A GRID INTERFACED DC – DC CONVERTER WITH HYBRID INPUT SOURCES

[1]Tirupathi Srinivasa Rao, [2]Mr. Sadiq Ahamed

[1]Student, [2]Asst.Proff, Dept.of EEE, Nimra College of Engineering & Technology, Ibrahimpatnam, VJA (India)

ABSTRACT

This paper proposes a grid connected dc-to-dc power conversion circuit for distributed generation systems. With the three-port converter, the load can be powered from two different dc sources, which can be a combination of two from a solar-cell panel, a fuel-cell set, a battery bank, etc. and for continuous supply we extended the circuit into grid connected Ac system. The power conversion circuit consists of two active power switches by commonly using an inductor and an output filter capacitor and also inverter is used to convert Ac supply into Dc supply and grid connection at Ac load. By adjusting the duty-ratio of the active power switch and gate triggering pulses of the inverter, the voltage regulation at the output as well as the power coordination between two input sources can be made. The circuit operation is described in detail with the theoretical analysis and computer simulation. An experimental circuit has been built and tested to verify the analyzed and simulated results.

Keywords: Three-Port Dc-To-Dc Power Converter; Distributed Generation System; Power Coordination.

I INTRODUCTION

Generally, electric power generated by renewable energy sources is unstable in nature, thus producing a bad effect on the utility grid. This fact spurs research on energy storage systems to smooth out active-power flow on the utility grid. Simplified existing energy storage system employing a line-frequency (50- or 60-Hz) transformer, a PWM converter, a bidirectional chopper, and an energy storage device such as electric double layer capacitors (EDLCs) or lithium-ion batteries. The transformer is indispensable for some applications that require voltage matching and/or galvanic isolation between the utility grid and the energy storage device. Replacing the line-frequency transformer with a high-frequency isolated dc-dc converter would make the energy storage system more compact and flexible.

Various bidirectional isolated dc-dc converters have been proposed as the interface to energy storage devices with focus on automotive or fuel cell applications. Most of the presented dc-dc converters have asymmetrical circuit configurations to couple the two dc links having largely different voltages, several tens volts and several hundred volts. A conventional power electronic converter is supplied from a single input source, but may provide multiple outputs. In the case that two or more voltage or current levels are required by the loads, a transformer with multiple output windings is employed [2], [3]. On the other hand, however, for some applications, the loads may not be powered from a single source but from two or more input sources specified by different voltage, current, and power ratings [4-13]. For example, a solar power based street lamp is mainly supplied from solar cells, but needs a subordinate battery power. Such a prerequisite can be found more and more frequently in applications with renewable power generation, especially in a hybrid system with different kinds of power sources.

Conventionally, multiple power converters are needed to convert power from manifold power sources. To cope with this prerequisite, this paper proposes a three-port dc-to-dc converter with grid connected ac to dc system, which is capable of converting power from two different inputs sources to the load. The hybrid power sources deliver energy to the load alternatively by switching active power switches on and off, respectively and also from grid connection if first phase is damaged.

II CIRCUIT CONFIGURATION

The power conversion circuit of the proposed hybrid input dc-to-dc converter along with grid connected system is shown in Fig. 1, which is essentially an integration of a boost converter and a buck-boost converter from one side and from other side it has boost inverter. The integrated dc to dc power converter consists of two active power switches, S_1 and S_2 for boost conversion and buck-boost conversion, respectively, by commonly using a diode, D, an inductor, *L*, and a filter capacitor, *C*. The AC load shares the supply from both dc to dc hybrid input source and grid connected AC system.

The two dc sources, V_1 and V_2, are treated as the primary and secondary sources, depending on the capacity and the dependability of the power sources, the AC source V_s is treated as a alternating third source. Two active power switches are turned on and off periodically at a same frequency but are activated alternately in a period. The powers delivered by two sources are coordinated by controlling their duty-ratios.

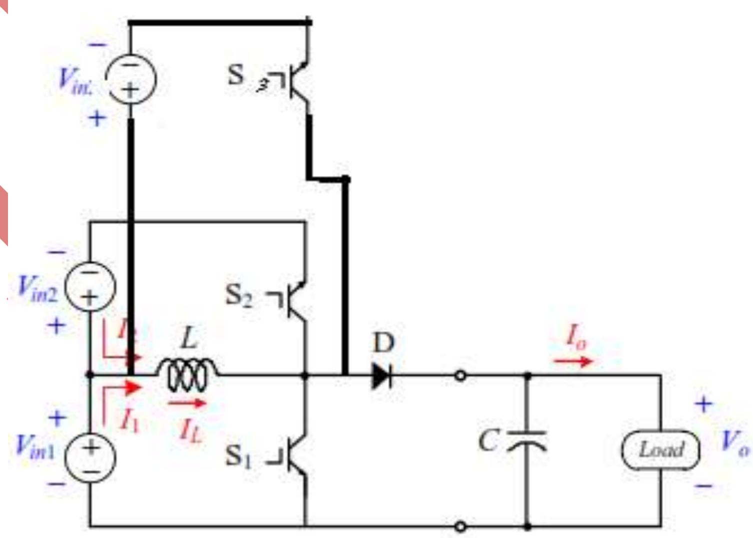

Fig 1: Proposed Converter Circuit

The power conversion circuit can be operated at the continuous conduction mode (CCM) or the discontinuous Conduction mode (DCM), depending on the continuity of the inductor current. In which, the duty-ratios of two active power switches are d_1 and d_2, respectively. At the CCM, the power conversion circuit is operated through Stages I, II, and III sequentially in a switching period, T2. Stage IV occurs only at the DCM when the inductor current falls down to zero. The steady state operation is described in the followings. The theoretical waveforms for both CCM and DCM are shown in figure 2 and figure 3.

The relationship between the input voltages and the output voltages can be obtained by the voltage second balance. Therefore,

$$Vo = \frac{d1V1 + d2V2 + d3V3}{1 - d1 - d2 - d3} + V1$$

The output voltage of the converter is the sum of V1 and the buck-boost conversion output voltage from input voltage.

The output power is the sum from three inputs.

$$V_0 I_0 = V_1 I_1 + V_2 I_2 + V_3 I_3$$

Then the output current can be obtained as

$$I_0 = \frac{(V_1 I_1 + V_2 I_2 + V_3 I_3)(1 - d1 - d2 - d3)}{d1V1 + d2V2 + d3V3}$$

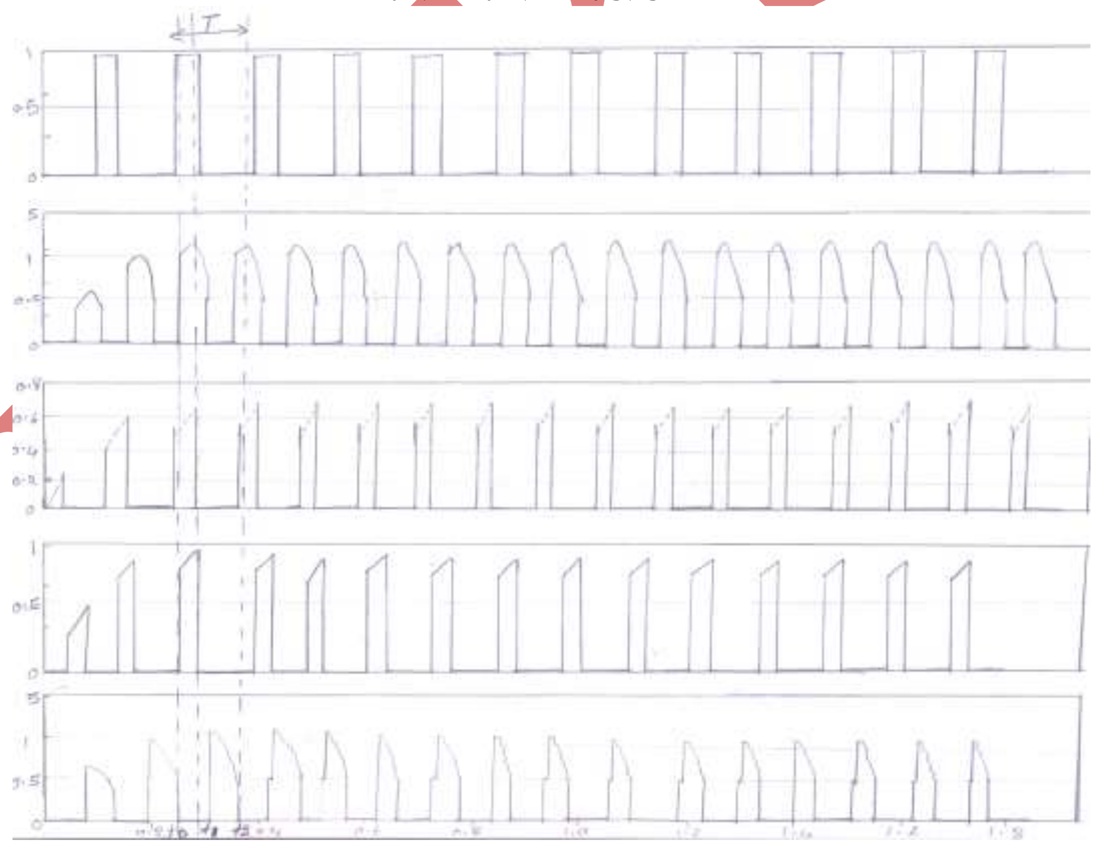

Fig 2: Theoretical Waveform For CCM

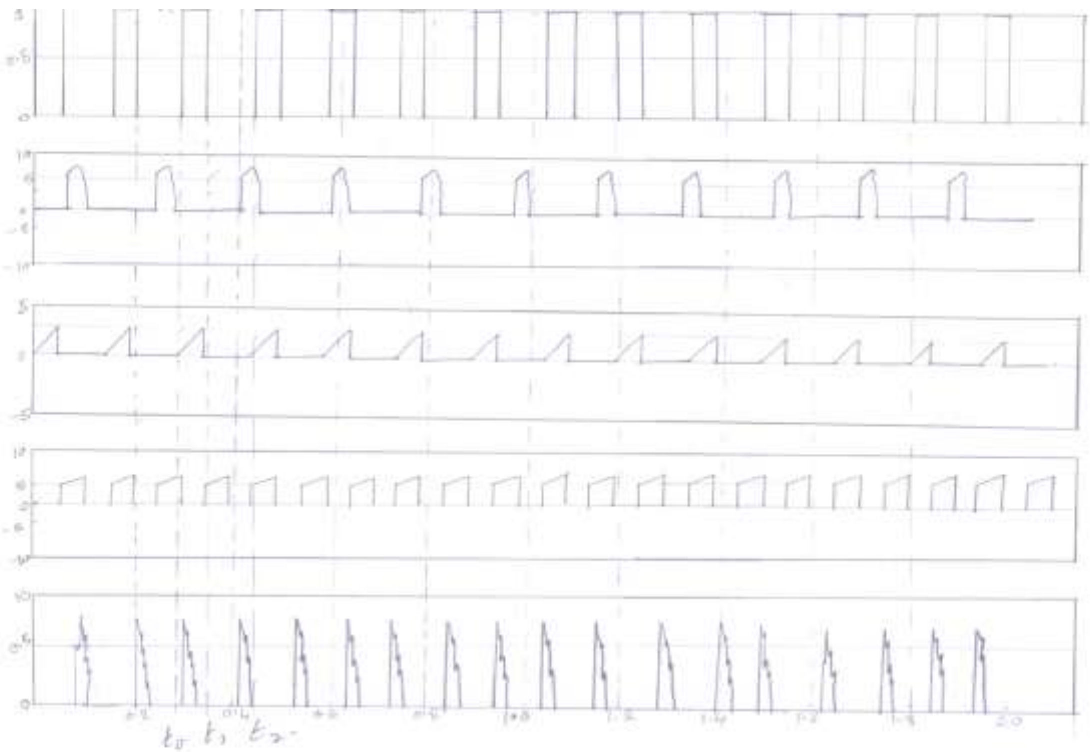

Fig 3: Theoretical waveform for DCM

The output voltage of the power converter is the sum of V_1 and the buck-boost conversion output voltage from V_1 and V_2. This equation indicates the output voltage is always higher than the input voltage. In practice, the sum of d_1 and d_2 in one cycle is limited to be less than 0.9.

III EXPERMENTAL RESULTS

A laboratory circuit of the proposed converter is built for performing experiments to verify the theoretical analyses. The converter is supplied from two dc power supplies to emulate primary and secondary input sources. Both two dc voltage sources can be varied in a wide range from 10 V to 30 V and Ac voltage of 150V. An AC load is used to regulate the power, voltage or current at the output. Table I lists the circuit parameters.

Primary input voltage	10V
Secondary input voltage	5 – 30 V
Ac Grid source	150 V

Constant Load current	0.3A
Inductance	237uH
Filter capacitor	330uF
IGBT S_1 and S_2	IXGR35N120B
Diode	PSR10C40

Fig. 4 shows the measured current waveforms on the key components when the converter is operated at CCM and DCM, respectively. The converter is operated in CCM mode, in this case V_0 and current wave forms are shown in figure 4(a) and figure 4(b) shows the current waveforms for DCM mode. In this the inductor current rises faster than that CCM.

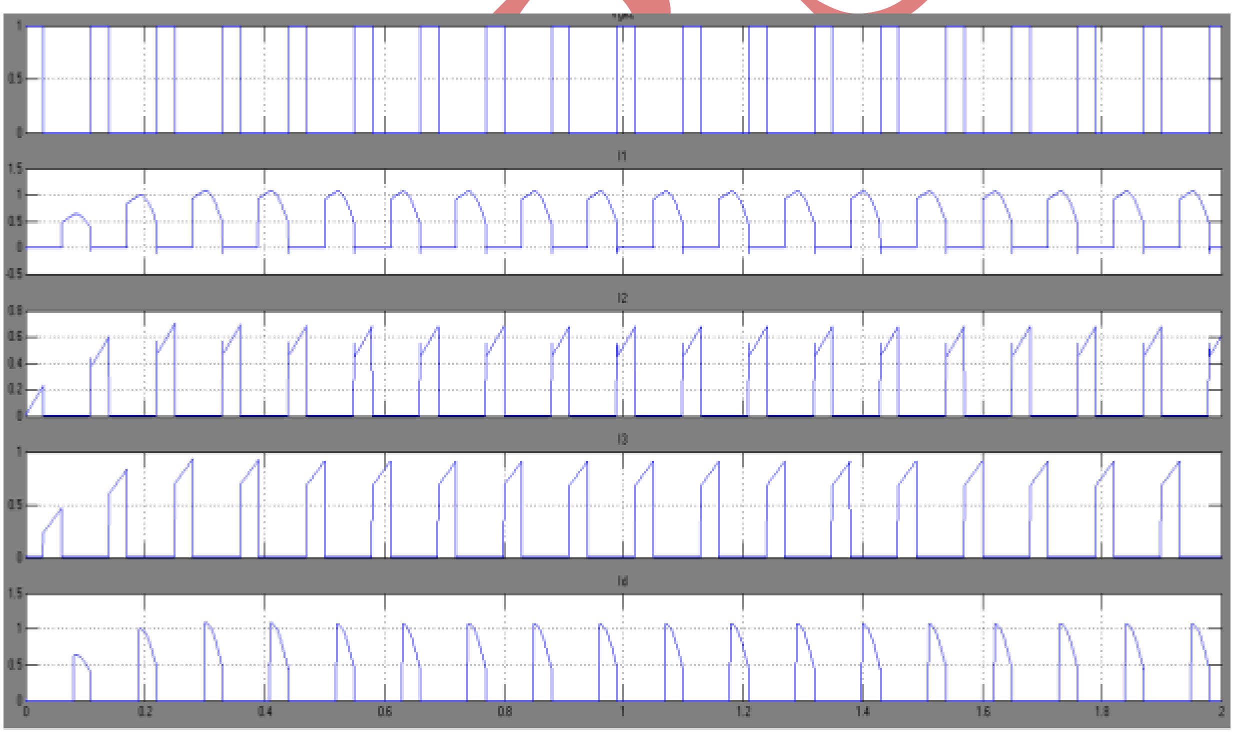

Fig 4(a) Experimental Results for CCM

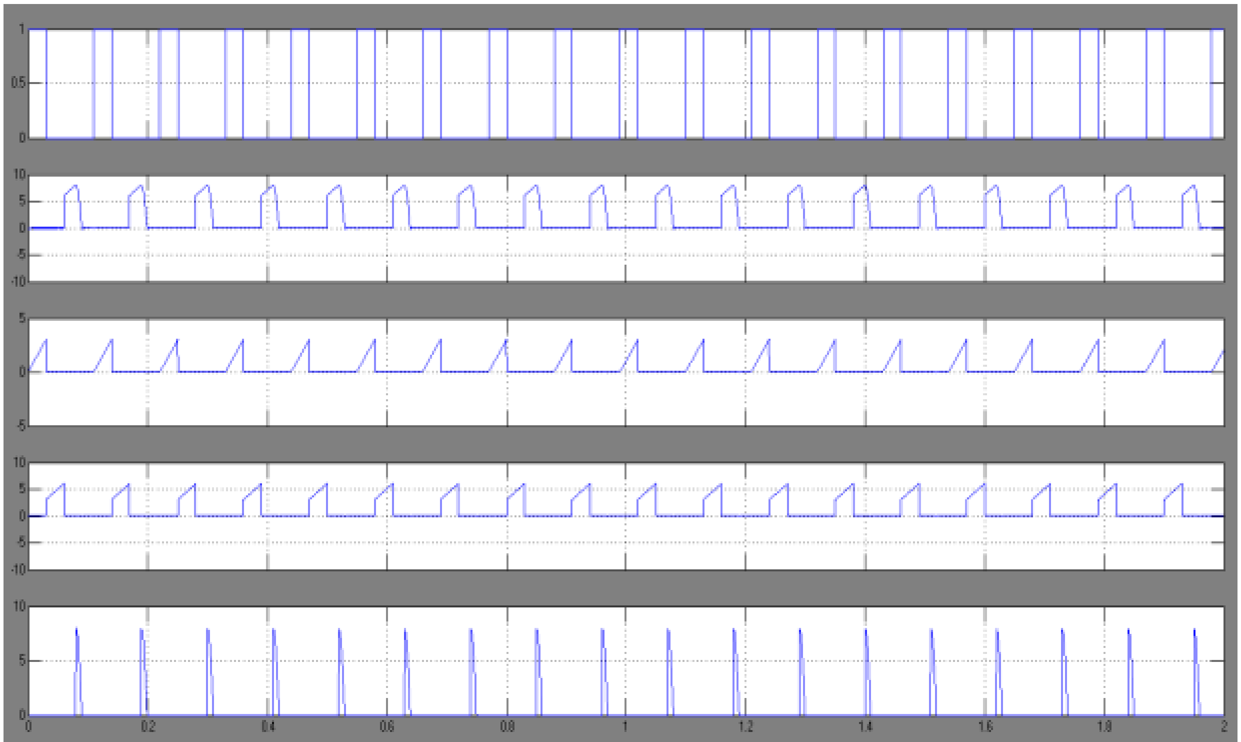

Fig 4(b) Experimental Results for DCM

IV CONCLUSION

This paper proposed a gird interfaced three-port dc-to-dc power conversion circuit which can be powered from three input sources. The power coordination between input sources and the voltage regulation can be made by adjusting the duty-ratios of two active power switches and gate pulses of the inverter switches. As compared with the conventional multiple-input power converter, the proposed conversion circuit has less component count. The power conversion circuit can be used in a distributed generation system with different dc power sources.

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