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Microcontroller Harnessed MOSFET Z-Source Matrix Converter

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Abstract: The proposed paper introduces a Z Source Matrix converter for buck and boost the output voltage and also with the change in frequency in stepwise manner. It performs direct AC-AC conversion by Pulse width modulation-duty ratio control. In addition, the converter employs a safe-commutation strategy whereas this strategy conduct along a continuous current path, which leads to the elimination of voltage spikes on switches without the need of Snubber circuit.To verify the performance of this converter simulation of the proposed converter was carried out in RL load for 35Vrms/50 Hz using MATLAB software and then the output is verified for 25Hz for asynchronous motor and then the output waveform is performed with unity power factor where the prototype model was performed for v/f speed control of motor.

Keywords: Duty ratio control,Pulse Width Modulation,,Snubber Circuit, Unity Power Factor , V/F Control,Z-Source Matrix Converter

1 INTRODUCTION

Voltage source inverters with a DC link is the popular set up used for AC-AC conversion requiring variable output voltage and variable frequency, usually a PWM inverter with diode rectifier front end and a DC capacitor link. In order to achieve smaller size and lower cost the best choice is a direct PWM AC-AC converter.Matrix converter is a direct AC-AC converter that can convert AC power supply voltage in to an AC voltage of variable frequency and voltage without energy storage element .Modulation schemes and applications are on research for single phase converters, which was initiated by Zuckerberger on a frequency step up and voltage step down converter.

The matrix converter has several advantages over traditional rectifier-inverter type power frequency converters. It provides sinusoidal input and output waveforms, with minimal higher Order harmonics and no sub harmonics it has inherent bi-directional energy flow capability; the Input power factor can be fully controlled. Last but not least, it has minimal energy storage requirements, which allows to get rid of bulky and lifetime- limited energy-storing capacitors.

But the matrix converter has also some disadvantages. First of all it has a maximum input output voltage transfer ratio limited to 87 % for sinusoidal input and output waveforms. It requires more semiconductor devices than a conventional AC-AC indirect power frequency converter, since no monolithic bi-directional switches exist and consequently discrete unidirectional devices, variously arranged, have to be used for each bi-directional switch. Finally, it is particularly sensitive to the disturbances of the input voltage system.

In order to overcome the drawbacks, a new topology based on Z-source converter has been used for AC-AC conversion. Z-source AC-AC conversion provides voltage regulation, harmonic currents and operates in boost and buck mode.This paper provides Z-source AC-AC converter for v/f control of output, that is providing variable output for step change in frequency. This is different from the conventional PWM AC/AC converters .we can show from simulation, analyses, and experimental results that the proposed converter could be used for V/F operation.

2 PROPOSED CONVERTER

The main purpose of the converter is to design single phase matrix converter fed to an motor and to implement V/F operation.A prototype of single phase matrix converter for variable voltage and variable frequency set up is proposed. The method used provides variable output voltage which is given for step up frequency using multiple PWM technique.We analyzed the characteristics of a single phase AC-AC converter with particular emphasis on harmonic content. Simulation study of a single phase matrix converter fed to a motor has been performed. A solid-state AC-AC converter converts an ac waveform to another AC waveform, where the output voltage and frequency can be set arbitrarily. AC-AC converters can be categorized as follows:Indirect AC-AC (or AC/DC-AC) converters,Hybrid matrix converters,Matrix converters (MC).

An AC-AC converter with approximately sinusoidal input currents and bidirectional power flow can be realized by coupling a Pulse-Width Modulation (PWM) rectifier and a PWM inverter to the DC-link. The DC-link quantity is then impressed by an energy storage element that is common to both stages, which is a capacitor C for the voltage DC-link or an inductor L for the current DC-link. The PWM rectifier is controlled in a way that a sinusoidal AC line current is drawn, which is in phase or anti-phase (for energy feedback) with the corresponding AC line phase voltage.

A. Single Phase Matrix Converter (SPMC)

The Z-source Single-Phase Matrix Converter. It uses four bi-directional switches to serve as a SPMC. This arrangement has the advantage of independent control of the current in both directions. Since these bidirectional switches are not available at present, they are substituted with two diodes and two MOSFETs connected in antiparallel.

Implementing this Z-source SPMC requires different switching arrangements based on the desired amplitude and frequency. The amplitude of the output voltage is controlled by the shoot through period and the frequency of the output voltage depends on the switching strategy. Furthermore, if inductive loads are used, a change in instantaneous current across the inductance will produce large voltage spikes that will destroy switches in use, due to stress. A systematic switching sequence is thus required that allows for the energy flowing in the MOSFET's to dissipate within the system.

In this paper, the frequency of the input voltage is taken as 50Hz, and the desired output frequency is assumed as 100Hz (step-up frequency), 50Hz (same frequency) or 25Hz (step-down frequency). The switching strategies for these output frequency in boost mode will be described below.

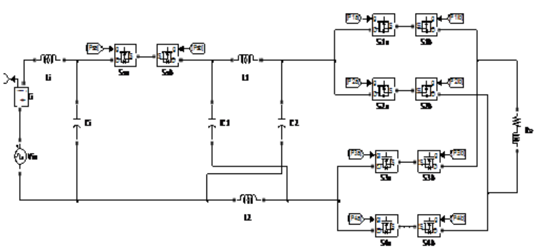

Fig 1 Z-Source Single phase Matrix converter

B.Input Filter

Power electronics circuits switch on and off large amounts of current at high voltages and thus can generate unwanted electrical signals that affect other electronic systems. In practice, the magnitudes of the higher-order harmonics can also be significantly affected by the current spikes caused by the finite slopes of the switching transitions. In consequence, it is always required that a filter be added at the power input of a power converter. By attenuating the switching harmonics that are presented in the converter input current waveform, the input filter allows compliance.The input filter can also protect the converter and its load from transients that appear in the input voltage, thereby improving the system reliability.To reduce the input current ripple with minimum dissipated energy on the reactive elements, it is necessary to add an input filter to the power converter. An LC low-pass filter is added to the input of converter.The filter output impedance can be reduced by increasing the filter capacitor size.

C. Block Diagram Description

AC is the form in which electric power is delivered to businesses and residences. The usual waveform of an AC power circuit is a sine wave. In certain applications, different waveforms are used, such as triangular or square waves. Audio and radio signals carried on electrical wires are also examples of alternating current. In these applications, an important goal is often the recovery of information encoded (or modulated) into the AC signal.

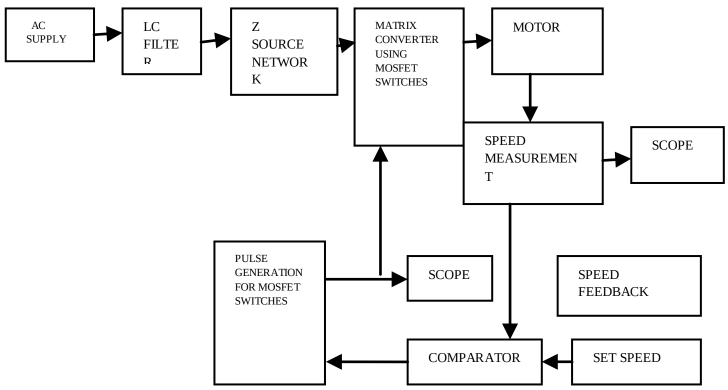

Fig 2 Proposed Block Diagram

The ac voltage is applied to the Z-source network were the input Vi voltage is bucked or boosted and the output Va is given to the single-phase matrix converter .By Depending on the switching sequence varies the frequency Va. The output voltage Vo with step change frequency and a variable amplitude is obtained .This converter has an LC input filter, a Z-source network, bidirectional switches, and a load. The LC input filter requires to reduce switching ripple in the input current. For filtering the switching ripple, inductors and capacitors are used.The symmetrical Z-source network, is the combination of two inductors and two capacitors.It acts as an energy storage/filtering element for the single-phase Z-source buck–boost matrix converter. The Z-source converter (ZSC) is an innovative power electronics converter topology presented recently. It employs a unique impedance network to couple the main circuit of the converter to the power source.The single phase Z-source AC-AC converters has several advantages such as providing large range of output voltages with the buck-boost mode, reducing inrush during start up period and harmonic currents.

3 METHODOLOGY

A.Switching strategies

The entire operation can be explained in four modes . Each mode has two states.The modes are non-shoot through state and shoot through state. The desired output frequency is then synthesized by proper Sequencing of these four modes. The sequence of switching control for output frequencies 100Hz, 50Hz and 25Hz in boost mode with safe commutation. The switching pattern in boost mode for 100 Hz and 25 Hz.

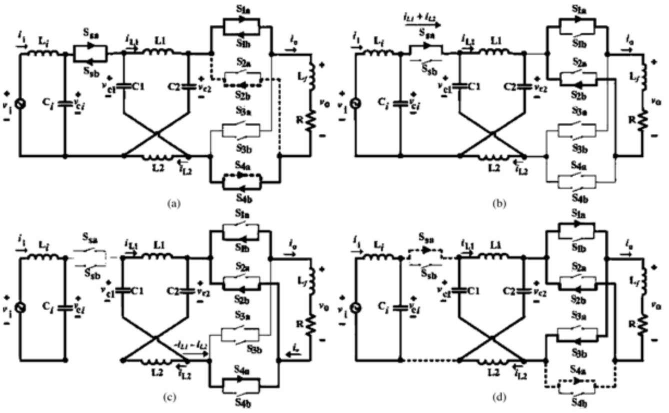

Fig 3 Switching Strategies of SPMC

This paper provides the MATLAB simulation results in order to verify the properties described before for the proposed single-phase Z-source buck–boost matrix converter. We selected the simulation parameters of the *LC* input filter, Z-source network, and load to be $Li = 0.1$ mH, $Ci = 6.8\ \mu$F, $L1 = L2 = 1$ mH, $C1 = C2 = 1\ \mu$F, $R = 100\ \Omega$, and $Lf = 3$ mH. The switching frequency was set to 20 kHz, and the dead time for commutation at 0.5 μs. The input voltage was 35 Vrms/50 Hz, and the output voltage was 66 Vrms with $D = 0.3$ in boost mode. Fig shows the simulation results for the proposed single-phase Zsource buck–boost matrix converter in boost mode with $D = 0.3$ at output frequencies of 100 Hz, respectively. As shown in Fig , when $D = 0.3$, the output voltage is boosted to about $Vo = 65$ Vrms from an input voltage of 35 Vrms. In addition, the output frequency is modulated to either 100 Hz (step-up frequency), 50 Hz (the same frequency), or 25 Hz(step-down frequency) from the input frequency of 50 Hz. Also the simulation results for the asynchronous motor fed by the boost mode for 25Hz is also shown in Fig. The output of the motor voltage and current forms an Unity Power Factor i.e Power factor 1.0 is obtained when voltage and current are in phase,therefore the circuit contains only resistance which is an important attribute of the Matrix converters.

The following waveform shows the output waveform for RL load

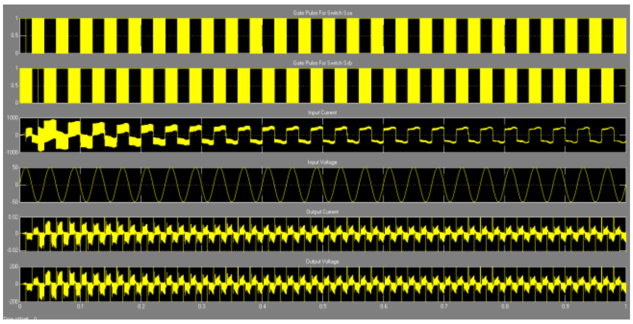

Fig 4 Output Waveforms for RL Load

The following waveform shows the output waveform for asynchronous motor voltage and current

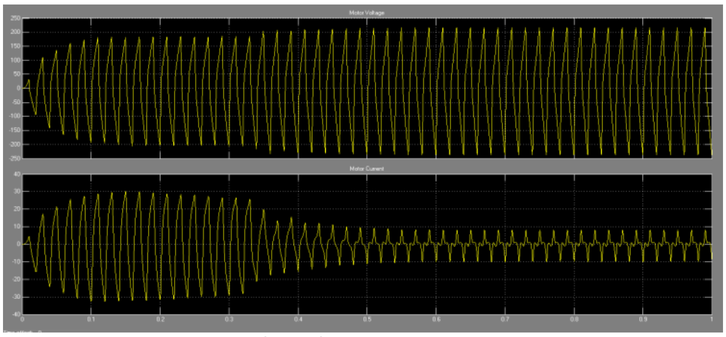

Fig 5 Output Waveform for Motor Voltage and Current

The following waveform shows the output waveform for Motor speed Vs Time

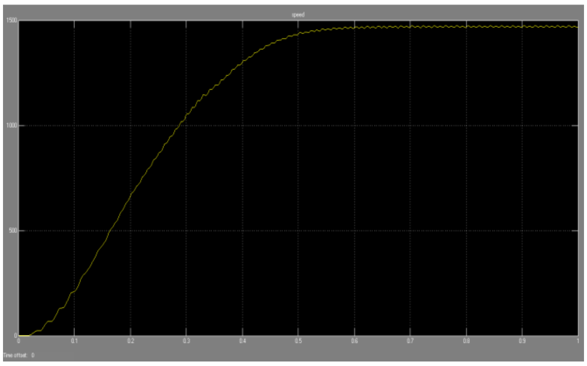

Fig 6 Output Waveform for Motor Speed Vs Time

4. CONCLUSION

In this paper, we have proposed a new single-phase Z-source buck–boost matrix converter that can buck and boost to the desired output voltage with step-changed frequency. The output of this single-phase Z-source buck–boost matrix converter produces the voltage in buck–boost mode with a step-changed frequency, in which the output frequency is either an integer multiple or an integer fraction of the input frequency. It also provides a continuous current path by using a commutation strategy. The use of this safe-commutation strategy is a significant increases as it makes it possible to avoid voltage spikes on the switches without the use of a snubber circuit. We presented a steady-state circuit analysis and described the operational stages. We performed a MATLAB simulation. The simulation and the experimental results with a passive *RL* load showed that the output voltage can be produced at three different frequencies, 100, 50, and 25 Hz, and in the buck–boost amplitude mode. Also the simulation of an Asynchronous Motor fed by the matrix converter provided an Unity Power Factor to the output voltage and current. We expect that this proposed strategy can be used in various industrial applications that require step-changed frequencies and variable voltage amplitudes. The proposed converter is particularly suitable for controlling the speed of a fan or a pump without the use of an inverter because for these applications, the input voltage frequency must be changed to control their speed by stages.

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