Design of Interleaved DC-DC Boost Converter FED Current Source Inverter for Piezo Electric Power Generation

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Abstract— Energy is one of the most important issues around the world. Due to lot of energy resources have been exhausted and wasted. Proposal for the utilization of waste energy of foot power with human locomotion is very much relevant. This project describes the use of piezo electric materials in order to harvest energy from people walking vibration for generating and accumulating the energy. The harvested energy is then regulated by interleaved dc-dc boost converter and inverted to AC by a current source inverter and which is then fed to the load. In this paper conventional dc-dc boost converter fed inverter and interleaved dc-dc boost converter fed current source inverter are simulated using MATLAB software and the performance of the design are compared.

Key words: Piezoelectric Sensor, Interleaved Dc-Dc Boost Converter, Current Source Inverter, Simulation of Interleaved Boost Converter, Simulation of Conventional Boost Converter

I. INTRODUCTION

Non-conventional energy system is very essential at this time to our nation. Micro energy harvesting technology based on generating micro energy from vibration and pressure using piezoelectric material which generate mW or µW of power of energy. Piezo electric material is one kind of transducer. This piezoelectric materials are engineered on the floor. When we apply force or pressure on this material it converts mechanical energy into electrical energy.

An efficient dc-dc boost converter is needed as the interface between a low voltage piezoelectric cell and high voltage bus for inverter operation. By using interleaved boost converter, the system can has high voltage step up and smaller ripple at the output voltage and output current. The switching loss for this circuit is also low and it has faster transient response.

CSI drive uses inductive energy storage – that is they use inductors in their dc link to store dc energy and regulate current ripple between the converter and inverter. In current source inverter input current is maintained constant and amplitude of output current is independent of load. More over CSI has more life time compared to VSI and also has high reliability.

II. ELECTRIC POWER GENERATION USING PIEZO ELETRIC SENSOR

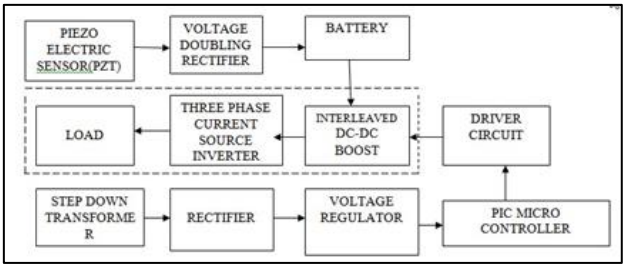

Fig. 1:

Piezo electric material is one kind of transducer .When we apply force or pressure on this material to convert it into electrical voltage. The material which behaves in such a way is known as piezo electric sensors. Thus the mechanical energy is converted into electrical energy. This system can be efficiently used in highly populated area the initial cost of system is high but it is used to generate electricity safetly and environment friendly. This system can be used in remote area where electricity supply is low. And it can be efficiently used for low power applications

In the conventional system, the piezoelectric cell is the energy source used. The energy produced is stored in a rechargeable battery and given to normal boost converter and inverter and given to the load. By this method output voltage

In the proposed system, the piezo electric sensors converts the pressure applied to it into an electrical energy the source of the pressure is from weight of the people walking over the steps. The output of a piezo electric sensor is not a steady one so an voltage doubling rectifier type series synchronised switch is used to convert variable voltage into linear one and also to increase maximum power output. The output dc voltage is stored in a rechargeable battery. then the energy is boosted up by an interleaved dc boost converter and converted to ac by an current source inverter and given to R load these components are controlled and triggered using PIC16F877A microcontroller it generate gate pulse to control the working of the components. The power supply to the microcontroller is given through step down transfomer and the voltage regulator.

III. INTERLEAVED BOOST CONVERTER

A. Design Methodology of IBC

The design methodology for all types of IBC's reuire a selection of proper values of inductor capacitor and proper choices of the power semicondutor devices to reduce the switching losses. The stpes involved in designing IBCs are as follows

- Decision of duty ratio and no of phases.
- Selection of inductor values

– Selection of power semiconductor switches
– Design of output filter.

1) Selection of Duty Ratio & No of Phases

Two phase IBC is chosen since the ripple content reduces with increase in number of phases. If the number of phases is increased further without much decrease in ripple content. Number of phases is chosen as two. The number of inductors switches and diodes are same as the number of phases and switching frequency is same for all phase. The input current ripple can be zero at specific duty ratios which are multiples of 1/N where N stands for no of phases. The duty ratio is taken as 0.5.

$$\frac{Vin}{L}\left(\frac{2-3D}{D'}\right)\frac{T}{N}d$$

2) Selection of Inductors

For the selection of the proper inductor and capacitor the design equation for all the three converters are given below

a) Coupled Inductor

The equivalent inductance expression for directly coupled IBC is

$$L = \frac{Vin\ DT}{\Delta Iph}$$

3) Selection of Power Devices

The semiconductor devices chosen for constructing the two phase interleaved boost converter is the IGBT. The main benefits of IGBT are lower on state resistance, lower conduction losses and high switching operation. The maximum voltage across the switching devices is given by

$$Vswitch = Vin\ \frac{1}{1-D}$$

4) Output Filter

A capacitor filter needed at output to limit the peak to peak ripple of the output voltage. For 5% output voltage ripple the value of the capacitance is given by

$$C = \frac{VoDT}{R\Delta Vo}$$

B. Operation & Analysis of Interleaved DC-DC Boost Converter

A boost converter is a switching converter that operates periodically by opening and closing of an electronic switch. Interleaving technique is an interconnection of multiple switching cells that will increase the effective pulse frequency by synchronizing several smaller sources and operating them with relative phase shift. An interleaving technique saves energy & improves power conversion without affecting conversion efficiency.

The switches are controlled by phase shifted switching function known as interleaving operation. Here two inductance value are considered equal L1=L2=L and equal duty cycles are D1=D2=D (phase shifted by 180*).

1) Mode I: Switch S1 Closed Switch S2 Opened

In this mode diode D1 is reverse biased while diode D2 is forward biased the input supply energy to the inductor L1 resulting in rise of inductor current IL1.At the same time inductor L2 supplies energy to the load resulting in decrease of inductor current IL2.

2) Mode II:Switch S1 Opened Switch S2 Opened

In this mode both diode D1,D2 are forward biased. It makes both inductors discharges and supply enery to the load resulting in decrease in inductor current.

3) Mode III: Switch S1 Opened Switch S2 Closed

In this mode diode D1 is forward biased while diode D2 is reverse biased. Inductor L1 discharging and supplying energy to load resulting in fall of inductor current. At the same time the input supplies energy to the inductor L2 resulting in increase in inductor current.

4) Mode IV: Switch S1 Opened Switch S2 Opened

In this mode both diodes are forward biased. This makes inductor discharges and supply energy to load resulting in decrease of inductor current.

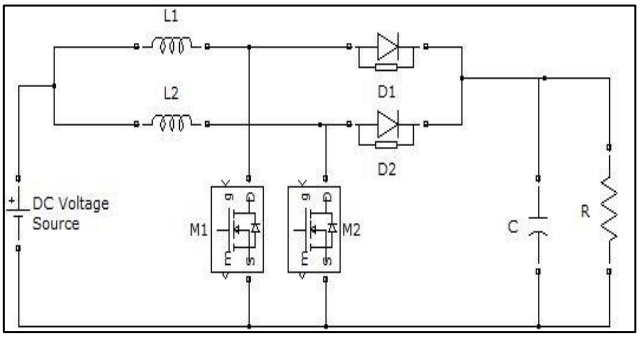

Fig. 2: Circuit diagram of interleaved boost converter

C. Parameters Used

COMPONENTS USED	RATINGS
INPUT VOLTAGE (Vin)	24V
INDUCTOR(L)	4.3mH
CAPACITANCE(C)	78µF
RESISTORS(R)	3.2Ω
FREQUENCY(f)	2KHZ
DUTY CYCLE(D)	0.5

Table 1:

D. Operation of Current Source Inverter

The Inverter is the power electronic circuit, which converts the DC voltage into AC voltage. The DC source is normally a battery or output of the controlled rectifier. Here the output is from interleaved DC-DC boost converter. The output voltage waveform of the inverter can be square wave, quasi-square wave or low distorted sine wave. The output voltage can be controlled with the help of drives of the switches.

The pulse width modulation techniques are most commonly used to control the output voltage of inverters. Such inverters are called as PWM inverters. The output voltage of the inverter contain harmonics whenever it is not sinusoidal. These harmonics can be reduced by using proper control schemes.

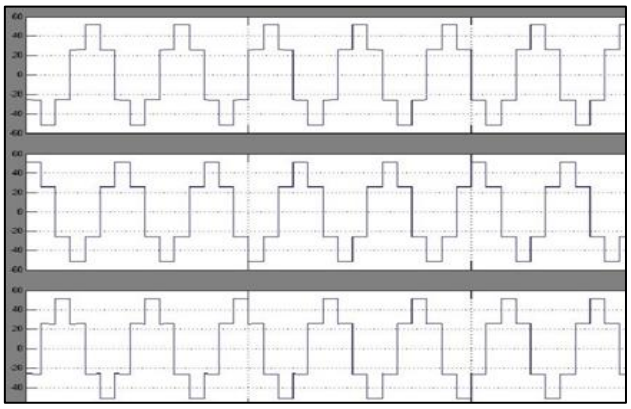

Fig. 2:

When input current is maintained constant, then it is called Current source inverter (CSI). CSI is fed with adjustable current from a DC voltage source of high impedance. The input current is constant but adjustable. The amplitude of output current is independent of the load. The magnitude of output voltage and its waveform depends upon the nature of the load impedance. The CSI does not require any feedback diodes. Commutation circuit is simple as it contains only capacitors. They cannot be used any devices have to withstand reverse voltage.

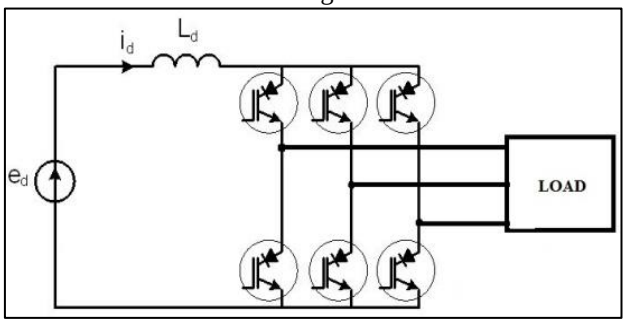

Fig. 3:

IV. SIMULATION & RESULT

The simulation models are created using MATLAB/Simulink and performance parameters of Interleaved Boost Converter fed Current Source and Conventional Boost Converter fed Inverter are verified.

A. Simulation of Interleaved Boost Converter Fed CSI

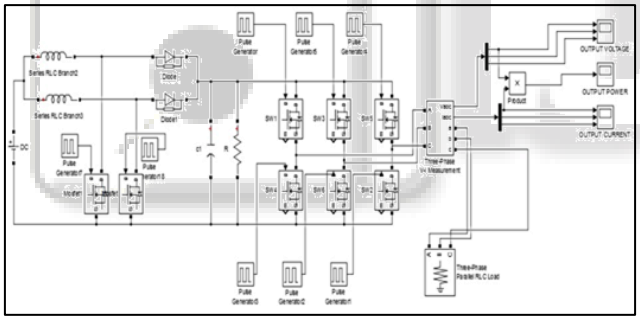

Fig. 4:

1) Output Voltage of IBC fed CSI

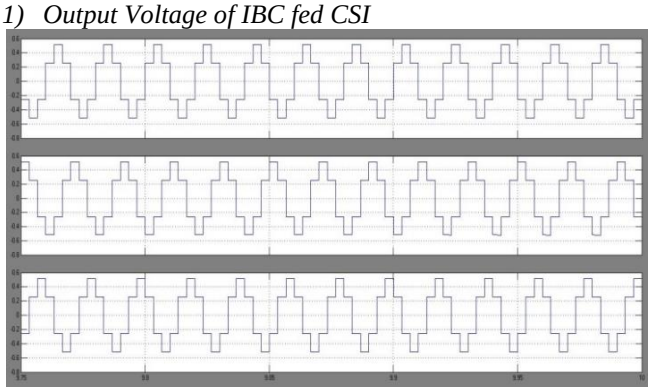

Fig. 5:

2) Output Power of IBC fed CSI:

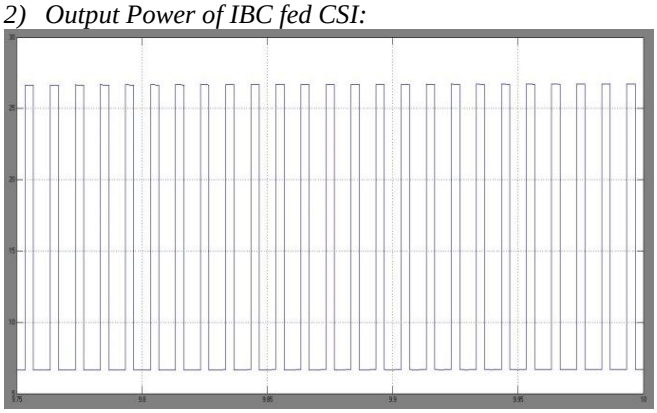

Fig. 6:

B. Simulation of Conventional Boost Converter Fed Inverter

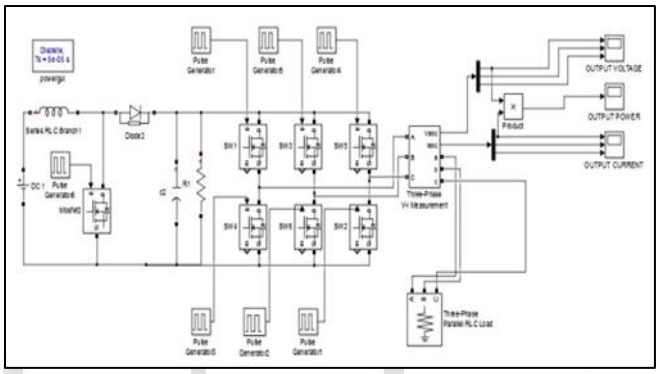

Fig. 7:

1) Output Voltage of Boost Converter Fed Inverter:

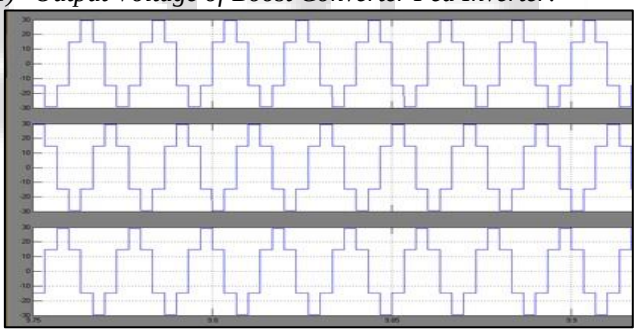

Fig. 8:

2) Output Current of Boost Converter Fed Inverter

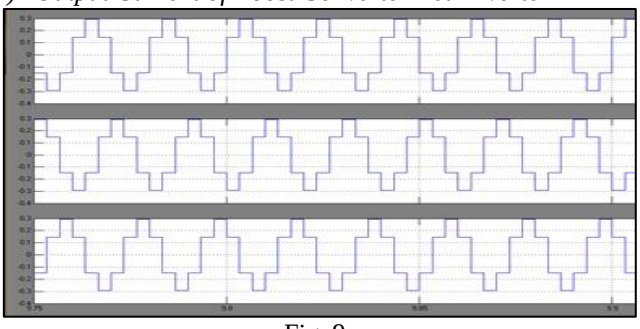

Fig. 9:

3) Output Power of Boost Converter Fed Inverter

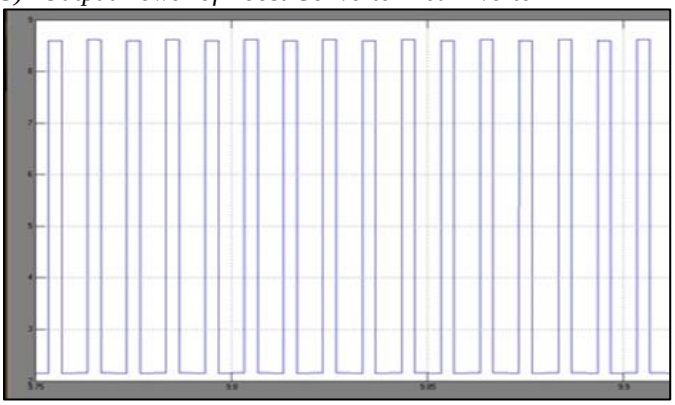

Fig. 10:

C. Comparison between Interleaved Boost Converter Fed Current Source & Conventional Boost Converter Fed Inverter

PARAMETERS	INTERLEAVED BOOST CONVERTER FED CSI	BOOST CONVERTER FED INVERTER
Input voltage	24V	24V
Output voltage	52V	30V
Output current	0.5A	0.3A
Output Power	27W	9W

Table 2:

V. CONCLUSION

The 'Generation of Power using foot step' gives an efficient power generation in highly populated countries as it reduces power demand without pollution. And also the performance parameters of conventional boost converter fed inverter and interleaved boost converter fed current source inverter are compared with simulated results using MATLAB/Simulink. Thus by using Interleaving technique we can reduce the output voltage hence switching losses can be reduced and efficiency is improved. And Current Source Inverter is used for its high reliability.

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