Interleave Isolated Boost Converter as a Front End Converter for Solar/Fuel Cell Application to Attain Maximum Voltage in MATLAB

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Abstract

Objectives: Solar power or fuel cell produces a very low output voltage (~20 v to 60 v), so we need to boost up voltage with high efficient converter. Method Analysis: Here an isolated converter is used in order to overcome back EMF problem from the load. Designing an Isolated DC low voltage to DC high voltage converter will be of great challenge because converter must handle high input current at the supply side and high output voltage at the loads side. For efficient way, we will be connecting the input parallel and connect the output in series. Findings: Based on this concept two inductors connected in parallel at the input side to share the input current and the capacitor are connected in series at output side to share output voltage in an interleaved manner. Thus the two boost converter cells are demagnetizing by repelling each other, therefore the transformer structure is simplified. By using interleaved operation ripple current will reduced, therefore capacitor and inductor size is reduced both at input and output side. Improvements: And features make on this interleaved isolated boost converter, then it desirable for high power low to high DC application, 40 V DC is boosted to 680 V DC is simulated using MATLAB.

Keywords: Boost Converter, Fuel Cell, MATLAB Simulink, Micro Inverter, Renewable Energy, Solar PV Cell

1. Introduction

There is scarcity of power globally, especially in rural area, especially for irrigation as part of agricultural practice. As we depend 70% on non-renewable energy source which has many problems such as an increase in fuel cost, depletion of fuel, increase in concern for climatic changes such as Greenhouse gas effect, etc., the renewable energy source such as Solar power or fuel cell produce a very low output voltage insufficient to operate a three phase induction motor or to connect to the grid. Renewable Energy source such as Fuel/PV cell needs a power converter (dc/dc) to convert the variable low voltage Fuel cell/PV cell stack voltage to the High DC voltage required for the input of the VSI Inverter to convert AC voltage for the motor.

Power converter helps the variable DC power to either produce a high-voltage DC or AC. Then power converter design and it is also influenced by source behavior like an input current ripple in order to meet reliability requirement of FUEL/PV cell. Also, researchers having high efficiency at the non isolated condition, for PV/FUEL CELL high step-up interleave DC/DC converter is executed\textsuperscript{2} can be connected to the motor. This converter must handle high current at the supply and high voltage

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at the load side output with low cost, high efficient and high power density. In fuel cell, for motor the DC power is converted into AC power. The boost converter is initiate to step-up the lower fuel cell voltage to peak line voltage at the intermediate DC link. We can't able to control the high ratio of the boost converter using the conventional non isolation technique.

Therefore the using transformer should be must and also, it separates the Fuel cell from motor then it ensures safety shown in Figure 1. For a compact design, lower in cost, frequency HF operation is desired because HF operation is to reduce size of transformer, other reactive components, converter and filter. Nowadays the Interleaved Isolated converter got interest over researcher. This converter is used to boost the voltage from 40V D.C. to 600V D.C. for 300 W circuits.

Renewable energy source such as Fuel/PV cell needs a power converter (dc/dc) to convert the variable low voltage Fuel cell/PV cell stack voltage to High DC bus voltage required for the input of the VSI Inverter to convert that into AC grid voltage. Also, researchers having high efficiency at the non isolated condition, for PV/FUEL CELL high step-up interleave DC/DC converter is executed grid connected power applications. The Grid-tied application is to meet the low voltage DC to high voltage DC conversion which has a high step up ratio. This can be used for Medium power applications in the range from 300 W to 1200 W.

2. Circuit Operation Principle and Characteristics

2.1 Interleave Isolated Boost Converter

In Medium to High power applications two or more boost converter is paralleled in an interleaved manner to increase the output current and reduce the input current ripple. However, current sharing among the parallel port is a major design problem. However, voltage Double circuit is used that is more advantageous than Full bridge rectifier circuit Two Boost converter are paralleled to achieve the required output voltage as to reduce the input current ripple is operated with two converters with 180 degree phase shift.

The converter circuit as shown Figure 2 which contains two inductor L1 and L2, capacitor C1, two grounds referenced IGBT such IGBT1 and IGBT2, a high frequency Transformer T1, rectifier diode D1 and rectifier diode D2 and output capacitors are C2, C3 and C4. Output capacitor C2 and C3 with diodes form a voltage doublers, which is initiate to boost the High frequency transformer output voltage. The two driving gate signal is command to the two BOOSTER IGBT gates with 180 degree phase shift and having duty cycle less than 0.5. As duty cycle is less than 0.5 there is a problem of controlling DC-DC Converter. Two ways can be used to overcome the problem viz., while switching frequency is a variable control means obviously the duty cycle must be constant. Then by keeping switching frequency is constant and it enables burst mode operation.

And the 2nd solution is preferred for low power control. In this sine pulse modulated gate signal is given as triggering pulse for the IGBT1 and IGBT2 switches this pulse is given and operation of circuits can explain each interval as mode of operation as given below.

Mode 1: As a control strategy of the two gate signal is overlapped at the switching period in the condition of both IGBT is ON. Therefore, both inductor L1 and L2 store energy. Where the two IGBT currents are equally divided. No current flow in secondary Transformer and Diode so no current is supplied by output capacitor.
Mode 2: During switching interval first IGBT is still ON while second IGBT is turned off for the particular condition. The energy stored in inductor L2 is transferred to secondary winding and capacitor C2 is charged during Diode D2 is in ON time.  

Mode 3: During interval both IGBT conduct back. It’s most probably model operation.  

Mode 4: During fourth interval IGBT1 is OFF and IGBT2 is kept OFF. When the energy stored in the inductor L1 is discharged on C3 with secondary winding of the transformer flowing through D1.

3. Simulation and Experimental Verification

Simulation is done with MATLAB 2013 in 8.1.064 version, where the circuit is same as that of simulation shown in Figure 3, but some block is added for measurement. Values specified in the simulation processes are

\[
\begin{align*}
L &= 1 \times 10^{-3} \text{H} \\
L_1 &= 1 \times 10^{-3} \text{H} \\
C_2 &= 1 \times 10^{-3} \text{F} \\
C_3 &= 1 \times 10^{-3} \text{F} \\
C_{OUT} &= 1 \times 10^{-2} \text{F}
\end{align*}
\]

The two pulses as shown Figure 4 are given for two switches S1 and S2. Here, S1 represents as IGBT1, S2 represents as IGBT2 pulse generator 3 produce pulses which is given to IGBT1, pulse generator 1 produce pulse which is given to IGBT2. Two pulse generators are opposite in phase in a given period, IGBT2 trigger pulse opposite to IGBT1 with small delay, which can be explained in the waveform diagram shown in Figure 5.

It can be seen that at 0.3 resolutions, i.e., a time period, which can do before coupling the simulation circuit. But output is only available at 20 resolutions, i.e., a time period, which can do before coupling the simulation circuit.

3.1 Waveform of Gate Triggering Pulse

The input and output parameters of triggering pulse values are tabulated in Table 1. Pulses are given to the circuit and the circuit can as per mode of operation. In this circuit, the triggering pulse waveform is used to convert the interleaved system to ensure boost process.

| S.No | Parameter                     | Specific Values            |
|------|-------------------------------|-----------------------------|
| 1.   | Input Voltage (Given)         | 40 V DC (as shown in Figure 6) |
| 2.   | Output Voltage (Simulated)    | 684.4 V DC (as shown in Figure 7) |
| 3.   | Output Current (Simulated)    | 7 mA                        |

![Figure 3. Simulation of Interleave Isolated Boost Converter using MATLAB](image-url)
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3.2 Input Voltage Waveform

Input Voltage Waveform is presented in Figure 6. The input voltage of 40 V DC is given to the system to operate interleaved boost converter shown in Figure 6. From the Figure 6, it may be observed that it can be used to initialize the IGBT device, which is used to generate the pulses. It can be activated to further process of the interleaved system, i.e., it is the level to adapt the voltage for the particular boost system of the interleaves concept.

3.3 Output Current and Voltage Waveform

Output current and voltage waveform are presented in Figure 7. From the Figure 7, it was found that the Pulse Generator 3 produces pulse, which is given to IGBT 1. Pulse Generator 1 produces pulse, which is given to IGBT 2. Two pulse generators are opposite in phase in a given period, i.e., IGBT2 Trigger Pulse Opposite to IGBT 1 with Small Delay. The output simulated voltage is about 684.4 V DC and output simulated current is about 7 mA shown in Figure 7. Further, it was observed that at 0.3 resolutions, i.e., a time period, which can do before compiling the simulation circuit, pulses are given. So, the circuit may be operated as per mode of operation.

4. Applications

This paper used for various applications such as transmission and utilization, the motor application's for single and three phases and solar based conversion application's. The fuel cell can be used, but conversion of Renewable Energy resource into useful DC or AC power to residential and industrial application is needed, but solar power or fuel cell produce a very low output voltage about (20 v to 60v), so, need to boost up voltage with high efficient converter.

By using interleaved operation ripple current will reduced, therefore capacitor and inductor size is reduced both at input and output side. And features make on this interleaved isolated boost converter, then it desirable for high power low to high DC application.

5. Conclusions

This work is given solution for the problem of renewable energy, motor back EMF and ripple current also reduced. Functions are concluding as
• To overcome the problems of renewable energy source such as solar.
• To back EMF problem from the load. Designing an isolated DC low voltage to DC high voltage converter will be a great challenge because converter must handle high input current at the supply side and high output voltage at the load side.
• By using interleaved operation ripple current will reduced, therefore capacitor and inductor size is reduced both at input and output side.

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