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Design and Implementation of Multi Input Transformer Coupled Bidirectional Dc-Dc Converter for PV-Wind-Battery System

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ABSTRACT

The Multi input transformer coupled bidirectional dc-dc converter for renewable energy applications is proposed. The system is integrated the solar PV panel with wind turbine and the battery for increase the reliability of the system. To track the maximum power from the solar PV panel MPPT algorithm is used. This improves the efficiency and reliability of the system. Simulation results obtained using MATLAB/Simulink show the performance of the proposed control strategy for power flow management under various modes of operation.

Keywords: Multi Input Transformer(MIC), Maximum Power Point Tracking(MPPT), Power Flow Management

I. INTRODUCTION

Due to increasing energy demand and concerns over climate change motivate power generation from renewable energy sources. Solar photovoltaic (PV) and wind have emerged as popular energy sources due to their eco-friendly nature and cost effectiveness. However, these sources are not reliable. Hence, it is a challenge to supply stable and continuous power using these sources. This can be addressed by efficiently integrating the multiple renewable energy sources with storage elements.

II. METHODS AND MATERIAL

1. Literature Review

For achieving the integration the traditional approach involves using dedicated single-input converters one for each source, which are connected to a common dc-bus [1] - [10]. However, these converters are not effectively utilized, due to the intermittent nature of the renewable sources. In addition, there are multiple power conversion stages which reduce the efficiency of the system.

Large amount of literature exists on the integration of solar and wind energy as a hybrid energy generation system with focus mainly on its optimization [7], [8]. In [7], the sizing of generators in a hybrid system is investigated. They are number of converter can be used to interface the multiple sources with common DC link bus.

The control technique for a stand-alone hybrid energy system is investigated on [9] - [11]. Steady state performance of a standalone hybrid PV-wind system with battery storage is analyzed in [9].

Tracking the maximum power from the souces is an major aspects,so the investigation Of various techniques of MPPT algorithms in [13].for increasing the efficiency and also reducing the losses, selection of converter is analysed in [11] PV-wind hybrid system, proposed by Daniel et al. [12], has a simple power topology but it is suitable for stand-alone applications. An integrated four-port topology based on hybrid PV-wind system is proposed in [10]. However, despite simple topology the control scheme used is complex. In [19], to feed the dc loads, a low capacity multi-port converter for a hybrid system is presented.

The control technique for a stand-alone hybrid energy system is investigated on [9] - [10]. Steady state performance of a stand-alone hybrid PV-wind system with battery storage is analyzed in [9]. Hybrid PV-wind based generation of electricity and its interface with the power grid are the important research areas Chen et al. in [7],However, these converters are not effectively utilized, due to the intermittent nature of the renewable sources. In addition, there are multiple power conversion stages which reduce the efficiency of the system.

2. Description of the Proposed System

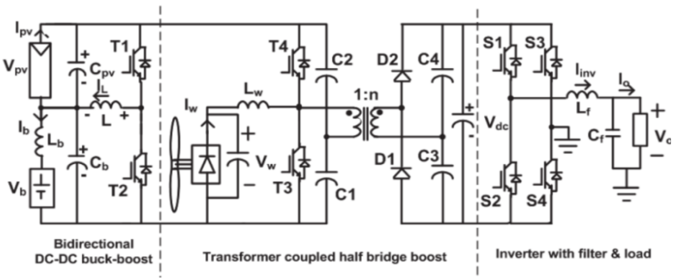


Figure 1. Proposed System Configuration

The proposed converter consist of dual half bridge converter ,boost converter and the full-bridge inverter ,solar PV panel, wind turbine and battery storage the half bridge boost converter has two DC link on higher frequency tranformer.so controlling the voltage on one of dc link, ensures the controlling the voltage of another side, this makes the control is simple. The bidirectional buck boost converter is connected on primary side of the transformer and inverter is integrated on the secondary side of the converter.

The galvanic isolation between the sources and load is achieved by the transformer. The bidirectional converter is used to supply the continuous power supply from the solar PV panel with the battery charging//discharging control. The half bridge converter is used to supply the power from the wind generator. The required 400v dc link voltage is achived only by four controllable switches, this reduced the number of circuit components and also increase the efficiency compared with the existing standalone schemes.

2.1 MPPT Mode for Wind Generator

When switch T_3 is ON, the current flowing through the source inductor increases. The capacitor C_I discharges through the transformer primary and switch T_3 as shown in Fig. 2 In secondary side capacitor C_3 charges through transformer secondary and anti-parallel diode of switch T_5.

When switch T_3 is turned OFF and T_4 is turned ON, initially the inductor current flows through anti- parallel diode of switch T_4 and through the capacitor bank. During this interval, the current flowing through diode decreases and that was flowing through transformer primary increases. When current flowing through the inductor becomes equal to that flowing through transformer primary, the diode turns OFF.

Since, T_4 is gated ON during this time, the capacitor C_2 now discharges through switch T_4 and transformer primary. During the ON time of T_4, anti-parallel diode of switch T_6 conducts to charge the capacitor. During the ON time of T_4, the primary voltage $V_{P=}$-$V_{c1.}$

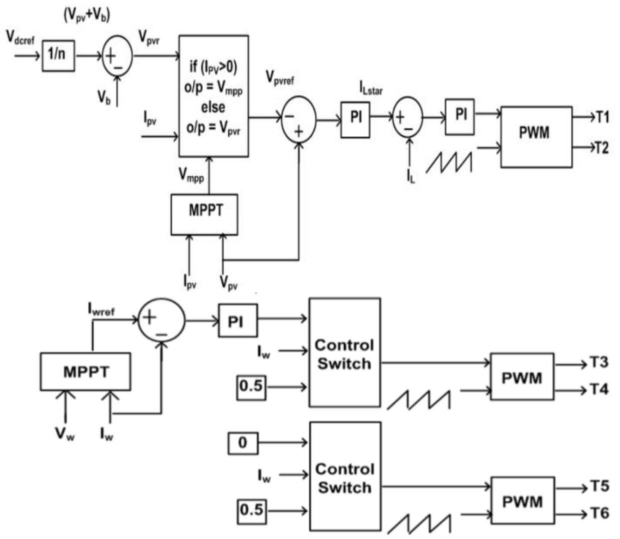
The secondary voltage $VP=nV_P$ or $V_P= nV_{C1}$ and voltage across primary inductor L_W is V_W. When T_5 is turned OFF and turned T_5 ON, the primary voltage $V_{P=}V_{c2}$.

The PV array voltage exhibits narrow variation in voltage range with wide variation in environmental conditions. On the other hand, the battery voltage is generally stiff and it remains within a limited range over its entire charge-discharge cycle. Further, limits the operating range of the batteries used in a stand-alone scheme to avoid overcharge or discharge.

2.2 MPPT Mode for Solar PV Panel

In the proposed configuration as shown in Fig. 1 bidirectional buck-boost converter is used for MPP tracking of PV array and battery a Charging/discharging control. Further, this bidirectional buck-boost converter charges/discharges the capacitor bank C_I-C_2 of transformer coupled half-bridge boost converter based on the load demand. The half-bridge boost converter extracts energy from the wind source to the capacitor bank C_I-C_2.

During battery charging mode, when switch T_1 is ON, the energy is stored in the inductor L. When switch T_1 is turned OFF and T_2 is turned ON, energy stored in L is transferred to the battery. If the battery discharging current is more than the PV current, inductor current becomes negative.



Figurt 2.

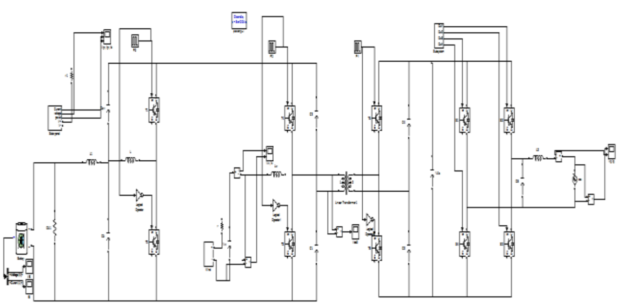
2.3 Power Flow Management

The hybrid PV-wind-battery based system consisting of four power sources (grid, PV, wind source and battery) and three power sinks (grid, battery and load), requires a control scheme for power flow management to balance the power flow among these sources.

The control philosophy for power flow management of the multi-source system is developed based on the power balance principle. In the stand-alone case, PV and wind source generate their corresponding MPP power and load takes the required power. In this case, the power balance is achieved by charging the battery until it reaches its maximum charging current limit I_{bmax}.

III. RESULTS AND DISCUSSION

3.1 Simulink Model of the Bidirectional Converter



The proposed system is modelled by using MATLAB at the version of 2010

Detailed simulation studies are carried out on MATLAB/Simulink platform and the results obtained for various operating conditions are presented in this section.

The values for source-1 (PV source) and source-2 (wind source), are set at 40 V (V_{mpp}) and 5 A (I_{mppp}) respectively and both the sources attain the set value required for MPP operation.

3.2 Simulink Waveform of both Sources In MPPT Mode

The output voltage and output current from the solar PV is simulated when both of the sources in MPPT mode.

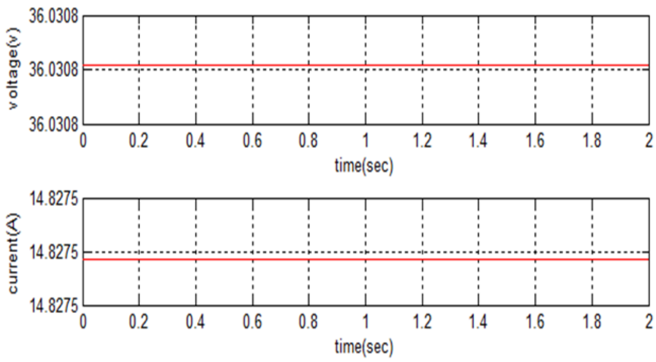


Figure 3. Simulink Waveform of both Sources on MPPT Mode

3.3 Simulink Waveform for Wind Generator at MPPT Mode

The output voltage from the generator is simulated when the wind generator is operating on MPPT mode.

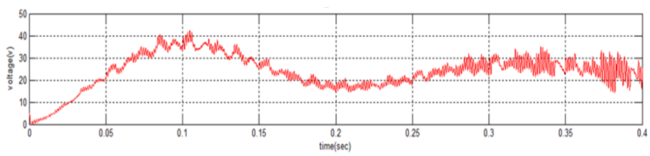


Figure 4. Simulink of wind Generator on MPPT Mode

Table 1. Simulation Parameters

Parameter	**Value**
Solar PV power	v_{mpp}=36v
Wind power	V_{mpp}=36v
Transformer turns ratio	5.5
Inductor-half bridge boost converter, L_w	500mh

3.4 Simulink Waveform of the Output

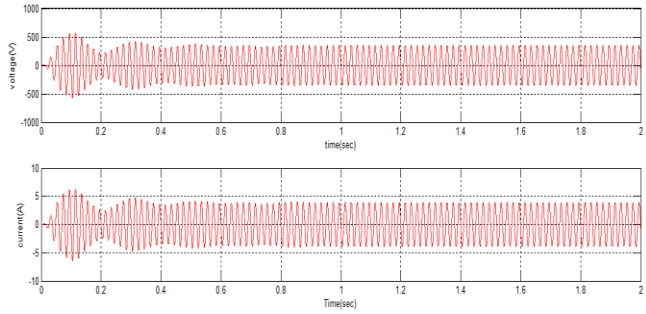


Figure 5. Simulink Waveform of Output Voltage on MPPT Mode

The output voltage and current across the load is simulated by the using the solar PV and wind.

3.5 Simulink Waveform of Battery in MPPT Mode

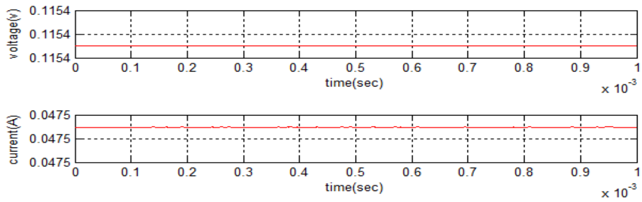


Figure 6. Simulink Waveform of Battery in MPPT Mode.

3.6 Simulink Voltage And Current Waveform of Solar PV in Battery Standalone Mode

This waveform shows that absence of solar PV in battery standalone mode.

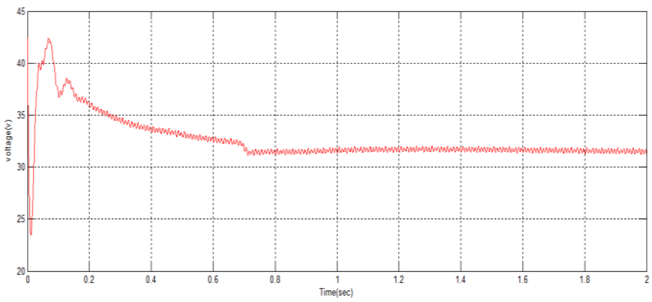


Figure 7. Simulink Waveform of the Solar PV Panel on in Battery Standalone Mode

3.7 Simulink Voltage and Current Waveform of Wind Generator In Battery Standalone Mode

This waveform shows that absence of wind generator in battery standalone mode.

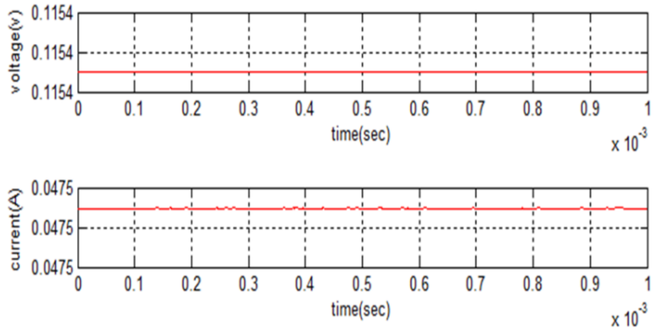


Figure 8. Simulink Waveform of Wind Generator in Battery Standalone Mode

3.8 Simulink Voltage And Current Waveform In Battery Standalone Mode

The output voltage and current across the load is simulated in battery standalone mode by using the proposed converter and the inverter.

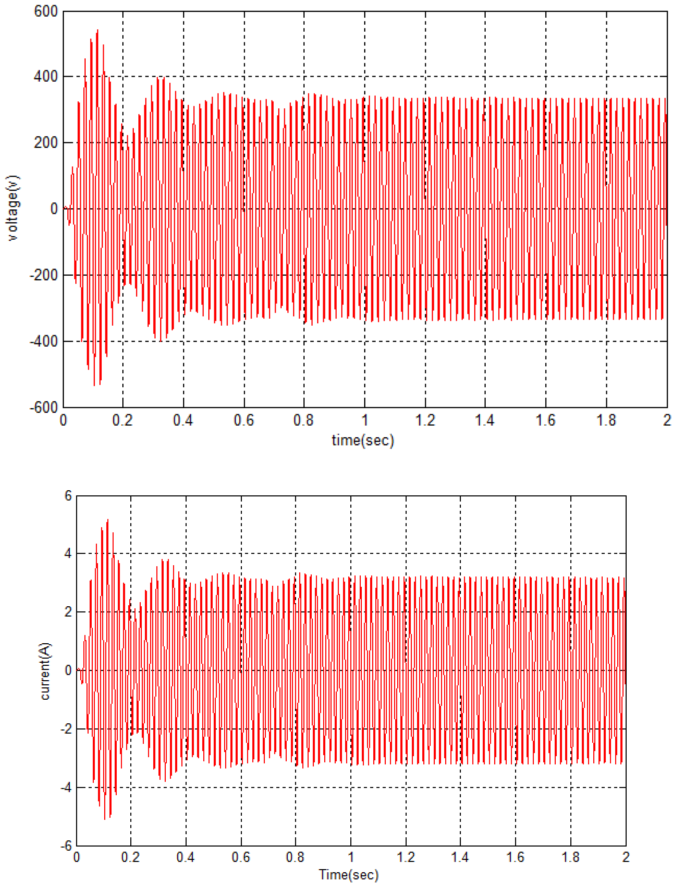


Figure 9. Simulink Voltage and Current Waveform on Battery Standalone Mode

IV. CONCLUSION

Stand-alone 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. A novel multi-input transformer coupled bidirectional dc-dc converter followed by a conventional full-bridge inverter realizes it. A versatile control strategy which achieves 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.

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