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Single Phase Inverter Using Matrix Converter Topology

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Abstract —This paper present for the implementation of single phase matrix converter (SPMC) is working as a DC-AC Inverter. The Sinusoidal Pulse Width Modulation (SPWM) was use to synthesize the output voltage and current waveform. Matrix converter can developing and performing function of all operations in one converter. Single circuit is developed and all converter as a cycloconverter, inverter, chopper, rectifier each function can be preform by these single matrix converter circuit. IGBT with antiparallel diode is use switching device for controlling bi-directional switching. Safe Commutation strategies are also implemented for reduce the voltage spike on switches. Simulation Result has been carried out by using MATLAB/Simulink and simulation of results are present to the matrix converter topology.

Keywords-component-Single Phase Matrix converter (SPMC), Bi-Direction switch, Sinusoidal Pulse Width Modulation (SPWM), Commutation strategies.

I. INTRODUCTION

The Matrix Converter (MC) is an advanced circuit topology that could offer an "all silicon" converter solution without the use of reactive energy storage components. It offers many advantages with unrestricted switch control, possible all silicon solutions or with minimal reactive device use.

The topology was reported by Gyugyi and Pelly in 1976 [1] after some year ago this was developed by Venturini in 1980 [2]. It is mainly used for AC-AC conversion. Other name of the Matrix converter is a PWM cycloconverter. It provides the all-silicon solution for the AC-AC conversion by removing the DC link, which is use for the conventional rectifier-inverter based system. Other advantages of matrix converter are good input power quality, potentiality of increasing power density, reducing cost and size, bidirectional energy flow. The single phase matrix converter topology was first realized by Zuckerberger and Weinstock in 1997 [3].

In this paper the analysis of switching pattern is developed to working of the Matrix Converter as a frequency converter, rectifier, inverter and chopper. The output voltage is synthesized using Sinusoidal Pulse Width Modulation (SPWM) and Multiple Pulse Width Modulation (MPWM). The input is either DC or AC source depending into the type of converter topology used. The switching control sequence is provided to safe commutation strategy. SPMC can provide a generalized converter topology reducing the need for the new hardware design. Results of simulations are presented to verify the operation.

II. SINGLE PHASE MATRIX CONVERTER

The SPMC which uses four bidirectional switch is shown in Fig. 1 each capable of conducting current in both direction blocking forward and reverse voltages and are so arrange for the input terminals can be connected to output terminals in a matrix manner [4] Due to non-availability of bidirectional fully controlled high switching frequency switches, IGBT with antiparallel diode is common emitter configuration or diode bridge configuration as shown in the Fig. 2. A single IGBT as a controlling switch in one direction can be used [4]. The process of switching on and off the bidirectional switches makes the required variable voltage and frequency waveforms at the output of by the matrix converter.

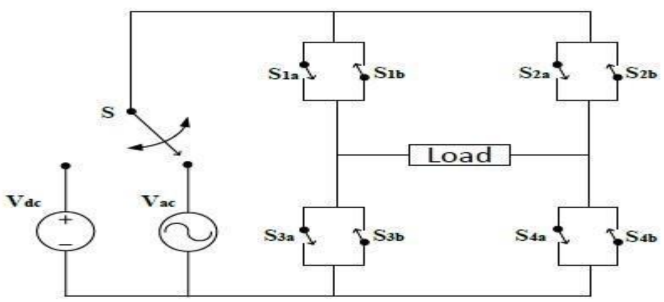

Figure. 1 Power circuit of single phase matrix converter

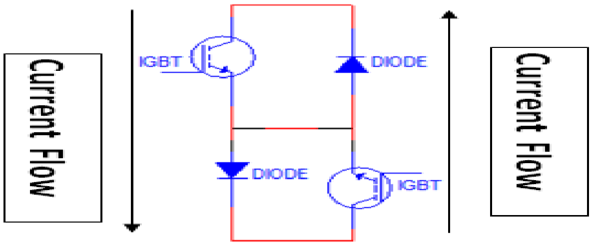

Figure. 2 Bi-Direction switch configuration of IGBT with anti-parallel diode

III. SINUSOIDAL PULSE WIDTH MODULATION

The sinusoidal pulse width modulation (SPWM) is a good wave shaping technique used for controlling the power electronic devices. In this spwm technique we use reference signal Vr is a sinusoidal of variable magnitude and frequency is compared with a high frequency triangular carrier wave of fixed amplitude Ac and fc carrier frequency have been shown in Fig. 3 [4]. The switching pulses will be generated at the particular time when sinusoidal output is high than triangular wave. The output voltage is controlled by varying amplitude. The width of each pulse is varied and proportional to the amplitude of sine wave evaluated at the center of the same pulse. The crossover points are used to determine the switching instants.

The modulating signal is a sinusoidal of amplitude Am, and the amplitude of the triangular carrier amplitude is Ac, the ratio m=Am/Ac is known the modulation index. By varying the modulation index, the output voltage could be controlled [5]. The switching frequency should be high as compared to sinusoidal reference signal. These methods aim for generating a converter output voltage with sinusoidal modulated pulse width. If the switching frequency is an integer multiple of fundamental output frequency, this will be called as synchronized sinusoidal modulation when the fundamental frequency the switching frequency are independent to each other.

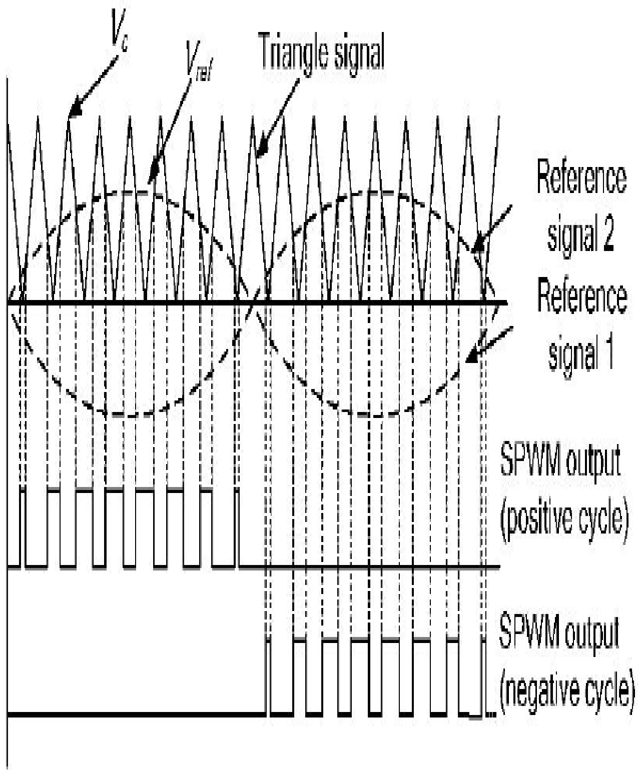

Figure. 3. Sinusoidal PWM Technique.

IV.COMMUTATION PROBLEM

The use of SPWM Pulse Width Modulation in Fig. 3, results with possible reversal voltage if inductive load is used, during switch turn-off, restated here briefly for completeness. Theoretically the switching sequence in the SPMC can be instantaneous and simultaneous, unfortunately, impossible for practical realization due to the turn-off IGBT characteristic, when the tailing-off of the collector current will create a short circuit with the next switch turn-on [8]. This problem occurs when inductive loads are used. Current is change due to PWM switching will result in voltage and current spikes being generated resulting in the occurrence for the dual situation. First current spikes could be generated in the short-circuit path and secondly voltage spikes could be induced as a result of change in the voltage direction across the inductance. Both will destroy the switches in use due to stress [9].

A systematic switching sequence is required to the allows for the energy flowing in the IGBT from TABLE I, of PWM switching sequence, selecting one switch from given two switches for which it can be operated as PWM switch, for that Switch corresponding commutation switches are given into the TABLE I. The energy stored in positive cycle should discharge in that cycle only otherwise carrying the energy to negative cycle will cause a voltage spikes across the output terminals of matrix converter.

A .SPMC as Inverter

Inverter converts a DC input into an AC output statically with output waveforms ideally sinusoidal. The circuit in Fig. 4 and 5 comprises four bidirectional switches, which is Sl, S2, S3 and S4 capable of conducting current into the both directions, blocking forward and reverse voltage for the symmetrical devices and switching between states without any delay [9]. The DC to single phase AC matrix converter will be design and controlled in such a manner that the fundamental of the output voltage.

T1: Sla and S4a will be on, with the rest turned off
T2: S2a and S3a will be on, with the rest turned off

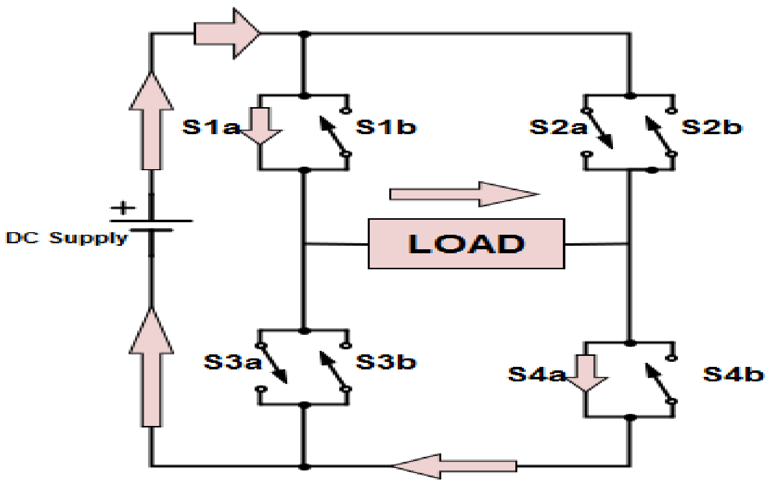

Figure. 4. Positive Cycle of SPMC Inverter

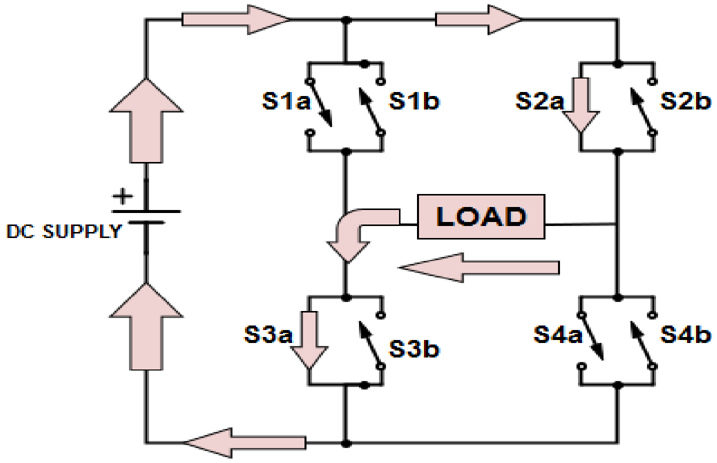

Figure. 5. Negative Cycle of SPMC Inverter

V. SIMULATION AND RESULT

A. SPWM Subsystem

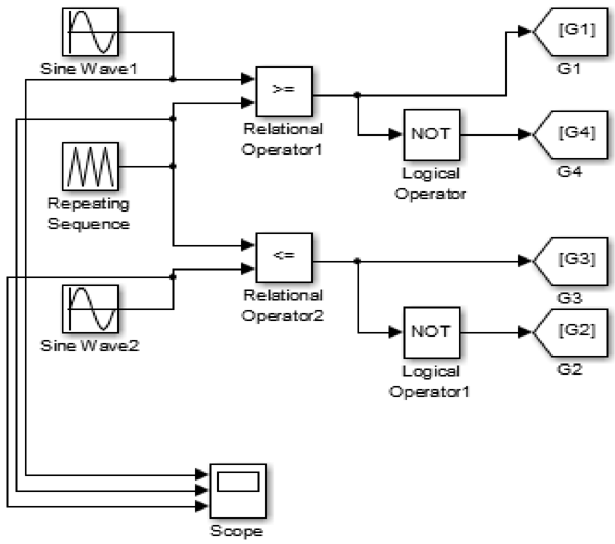

Figure. 6. Simulink Diagram for SPWM Generation

B. SIMULINK Diagram of Unipolar SPWM without Filter

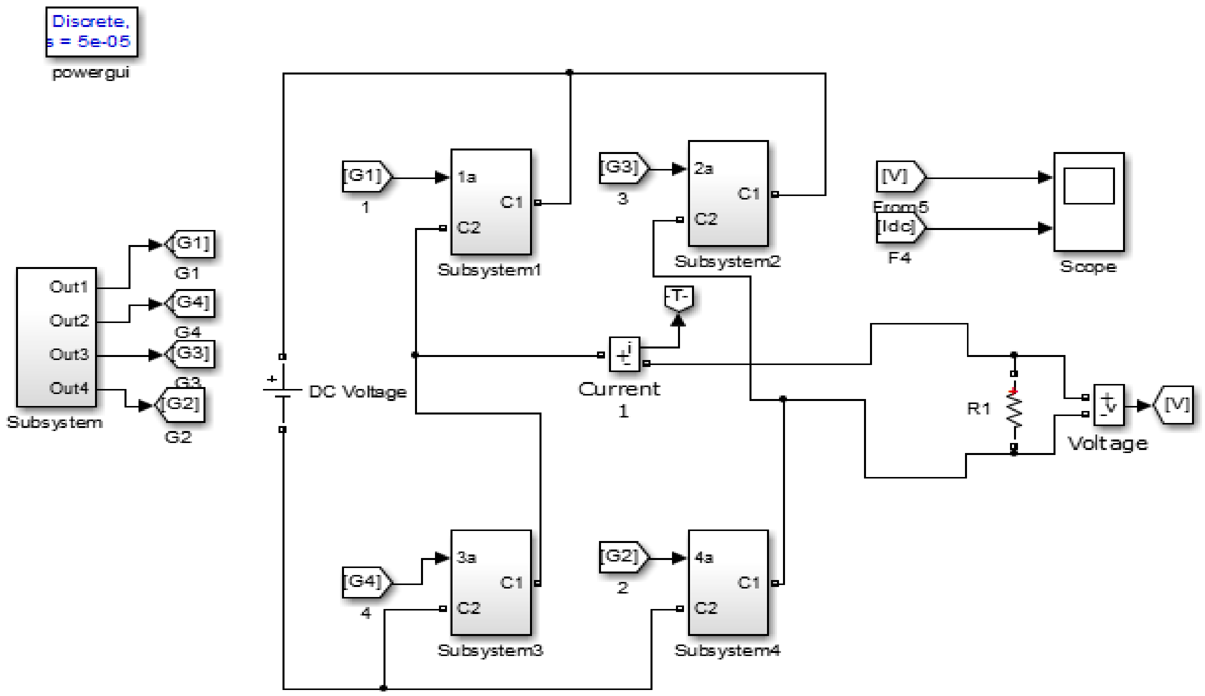

Figure. 7. Simulink Diagram of SPMC Inverter without Filter

C. Simulation Results of Output Voltage and Current

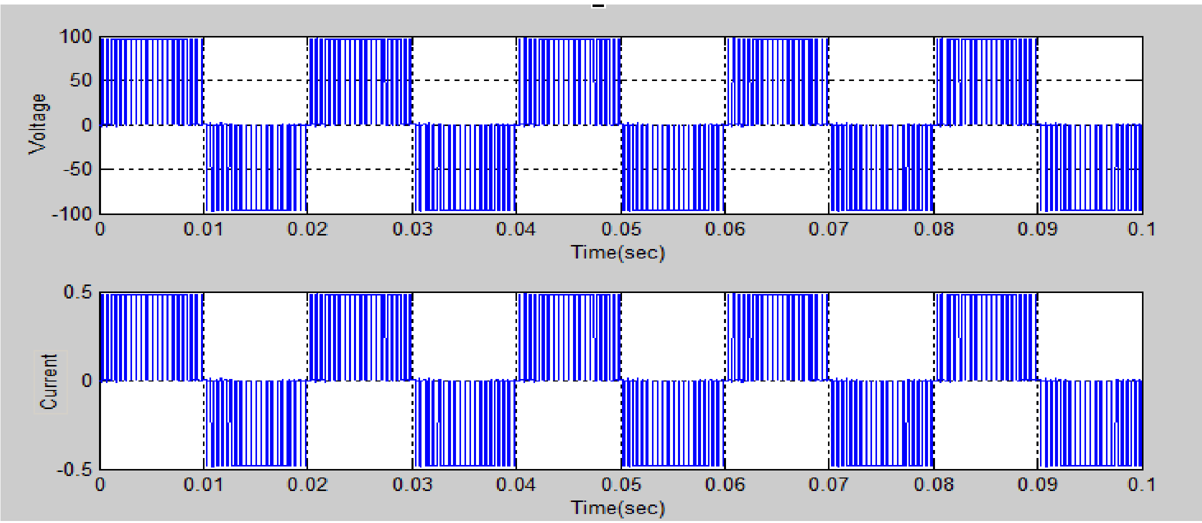

Figure. 8. Output Voltage and Current waveform without Filter

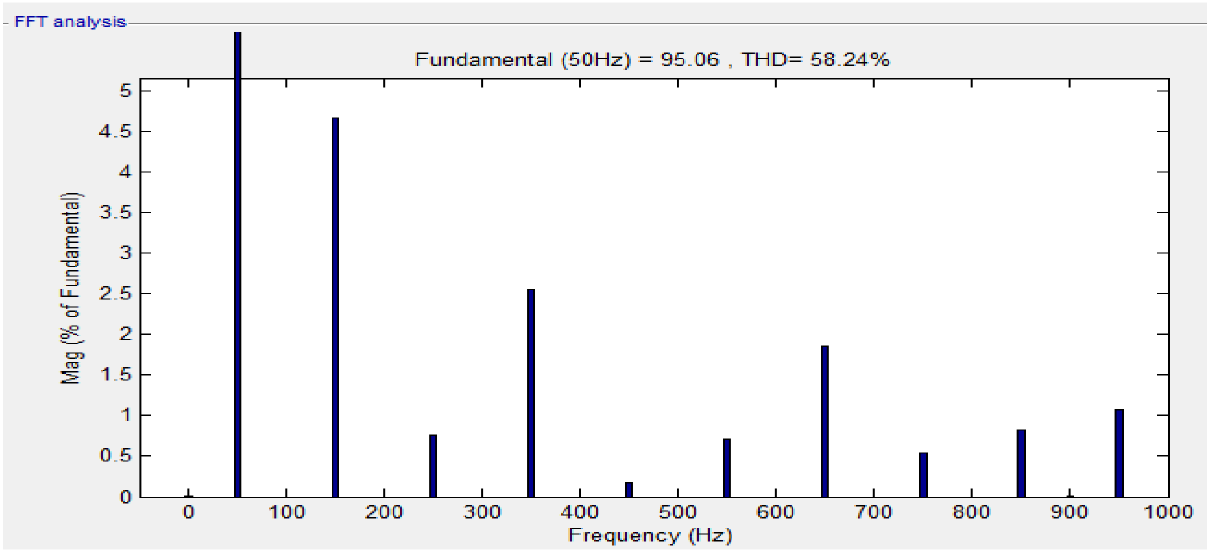

Figure. 9. THD % Output Voltage without Filter

Input voltage	**Input Frequency**	**Switching Frequency**	**Load**
100V	50Hz	1KHz	R=200Ω

Table 1. Input Partameter

D. SIMULINK Diagram of Unipolar SPWM with Filter

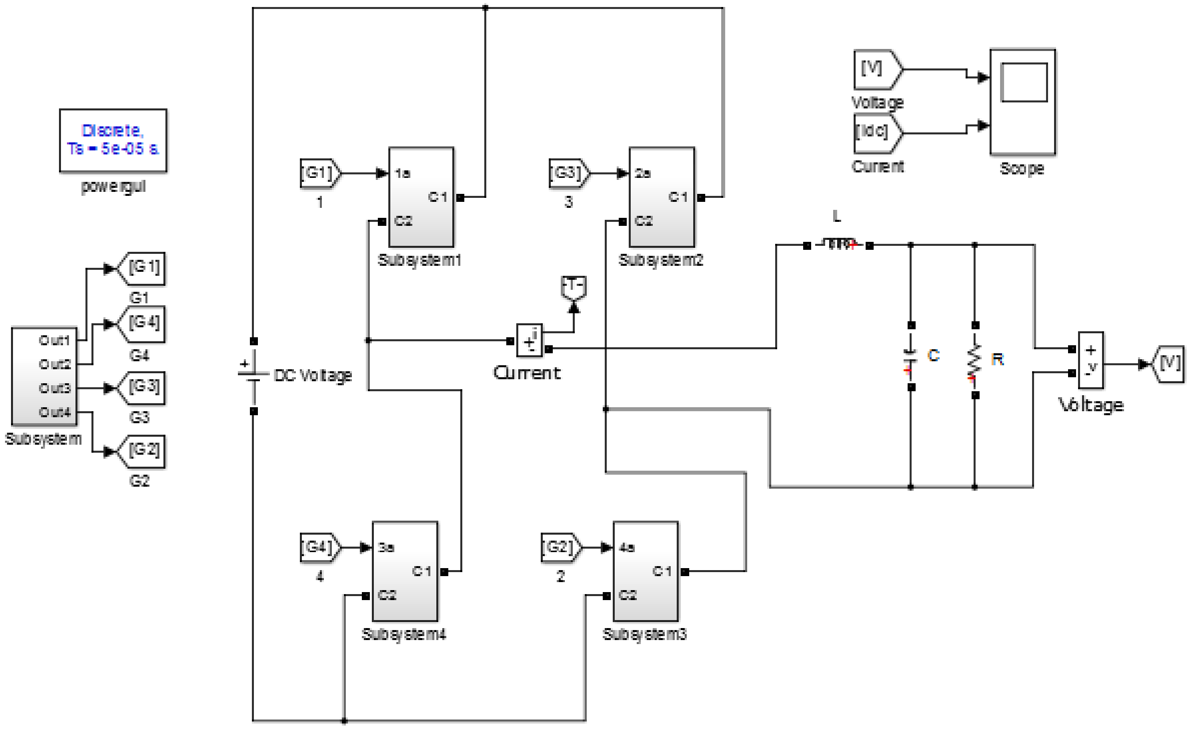

Figure. 10 Simulink Diagram of SPMC Inverter with Filter

F. Simulation Result of Output Voltage and Current

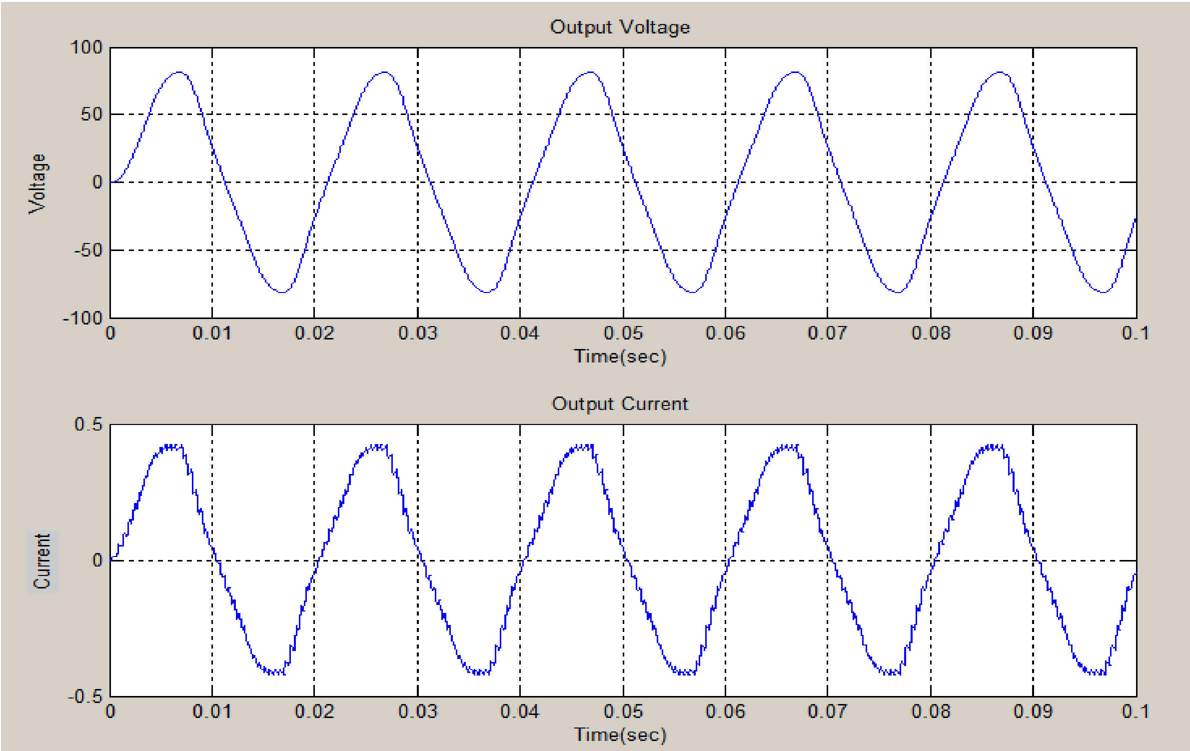

Figure. 11 Output Voltage and Current waveform with Filter

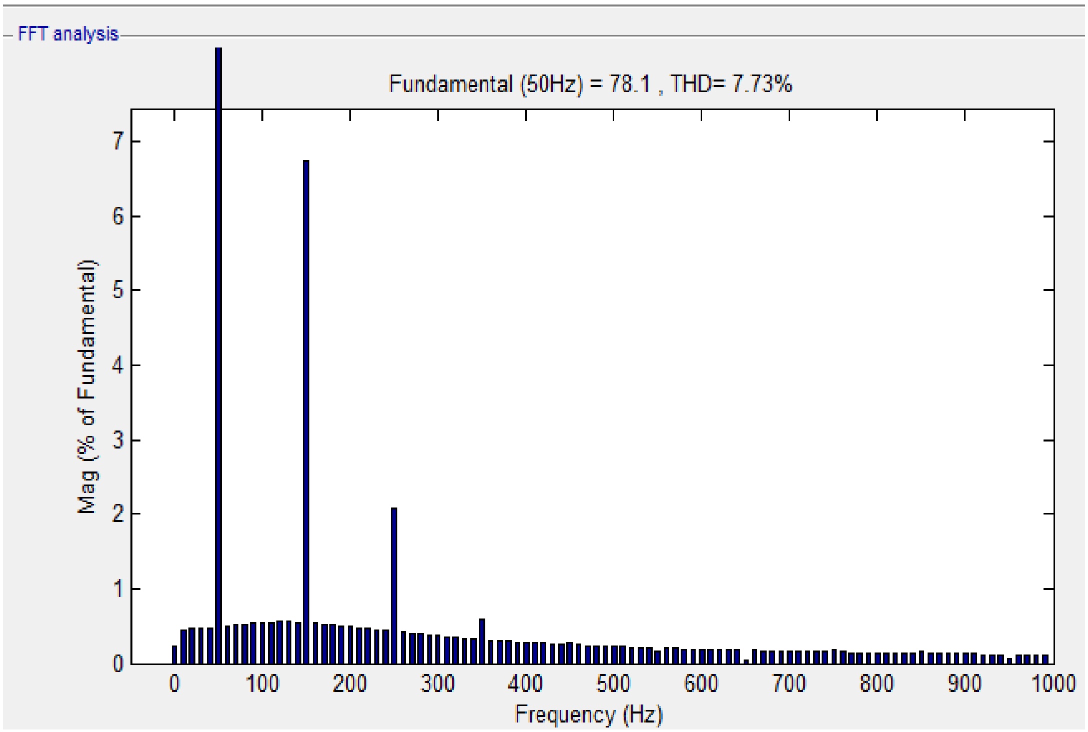

Figure. 12 THD % Output Voltage with Filter

G. Result of Unipolar SPWM with Filter

The simulation Result of single-phase matrix converter (SPMC) Inverter are present and arrange with the following Fig. 10 to 12. The circuit parameter is input supply DC voltage 100V, switching frequency 1 KHz, load R=200Ω. Without Filter Inverter Output is square wave but most of a Equipment operate as a purely sine wave. so the use of LC Filter and improvement in the output voltage waveform. AC output voltage of 81V peak is Obtained and it shape is sine wave .LC Filter must be used for the canceling harmonic distortion in the supply side and provided to the unity power factor operation.

Input voltage	**Input Frequency**	**Switching Frequency**	**Load**	**Filter**
100V	50Hz	1KHz	R=200Ω	L,C

Table II. Input Parameter

H. Advantage of Matrix Converter

- Power Flow of the matrix converter is bi-directional.
- Energy storage requirement component is very less.
- Power factor can be fully controlled.

I. Disadvantage of Matrix Converter

- Its voltage transfer ratio of input to output is limited to approx. Value is 87%.
- Semiconductor devices use in matrix converter are more.

J. Application of Matrix Converter

- It is used for Aerospace industry.
- Operate as an uninterruptible power supply.

VI. CONCLUSION

The single phase matrix converter (SPMC) has been presented to operate as a DC-AC converter. Output voltage is synthesize by the Sinusoidal Pulse Width Modulation (SPWM) technique and IGBT working for a power switching devices. The Safe commutation strategy could be implemented to solve switching transients. So the use of LC filter has indicated an improvement in the output voltage waveform and reduces Harmonic. Single Phase Matrix converter can be made proves by versatile topology extending the capabilities beyond the direct AC-AC converter as a cycloconverter, DC chopper and Rectifier operations can be performing by single matrix converter.

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