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A Multi Input Multi Output Converter for Hybrid Energy Systems

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Abstract

Multi input and multi output converters are becoming popular because they are cost effective and compact. This paper proposes a multi input multi output converter for Grid-Solar power integration for uninterrupted power supply. The proposed converter uses four winding transformer with two primary windings and two secondary windings. The grid supply is connected to the first winding of transformer through rectifier-inverter for controlled power transfer. The solar energy is inverted and applied to the second winding of primary. Two output ports are considered. The circuit is designed to get zero current switching during turn-off and zero voltage switching during turn-on to alleviate the switching losses. The simulation results for the proposed configuration are presented in this paper.

Keywords

Multi Input/Multi Output Converters, ZCS/ZVS, Grid-Solar Power Integration, Multi Winding Transformer

1. Introduction

The demand for uninterrupted, good quality power supply is the major challenge for the current hybrid energy systems. Integrated power converters are capable of interfacing and controlling energy sources concurrently [1] [2]. Multi input single output, multi input-multi output, single input-multi output converters were proposed for many applications. Multiport converters can be of isolate or non-isolated type. In isolated topologies, multi-winding transformers were employed to transfer the energy from the primary sides to the secondary sides with galvanic isolation provided between different ports. Several topologies proposed were based on flyback [3] [4]

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and bridge [5]-[8] configurations. They were used for single input and multi-outputs. These isolated converters offer flexible voltage transformation and regulation, but the transformer adds on weight and cost. As an alternate for this, several isolated multi-output converters were proposed. Primarily buck, boost, SEPIC and Cuk-converter topologies were extended to get multi-outputs [9]-[15]. However, these topologies were designed for power supplies. To feed AC load, the solar power has to be converted to AC. The distributed energy system consisting of grid supply and solar power needs a transformer for integration. Two different inverter configurations were proposed in the literature for this type of distributed energy systems. The first configuration consists of two inverters, connected in parallel, whose outputs are connected to the grid through a multi-winding step-up transformer. The main drawback of this scheme is that it operates at low frequency, hence bulky transformer is required [16]-[20]. The second type is with multi input DC-DC converter cascaded with inverter for AC loads. This configuration offers galvanic isolation and high boosting capability, however; it consists of multiple power processing stages. Moreover, bulky electrolytic capacitors are required at the DC link. Electrolytic capacitors cause severe reliability issues in inverters. They are extremely sensitive to temperature and their life deteriorates due to increase in temperature. In fact, capacitor reliability is currently inadequate for PV inverters; therefore, it is necessary to support design of alternative inverter topologies to simplify and reduce the cost of inverters while increasing their reliability. A multiport high frequency AC link inverter as the interface among the photovoltaic (PV) modules, battery energy storage system, and three-phase AC load was proposed in [21].

This paper proposes two-output ports converter topology for connecting PV supply and Grid supply through galvanic isolation. The proposed converter uses four winding transformer with two primary windings and two secondary windings. The grid supply is connected to the first winding of transformer through rectifier-inverter for controlled power transfer. The solar energy is inverted and applied to the second winding of primary. Two output ports are considered. The circuit is designed to acieve zero current switching during turn-off and zero voltage switching during turn-on to alleviate the switching losses. Section 2 describes the proposed configuration; Section 3 gives simulation results and analysis and the Conclusion is given in Section 4.

2. Proposed Configuration

The circuit diagram of the proposed topology is shown in **Figure 1**. Single phase supply from grid is rectified. The rectifier current is smoothened by filter inductor Lgf and the voltage is smoothened by the filter capacitor Cgf.

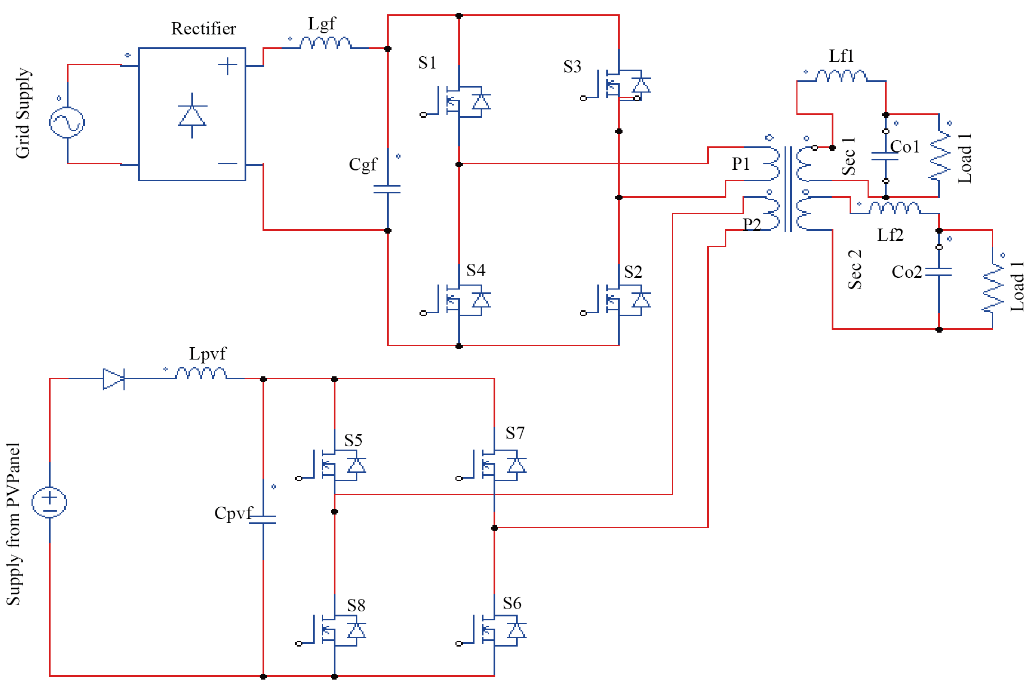

Figure 1. Proposed configuration.

The rectified voltage is fed to inverter 1 consisting of switches S1-S4. The inverted output is given to Transformer primary P1. Load 1 is connected to the first secondary Sec1. The LC filter Lf1 and Co1 are used to shape the output voltage to a sine wave.

The second input is from PV Panel. The ripples in current and voltage are minimized by using filter inductor Lpvf and Cpvf respectively. This stiff DC supply is converted to AC by using an inverter consisting of switches S6-S8. This inverter output is given to second primary winding P2 of the transformer. Load 2 is connected to second winding of secondary through the filter inductor Lf2 and filter capacitor Co2. The LC filters in secondary in addition to shaping the secondary voltages, will also helps in attaining zero voltage and zero current switching of all the inverter switches.

3. Simulation Results

The simulation is carried out in PSIM environment. The simulation circuit is shown in **Figure 2**. The simulation parameters are listed in **Table 1**.

The switching pulses, voltage across the switch and swicth currents for S1 & S2 are shown in **Figure 3**. For switches S3 & S4, they are shown in **Figure 4**. The switching pulses, voltage across the switch and swicth currents for S5 & S6 are shown in **Figure 5** and for the switches S7 & S8 shown in **Figure 6**.

It is observed from **Figures 4-6**, that for all the switches. The current through switches is zero during turn-on, voltage across switch is zero at the instant when turn-off is initiated as shown in **Figure 7**. Hence Zero current zero voltage switching is achieved. This soft switching will alleviate the switching losses.

The two primary voltages Vp1 and Vp2 are shown in **Figure 8**. The two secondary voltages are shown in **Figure 9**.

The load 1 and load 2 voltages are shown in **Figure 10** and **Figure 11** respectively. The output voltages are sinusoidal. Load 1 has a peak voltage of 210 V and load 2 has peak voltage of 115 V.

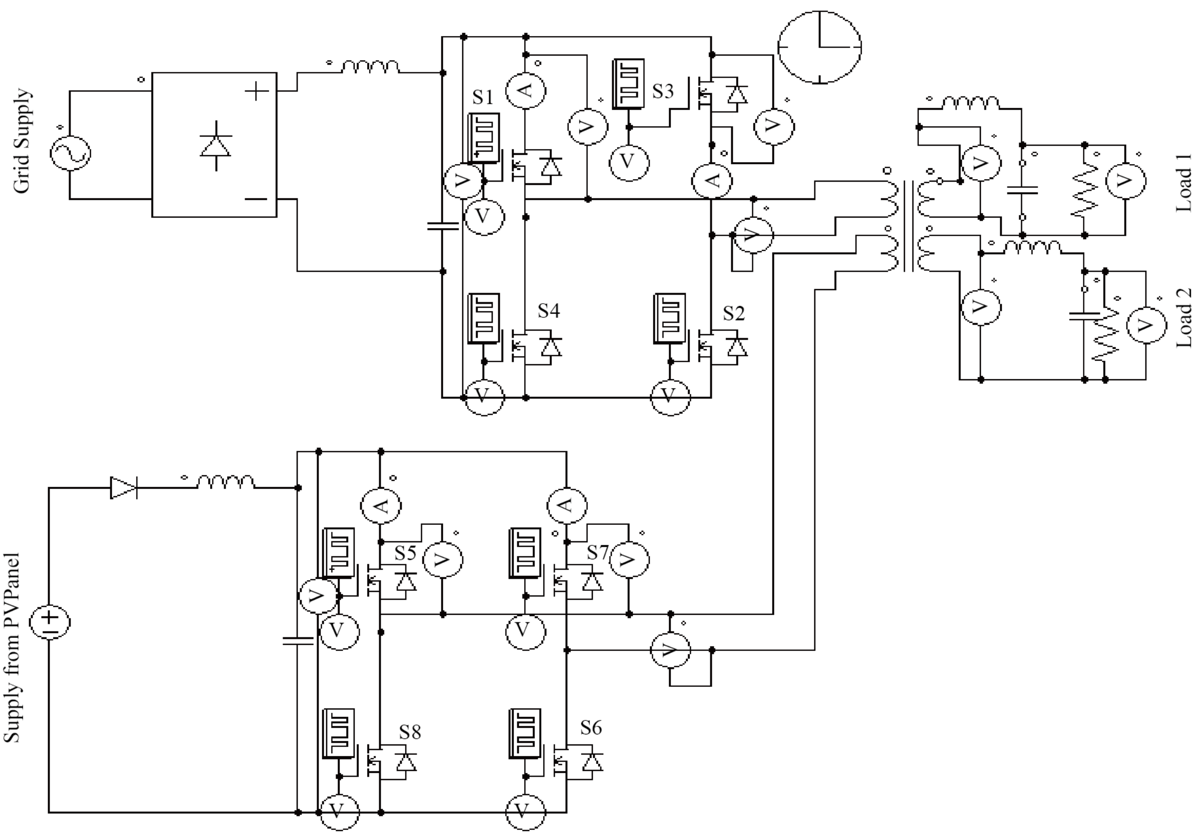

Figure 2. Simulation circuit.

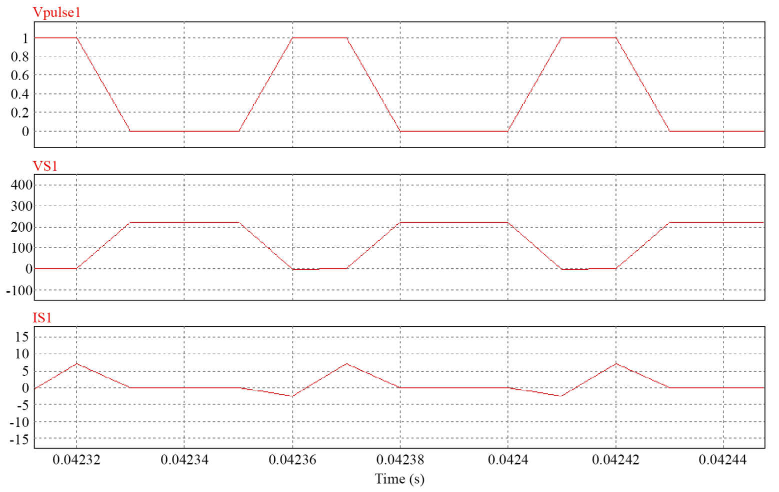

Figure 3. The switching pulses, voltage across the switch and swicth currents for S1 & S2.

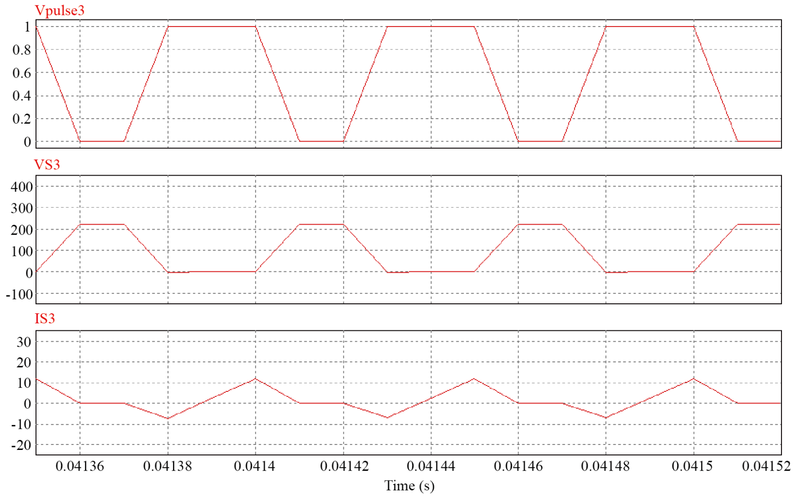

Figure 4. The switching pulses, voltage across the switch and swicth currents for S3 & S4.

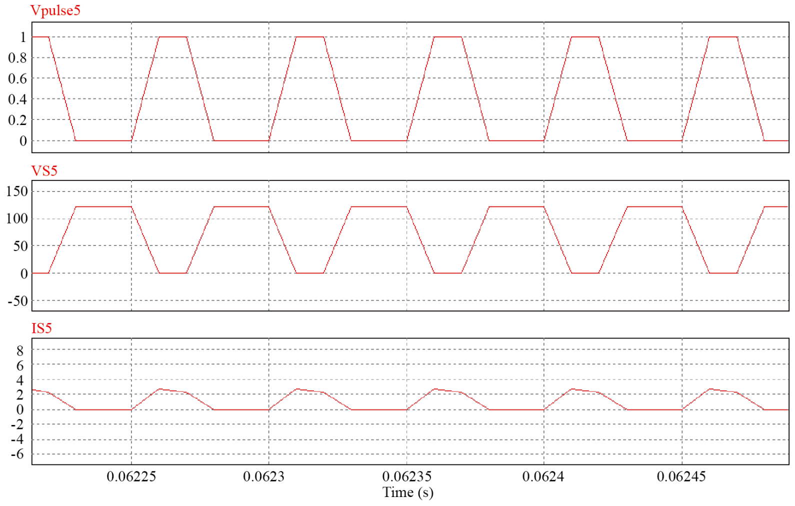

Figure 5. The switching pulses, voltage across the switch and swicth currents for S5 & S6.

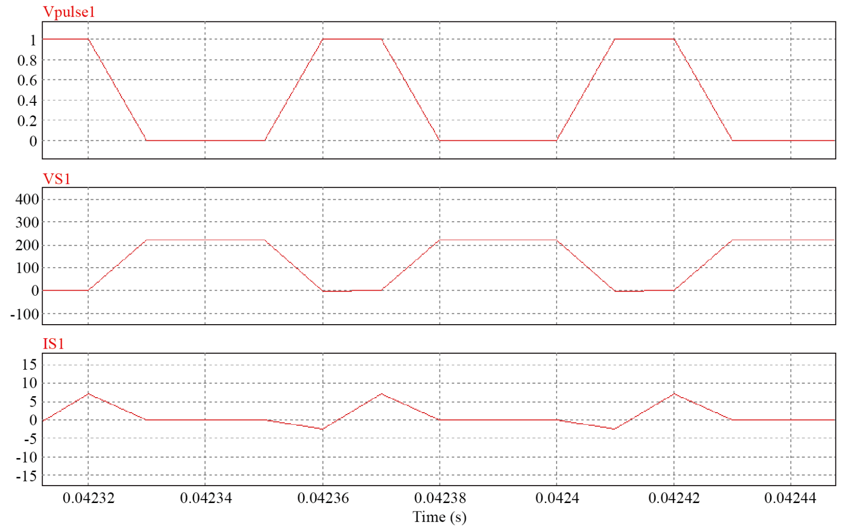

Figure 6. The switching pulses, voltage across the switch and swicth currents for S7 & S8.

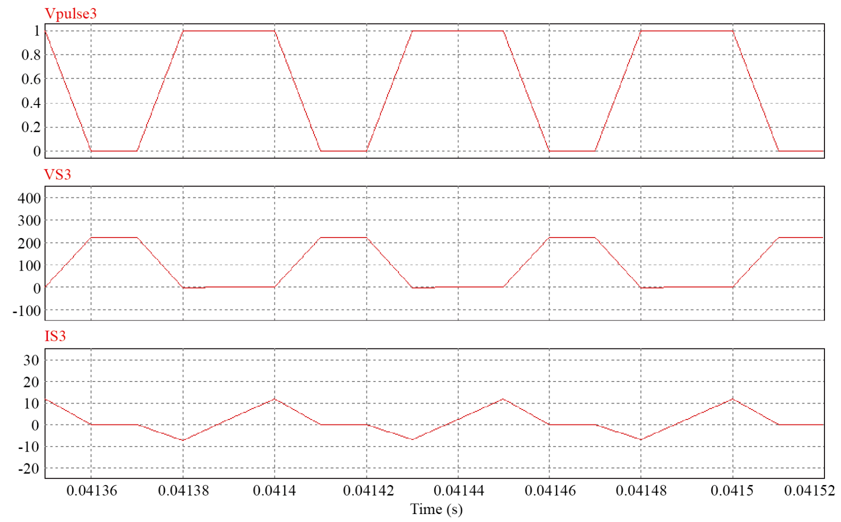

Figure 7. Zero Current Zero Voltage Switching of switches.

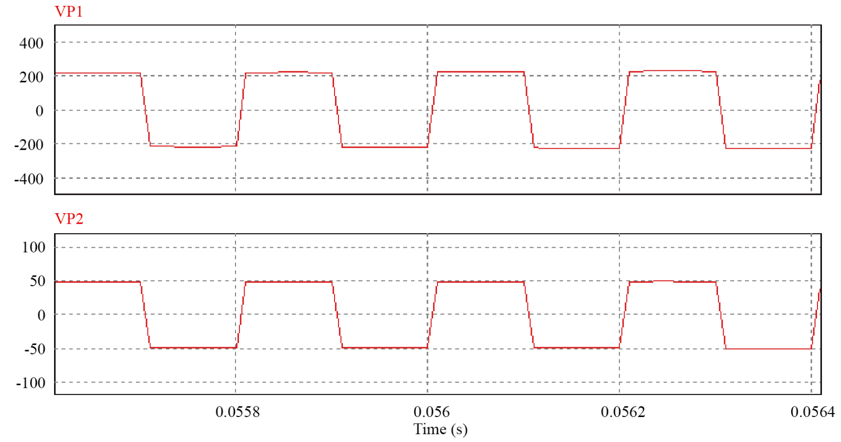

Figure 8. The two primary voltages Vp1 and Vp2.

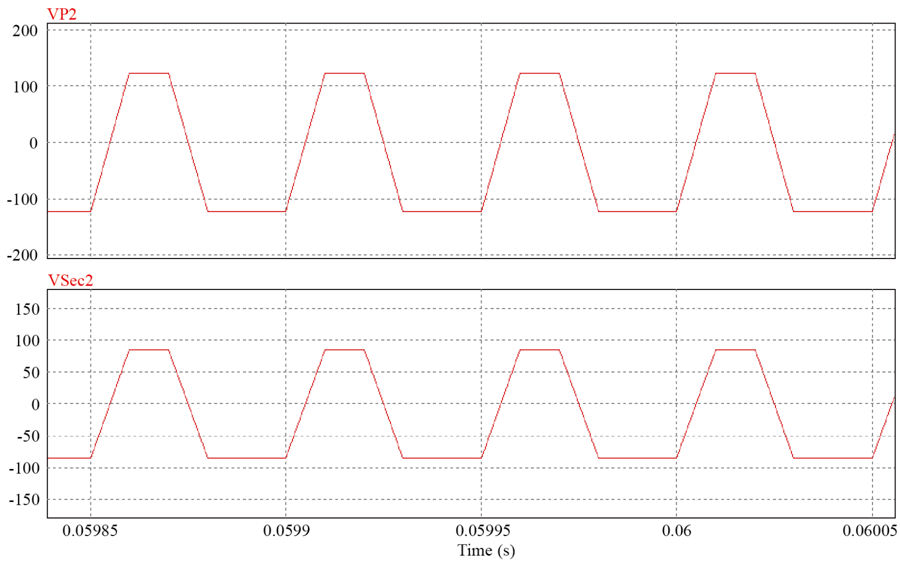

Figure 9. The two secondary voltages.

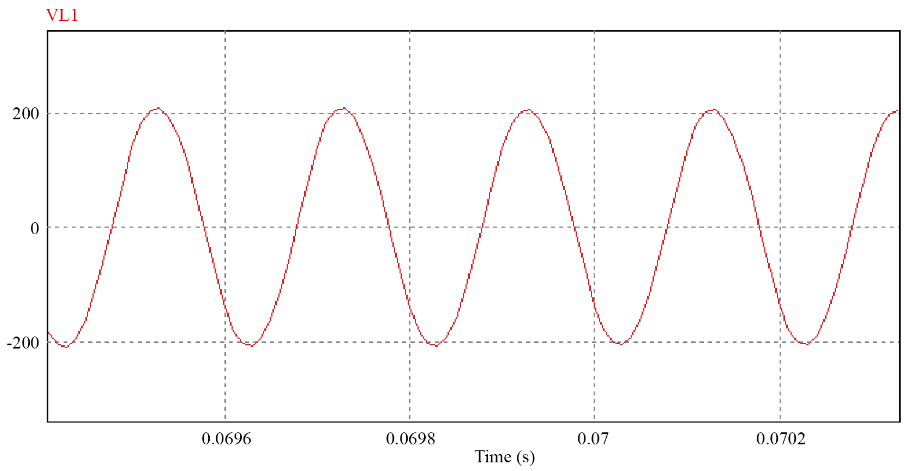

Figure 10. Load 1voltage.

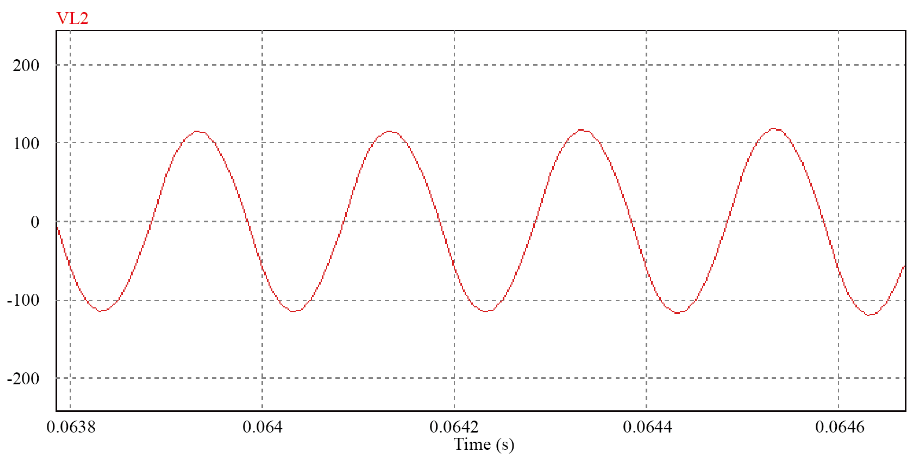

Figure 11. Load 2 voltage.

Table 1. Simulation parameter.

Parameter	Value
Lgf	1 μH
Cgf	1000 μF
Lpvf	0.1 μH
Cpvf	1000 μF
Switching Frequency	5 kHz
Lf1	10 μH
Co1	10 μF
Lf2	10 μH
Co2	10 μF
Load 1	12 Ω
Load 2	12 Ω
Grid Supply	220 V (Peak)
Supply from PV panel	50 V

4. Conclusion

A novel circuit for integrating Grid and Solar supply was proposed for two outputs. The proposed configuration has galvanic isolation. The soft switching of all the inverter switches is achieved which alleviates the switching losses. Two output voltages, which are sinusoidal, are obtained. This configuration can be further extended to get more than two outputs.

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