Analysis of Dual KY Boost Converter Using PV Array

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ABSTRACT

This paper deals with analysis of PV based dual KY boost converter. The aim of this work is to design the dual KY boost converter and single phase inverter for the dual PV system and dual DC source voltage. To obtain as much as energy from dual PV system, to generate single phase AC output. Dual KY boost converter can provide higher maximum power, faster response and smaller voltage ripple. The dual KY boost converters are designed to generate stable output values according to various conditions owing to various control techniques and MPPT control algorithm is developed.

1. INTRODUCTION

A dual KY boost converter is presented, which is the KY converter combined with the normal synchronously rectified boost converter. The input and output inductor currents are continuous, higher voltage conversion ratio and suitable for low-ripple applications. Using soft switching with surge current suppressed can operated in high-power applications. The small-signal ac model is derived, and the controller design is developed. KY converter shows better performance than boost converter. KY converter provides fast response to reach maximum power point compared than boost converter [1-3]. A novel voltage-bucking/boosting converter named as KY buck–boost converter. It has fast transient responses, synchronous rectification, load regulations and low output voltage ripples. Cuk converter, Sepic converter, Zeta converter, Luo converter etc. However, these converters, operating in the continuous current mode, possess right-half-plane zeroes, thereby causing the system stability to be low, load transient responses to be slow [4]. Luo converter in a single-stage topology. In single stage topologies the dc converter stands alone, but in multistage topologies, the dc converter is combined with dc converters or with ac inverters.

The objective of this work to propose a novel multi input inverter for the grid-connected hybrid solar/wind power system in order to simplify the power system and reduce the cost. The multi input inverter designed with buck/buck-boost fused multi input dc–dc converter and a single phase bridge type dc–ac inverter [5]. Power from the any renewable energy sources can be delivered to the grid individually or balanced Maximum Power Point Tracking (MPPT) feature can be realized for renewable energy, power converters and control algorithms have been used along with purposeful energy resources for the efficient operation of the micro grid. The proposed micro grid, based on hybrid energy resources, operates in autonomous mode and has an open architecture platform for testing multiple different control configurations. ac–dc, dc–ac and dc–dc converters are integrated in the distributed energy system due to different natures of the output voltages [6-7]. A stand-alone hybrid power system is proposed here. The system consists of solar power, wind power, diesel engine, and an intelligent power controller. To attain a active and balanced response for the active power control, the controller consists of a radial basis function network and an...
improved Elman Neural Network for Maximum Power Point Tracking (MPPT). The pitch angle of wind turbine is controlled by the, and the PV system uses radial basis function network, where the output signal is used to control the dc/Elman Neural Network dc boost converters to achieve the MPPT [8]. A semi isolated multi input converter for hybrid PV/wind power charger system which can simplify the power system, reduce the cost, deliver continuous power, and overcome high-voltage-transfer-ratio problems is proposed. In this paper, the operational principle of the proposed semi isolated multi input converter is explained [9]. The view of a standalone and grid-connected hybrid renewable energy system to supply ac loads.

The configuration of the hybrid renewable energy System and interfacing power converters for connecting the energy sources to the AC bus is extensively discussed. An outline of the control view in a hybrid renewable energy system and the application of the relevant control methods for system stabilization, effective inducing of real power and proper load sharing methods are available. The different approaches for hybrid renewable energy system design and control methods for power converters in the recently research literature are also briefly discussed. The AC bus-linked hybrid renewable energy System configuration reduces the number of power conversion stages and losses in power transferred to the load/ utility. The master-slave control with the droop concept does not require a communication link and provides good load sharing, such as the flexibility, expandability and modularity of the hybrid renewable energy system. The single-master and multi-master approaches are used in the inverter control strategies [10]. Several algorithms that are used to operate dc to dc converters around the Maximum Power Point are reported in the literature.

A Hopfield Neural Network is used to routinely tune the fuzzy membership function. The integrated components of a solar array, a buck-boost zeta converter and a designed MPPT tracking controller are implemented using Matlab Simulink tool to validate the Hopfield neural network. The extension of similar concept can be developed using an Adaptive Fuzzy Logic controller [11]. A novel isolated multiport dc to dc converter for simultaneous power scheduling of multiple renewable energy sources like solar and wind, which can be of different types and capacities. The novel proposed dc to dc converter only uses one controllable switch in each port to which a renewable energy source is connected. The advantage of the proposed multiport dc-dc converter is its simple structure which having the potential of implementing MPPT techniques for different renewable energy sources simultaneously. This paper introduces a multiple-input multiple output modular multilevel dc to dc converter (MIMO-MMC) and its associated control scheme. The proposed topology has a bidirectional structure and may be utilized in both low- and high-power applications. The proposed topology is analyzed under steady-state operation, and a control algorithm is proposed for the converter operating under both step-down and step-up configuration. The ability of the converter to exchange power bi-directionally in both step-down and step-up modes of operation is demonstrated through both simulation and experiment. MIMO-MMC’s modules are constructed from buck-boost converters similar to modules used for equalization of battery cells, solar cells and other low-power applications. The topology is fully symmetrical in that any of its terminal ports may be readily employed as either an input or an output [12-13].

2. DRAWBACKS OF EXISTING METHOD

The conventional converters for interfacing many renewable sources use a common dc link or common ac frequency link which has the drawbacks like requirement of more number of packaging and increased switches over the conventional structure was illustrated [14]. Multiport converter has many advantages against conventional structure in terms of the number of power devices and conversion steps which in turn improves the system efficiency. Several types of non isolated voltage-bucking/boosting converters causing the system stability to be low. The interleaved converter can also used. It consists of two single-phase boost converters connected in parallel. This removes the ripples but it increases the switching losses.

3. ADVANTAGES OF PROPOSED METHOD

This dual KY boost converter topology features higher efficiency with less power electronics devices and less power conversion process. The proposed dual KY boost converter has the advantages of simple topology and minimum number of power switches. The dual KY boost converter has continuous input and output inductor currents and high voltage ratio. The dual KY boost converter structure is promising from the viewpoints of low cost, centralized control and compact.
4. MULTI INPUT CONVERTER

The proposed multi input combination consists of a both buck and buck boost integrated multi input dc to dc converter shown in Figure 1. The two inputs 100Volt dc voltage is given. Based on the conduction status of the switches and the multi input dc to dc converter has four operation modes. When both the switches M1 and M2 are ON operates in first mode. In second mode and third mode one switch is ON and other switch is OFF. In the fourth mode when both the switches are switched OFF, the freewheeling path diodes and will provide a free-wheeling path for the inductor current. If one of the voltage sources is failed, the other dc source can still provide the output. Therefore, it is very suitable for renewable energy applications. It converts output voltage of 230 volt and output current of 2.3 amps for resistive load. Figure 2, 3 and 4 results for input voltage, output current and output power respectively.

5. DUAL KY BOOST CONVERTER ANALYSIS
5.1 Working of Dual KY Boost Converter

Figure 5 shows the proposed dual KY boost converter constructed by the KY converter combined with the boost converter. The dual KY converter is composed of four switches M1, M2, M3 and M4, one diode D, one output inductor Lo, two input inductors Li1, Li2, two energy transferring capacitors Ce1,Ce2, buffer capacitor Cs and one output capacitor Co. The storage capacitor Cs is a buffer between the KY converter and the traditional synchronously rectified boost converter. The proposed dual KY boost Converter connected to dc Input shown in Figure 6. The multi input dc voltage 12 volt is given and the 110 volt is

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obtained at the output. Based on the conduction status of the switches and the dual KY converter has two operation modes. M1 is turned OFF and M2 is turned ON. The Diode D is forward biased and turned ON. During the mode, Cs is discharged, Ce1 is charged. Therefore, the voltage across Li1 is V1, thereby, causing Li1 to be magnetized, whereas the voltage across Lo is Vo subtracted from VCs, thereby, causing Lo to be demagnetized. Also, the current flowing through Co is equal to ILo minus the current flowing through RL, hence, the corresponding differential equations are written for single stage of KY boost converter.

$$
\frac{\partial i_{L1}}{\partial t} = V1
$$

$$
\frac{\partial i_{Lo}}{\partial t} = VCs - Vo
$$

$$
\frac{\partial v_{Co}}{\partial t} = ILo - Vo/RL
$$

$$
\frac{\partial VCs}{\partial t} = -i_{L1} - ILo
$$

Figure 5. Dual KY Boost Converter Connected to DC Input

M1 is turned ON and M2 is turned OFF. In this case, M1 is in the ON-state, and hence, D is reverse-biased and turned OFF. During this mode, Cs is charged. And Ce2 is discharged. Therefore, the voltage across Li1 is VCs subtracted from V1, thereby, causing Li1 to be demagnetized, whereas the voltage across Lo is Vo subtracted from 2VCs, thereby, and causing Lo to be magnetized. Also, the current flowing through Co is equal to ILo minus the current flowing through RL, whereas the current flowing through Cs is equal to the sum of ILi1 and 3ILo. And hence, the corresponding differential equations are.

$$
\frac{\partial i_{L1}}{\partial t} = V1 - VCs
$$

$$
\frac{\partial i_{Lo}}{\partial t} = 2VCs - Vo
$$

$$
\frac{\partial v_{Co}}{\partial t} = ILo - Vo/RL
$$

$$
\frac{\partial VCs}{\partial t} = -i_{L1} - 3ILo
$$
5.2 Dual KY Converter Connected to DC Input

Figure 6 shown the output voltage of 110 Volt for 12 volt input. Figure 7 shows and input power of 18 watts and Input Power From each Source 9 Watts. Figure 8 shows the output power of dual KY boost converter 14 Watts. Dual KY boost Converter connected to PV array input shows in Figure 9.

Figure 6. Dual KY Boost Converter Output Voltage 110V

Figure 7. Total Input Power=18 Watts

Figure 8. Dual KY Boost Converter Output Power=14 Watts

Figure 9. Dual KY Boost Converter to PV Array Input

Figure 10. Simulation of Dual KY Boost Converter Connected to PV Array Input
With above design values of PV arrays are connected as input and the waveforms are obtained. The analysis are done for PV array input of 18 volt and the output of 110 volt obtained across the load resistance.

### Table 1. Design Value of PV Array

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isc</td>
<td>5.96 A</td>
</tr>
<tr>
<td>Voc</td>
<td>6.2 V</td>
</tr>
<tr>
<td>Series Resistance</td>
<td>0.18 Ohm</td>
</tr>
<tr>
<td>Parallel Resistance</td>
<td>2 Ohm</td>
</tr>
<tr>
<td>No.of.Modules in Series</td>
<td>4</td>
</tr>
<tr>
<td>No.of.Modules in Parallel</td>
<td>4</td>
</tr>
<tr>
<td>Irradiance</td>
<td>1000 w/m2</td>
</tr>
<tr>
<td>Temperature</td>
<td>25 C</td>
</tr>
</tbody>
</table>

#### 5.3 Dual KY Boost Converter Connected to Battery Output

Figure 13 shows the MPPT algorithm used to generate duty ratio for switches. Simulation of dual KY boost converter connected to battery terminals and checked the SOC (state of charge). The PV array input of 18 volt and the output of 118 volt obtained across the battery. Input Voltage from each PV Array 11 watts and the total Input Power is 22 watts.

![Diagram of P & O Algorithm for Generating Pulses](image-url)
6. SIMULATION OF DUAL KY BOOST CONVERTER CONNECTED TO INVERTER OUTPUT

Figure 17 shows the simulation of dual KY converter connected to single phase inverter. The analysis is done for PV array input of 18 volt and the KY converter output voltage is 230 volt and the output current is 3.5 amps. The dual KY Boost converter output connected to single phase Inverter. The single phase inverter output voltage is 230 volt and the THD value is nearly 8.22%. The corresponding waveforms shown from Figure 18 to Figure 24.
7. RESULTS AND ANALYSIS

The dual KY Boost converter output connected to single phase Inverter. The single phase inverter output voltage is 230 volt and the THD value is nearly 8.22%. The corresponding waveforms shown from Figure 18 to Figure 24.

Figure 18. Inverter AC Output Voltage 230 Volt

Figure 19. THD =8.22% for Single Phase Inverter Output Voltage

Figure 20. Single Phase Inverter AC Output Current 5 Amps

Figure 21. THD=6.58% for Single Phase Inverter Output Current

Figure 22. Dual KY Boost Converter DC Output Voltage 230 Volt

Figure 23. Dual KY Boost Converter DC Output Current 3.5 Amps

Figure 24. Ppv=450 Watts
8. CONCLUSION
Power from the dual PV array can be delivered to the utility grid simultaneously, MPPT feature can be realized for dual PV system. A large range of PV array voltage variation, PV current variation and temperature variation caused by different insolation. This stand-alone dual generation system can effectively extract the maximum power from the two PV solar energy sources. Boosting the DC voltage (18V to 230V) to a sufficient level using the dual KY boost converter, and obtaining pure AC voltage (230V) from the inverter are the keys to realize the above targets. A model of hybrid dual solar system with closed loop configuration employed with control technique is developed. The KY converter will offer low THD (6.58%), high power factor under nonlinear loading condition and good dynamic response under transient loading condition.

REFERENCES

Table 2. Output of Dual KY Boost Converter

<table>
<thead>
<tr>
<th>Parameters</th>
<th>VALUES</th>
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<tr>
<td>In</td>
<td>26.3 A</td>
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<tr>
<td>Vdc</td>
<td>19.5 V</td>
</tr>
<tr>
<td>PV panel Voltage</td>
<td>18 V</td>
</tr>
<tr>
<td>PV panel Current</td>
<td>25A</td>
</tr>
<tr>
<td>PV Panel Power</td>
<td>450 watts</td>
</tr>
<tr>
<td>KY Boost converter output voltage</td>
<td>230V</td>
</tr>
<tr>
<td>KY Boost converter output current</td>
<td>3.5A</td>
</tr>
<tr>
<td>Inverter AC Output Voltage</td>
<td>230 V</td>
</tr>
<tr>
<td>Inverter AC Output Current</td>
<td>5 A</td>
</tr>
<tr>
<td>Power factor</td>
<td>0.93</td>
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<tr>
<td>Efficiency</td>
<td>86.79%</td>
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