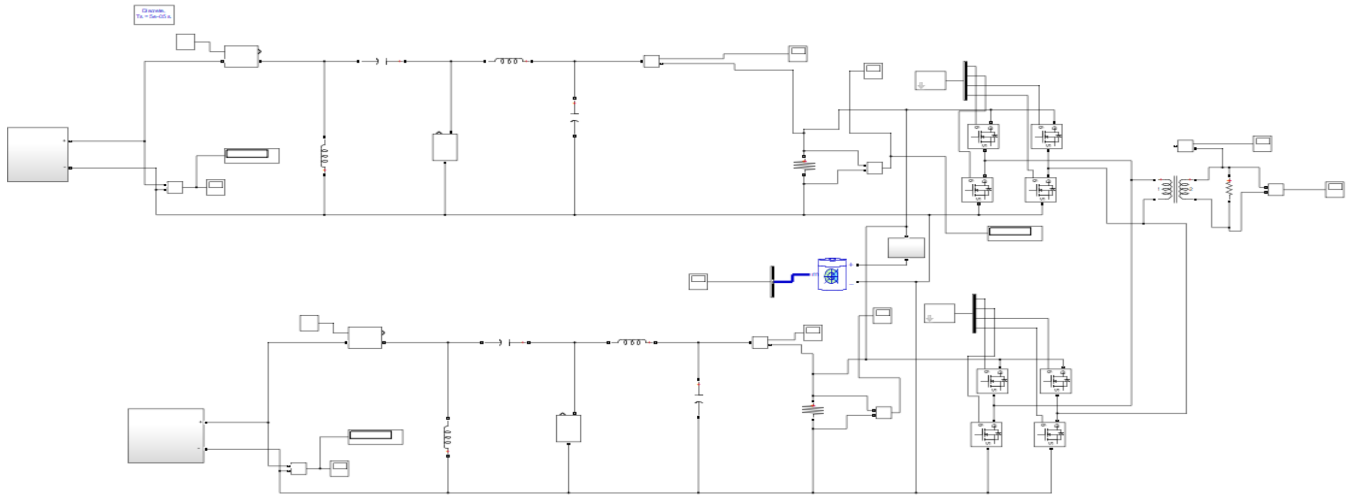


FIGURE 3.2.3 LUO CONVERTER OUTPUT

The very low output of PV and wind will not be enough for the loads as well as to charge the battery. The Luo converter is used to lift up the voltage. The positive lift and the negative lift of the luo converter boost the output in the ratio of 1:7. But practically the ratio is approximately 1:4.

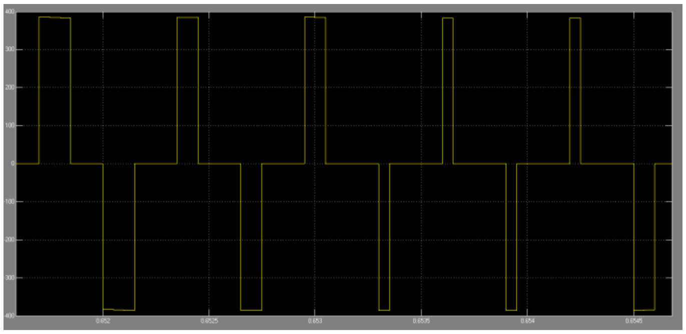
5. SIMULATION AND RESULT



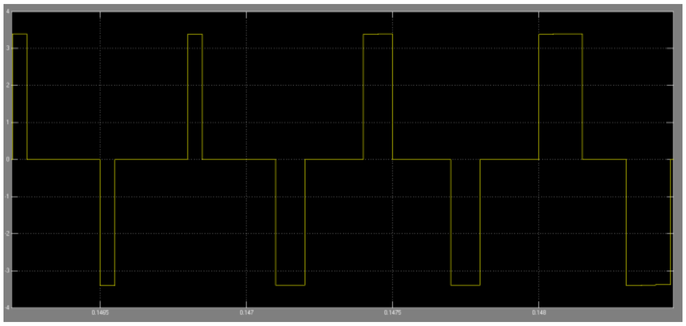
5.1 SIMULATION

In this simulation,the modelling of solar and wind system is accomplished. the photovoltaic powe rating is 70W. The output of solar is 70V and 1A. The simulation consist of a luo converter which is a proposed system of our project. To convert the DC voltage to AC single phase bridge rectifier is used.

The overall output waveforms of the project is shown here. The output voltage is 388V and the output current is 3.8A. Overall power rating is 1474W. To satisfy the load demand step down transformer is used. The luo converter output is shown . It harness upto 388V and it also charges the battery as well it supplies power to loads.



5.2 OUTPUT VOLTAGE



5.3 OUTPUT CURRENT

CONCLUSION

A grid-connected hybrid PV–wind-battery-based power evacuation scheme for household application is proposed. The proposed hybrid system provides an elegant integration of PV and wind source to extract maximum energy from the two sources. It is realized by a DC-DC luo converter followed by a conventional singlr phase full-bridge inverter. A versatile control strategy which achieves a better utilization of PV, wind power, battery capacities without effecting life of battery, and power flow management in a grid-connected hybrid PV–wind-battery-based system feeding ac loads is presented. Detailed simulation studies are carried out to ascertain the viability of the scheme. The experimental results obtained are in close agreement with simulations and are supportive in demonstrating the capability of the system to operate either in grid feeding or in stand-alone modes. The proposed configuration is capable of supplying uninterruptible power to ac loads, and ensures the evacuation of surplus PV and wind power into the grid.

REFERENCES

[1] F. Valenciaga and P. F. Puleston, "Supervisor control for a stand-alone hybrid generation system using wind and photovoltaic energy," *IEEE Trans. Energy Convers.*, vol. 20, no. 2, pp. 398–405, Jun. 2005.

[2] C. Liu, K. T. Chau, and X. Zhang, "An efficient wind–photovoltaic hybrid generation system using doubly excited permanent-magnet brushless machine," *IEEE Trans. Ind. Electron.*, vol. 57, no. 3, pp. 831–839, Mar. 2010.

[3] W. Qi, J. Liu, X. Chen, and P. D. Christofides, "Supervisory predictive control of standalone wind/solar energy generation systems," *IEEE Trans. Control Syst. Technol.*, vol. 19, no. 1, pp. 199–207, Jan. 2011.

[4] F. Giraud and Z. M. Salameh, "Steady-state performance of a grid-connected rooftop hybrid wind-photovoltaic power system with battery storage," *IEEE Trans. Energy Convers.*, vol. 16, no. 1, pp. 1–7, Mar. 2001.

[5] 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 Trans. Ind. Electron.*, vol. 55, no. 4, pp. 1677–1688, Apr. 2008.

[6] M. Dali, J. Belhadj, and X. Roboam, "Hybrid solar–wind system with battery storage operating in grid-connected and standalone mode: Control and energy management—Experimental investigation," *Energy*, vol. 35, no. 6, pp. 2587–2595, Jun. 2010.

[7] W. D. Kellogg, M. H. Nehrir, G. Venkataramanan, and V. Gerez, "Generation unit sizing and cost analysis for stand-alone wind, photovoltaic, and hybrid wind/PV systems," *IEEE Trans. Energy Convers.*, vol. 13, no. 1, pp. 70–75, Mar. 1998.

[8] L. Xu, X. Ruan, C. Mao, B. Zhang, and Y. Luo, "An improved optimal sizing method for wind-solar-battery hybrid power system," *IEEE Trans. Sustain. Energy*, vol. 4, no. 3, pp. 774–785, Jul. 2013.

[9] B. S. Borowy and Z. M. Salameh, "Dynamic response of a standalone wind energy conversion system with battery energy storage to a wind gust," *IEEE Trans. Energy Convers.*, vol. 12, no. 1, pp. 73–78, Mar. 1997.

[10] S. Bae and A. Kwasinski, "Dynamic modeling and operation strategy for a microgrid with wind and photovoltaic resources," *IEEE Trans. Smart Grid*, vol. 3, no. 4, pp. 1867–1876, Dec. 2012.

[11] C. W. Chen, C. Y. Liao, K. H. Chen, and Y. M. Chen, "Modeling and controller design of a semi-isolated multi-input converter for a hybrid PV/wind power charger system," *IEEE Trans. Power Electron.*, vol. 30, no. 9, pp. 4843–4853, Sep. 2015.

[12] M. H. Nehrir, B. J. LaMeres, G. Venkataramanan, V. Gerez, and L. A. Alvarado, "An approach to evaluate the general performance of stand-alone wind/photovoltaic generating systems," *IEEE Trans. Energy Convers.*, vol. 15, no. 4, pp. 433–439, Dec. 2000.

[13] W. M. Lin, C. M. Hong, and C. H. Chen, "Neural-network-based MPPT control of a stand-alone hybrid power generation system," *IEEE Trans. Power Electron.*, vol. 26, no. 12, pp. 3571–3581, Dec. 2011.

[14] F. Valenciaga, P. F. Puleston, and P. E. Battaiotto, "Power control of a solar/wind generation system without wind measurement: A passivity/ sliding mode approach," *IEEE Trans. Energy Convers.*, vol. 18, no. 4, pp. 501–507, Dec. 2003.

[15] A.Manikandan ,N.Vadivel "Design And Implementation Of Luo Converter For Electric Vehicle Applications" International Journal of Engineering Trends and Technology (IJETT) – Volume 4 Issue 10 - Oct 20.