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SIMULATION AND ANALYSIS OF MULTIPLE CONVERTER USING MATRIX TOPOLOGY

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ABSTRACT
This paper presents novel concept of a multiple converter. It works in three modes- AC-AC converter voltage regulator, AC-AC converter frequency changer and AC-DC converter. All three modes work simultaneously. AC-AC converter mode of operation alters low input frequency to high output frequency across the load. AC-DC converter mode of operates with variable amplitude across load. This concept is implemented for a single phase supply using MATRIX topology. The control signals for the power switches are generated in a very clear form. The Simulation of the Converter is carried out in MATLAB/SIMULINK and results are presented for both modes of operation with low frequency and high frequency operation for AC-AC Mode and Variable voltage for AC-DC conversion mode.This paper discusses the proposed new multiple converter for single phase input using matrix topology for AC-AC conversion and AC-DC conversion using just a single control logic..

Keywords - **multiple converter, matrix converter, simulation, modelling MATLAB/SIMULINK**

I. INTRODUCTION
Two types of converters, AC-AC and AC-DC are used in industries. AC–AC conversion has two stages, AC-DC-AC are used to get AC output. Rectifires directly give DC output. Traditionally ac and dc conversion systems are used separately for ac and dc loads. Currently no system is available to get AC and DC output simultaneously. Novel concept of multiple converter means that it can give AC and DC output simultaneously using single control circuit. For the implementation of such a multiple converter 'matrix topology 'is used. The Matrix Converter (MC) is an array of bidirectional switches as the main power elements, which interconnects directly the Input supply to the load, without using any dc-link or large energy storage elements. The development of this Matrix topology starts with the early works of Aventurine and Alesina, published in 1981 [1].Modeled and designed AC-DC converter is described in earlier work[2] [3].Single phase matrix converter that was first realized by Zuckerberger is explained in reference [4].
Simulation model of single phase matrix converter for cycloconverter operation has been presented[5]. Development of Mathematical model of matrix converter for Adjustable speed AC drives[6]and also implemented analysis and simulation of matrix converter for AC-AC conversion using PSIM[7] have been published..Small signal model of AC-DC converter with active input current Shaper has been developed useful for power factor correction [8]. Authors have discussed about different switching strategies for matrix converter and modeled these using direct space vector modulation [9] Modeling of AC-AC converter can be explained and mathematical model of reactance frequency converter using matrix topology have been described by differential equations[10] [11].Different switching pattern generation for AC-AC converters have also been discussed, and also the analysis of AC-AC converter for induction motor has been explained[12] [13].Generalized efficient technique of modeling and modulation has been developed for a three-phase matrix converter[14] All previous works have focused attention to either direct AC-AC converter, or to AC - DC converter. In this paper the authors focus on a new multiple converter using matrix topology for AC-AC conversion and AC-DC conversion using a single circuit.

II. MULTIPLE CONVERTER
A Multiple Converter provides three different modes of operation via AC-AC converter (Variable voltage), AC-AC converter (Variable Frequency) & AC-DC converter for controlling AC & DC loads. A multiple converter consists of a matrix of input and output lines with four bidirectional switches at the intersections which connect the single-phase input to

output .Fig. 1 is the Block diagram of a multiple converter. It consists of ac supply, control logic, ac-ac converter and ac-dc converter. Control logic generates switching pulses to drive ac-ac converter as well as ac-dc converter. These three blocks are separately analyzed.

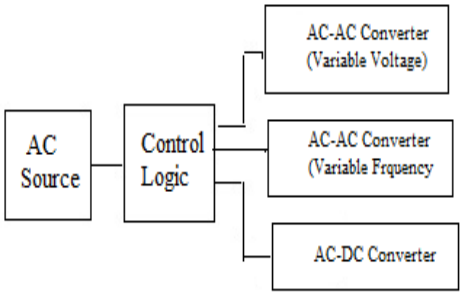

Fig. 1. Block Diagram of Multiple converter

AC-AC converter (Variable voltage)

In this converter two one bidirectional switches are connected between load and supply shown in figure 2

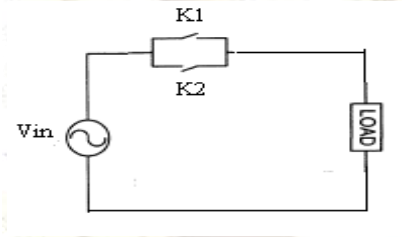

Fig. 2. AC-AC converter

One bidirectional switch forms one as to one matrix.

$$\begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix}\begin{bmatrix}V+\\ V-\end{bmatrix}=\begin{bmatrix}V+\\ V-\end{bmatrix}$$

In positive half cycle switch K1 is made high (on) and positive voltage appears across load i.eVo+ and in negative Half cycle i.e. Vi – switch K2 is made High (on) and negative voltage appears across load.

AC-DC Converter

This converter contains four switches. Load is connected between two switches shown in figure 3.

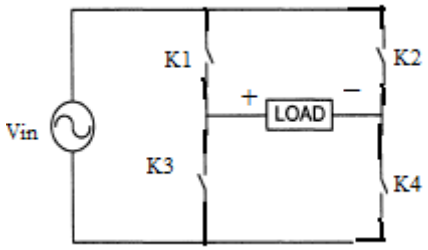

Fig. 3. AC-DC converter

K1K2K3&K4 four switches forms two by two matrix.

$$\begin{bmatrix}1 & 0\\ 1 & 0\end{bmatrix}\begin{bmatrix}V+\\ V-\end{bmatrix}=\begin{bmatrix}V+\\ V+\end{bmatrix}$$

When switches K1 and K2 are made high then the current flowing through load is from positive to negative direction and the positive voltage appears across the load. At negative input cycle switches K3 and K2 are made High , current flowing through positive to negative and again positive voltage appears across load. In this case both in the positive and negative half cycle positive voltage appears across the load.

AC-AC converter (Variable frequency)

In this converter four bidirectional switches are used..Arrangement of the switches shown in figure 4.

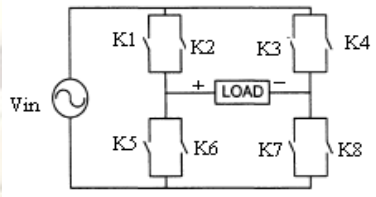

Fig. 4. AC-AC converter (variable frequency)

Four bidirectional switches forms a four by two matrix.

$$\begin{bmatrix}1 & 0 & 0 & 0\\ 0 & 0 & 1 & 0\\ 0 & 0 & 0 & 1\\ 0 & 1 & 0 & 0\end{bmatrix}\begin{bmatrix}Vi+\\ Vi-\\ Vi+\\ Vi-\end{bmatrix}=\begin{bmatrix}Vo+\\ Vo+\\ Vo-\\ Vo-\end{bmatrix}$$

Operation oh this converter is divided in to four different steps
Table 1

Step	Input	Switch position	Output
first	Positive	K1 K7 High	Positive
Second	Negative	K5 K3 High	Positive
Third	Positive	K4 K6 High	Negative
Fourth	Negative	K8 K2 High	Negative

This converter operates in four quadrants. According to output frequency desired one selects the steps. Table 1 shows four steps with switch positions.

All above three modes operate simultaneously using single control logic.

III.SIMULATION MODEL OF MULTIPLE CONVERTER

Simulation is carried out in Matlab-Simulink for Input Voltage of 100 V,50Hz with R Load (100 ohm) and RL Load(R-100 ohm & L-I. mH).SPWM Technique is used for Controlling Switches. All three operations of AC-AC (variable amplitude), AC-AC(variable frequency) and AC-DC Mode work simultaneously. The scheme of the block diagram describing the matrix converter, its controller and the load is shown in Figure.5

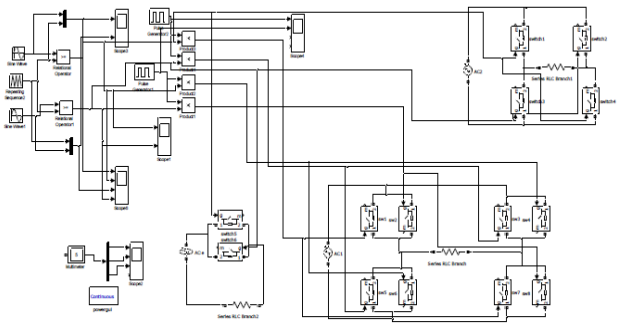

Figure 5: Simulation Model of Multiple converter

The driver circuit algorithm is designed by using MATLAB SIMULINK.V_{ref1} and V_{ref2} output from the sine wave block is multiplied using 'Multiply Block' with Triangular Wave output. The 'repeating sequence 'block is used to generate triangular carrier signal 'Vc'. To produce the SPWM the 'relational operation 'block are used as a comparator that triggers an output switching function between "0" and "1" that represents the SPWM pulse train. The magnitude of sine wave is changed from the sine wave block that represents the change in modulation index.

The finial switching pattern for the AC/AC Converter is produced by multiplying the output from SPWM generator with the state selector using the "multiply" block. Each output from the "pulse generator "is multiplied with both outputs from the SPWM and are shown in figure 5.

IV.SIMULATION RESULT

Result of simulation are shown below.The Simulated SPWM Output is shown if figure 6

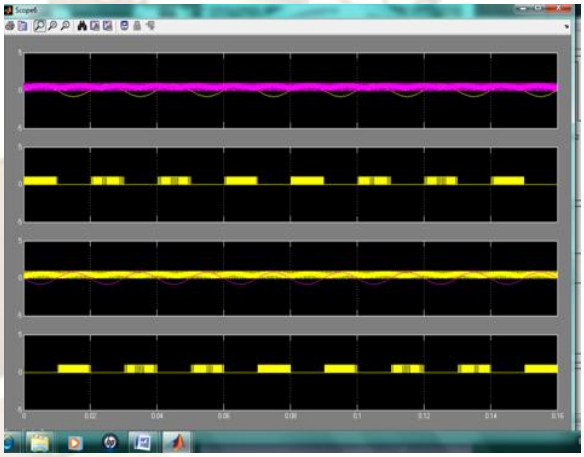

Figure 6: SPWM Output

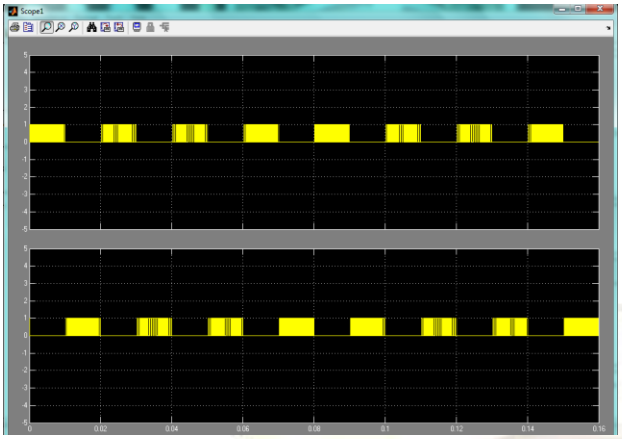

Figure 7: Switching Pattern for AC-AC (variable voltage) converter and AC-DC converter

Figure 7 shows the simulation result of switching pattern for ac-ac variable voltage and ac-dc output of multiple converter. Figure 9 shows output across load ac-ac voltage regulator, ac-dc and variable frequency (frequency 25 Hz). Figure 8 switching patterns for variable frequency output 25Hz.

Figure 8: Simulation Model of Multiple converter
Switching Pattern for Frequency 25Hz

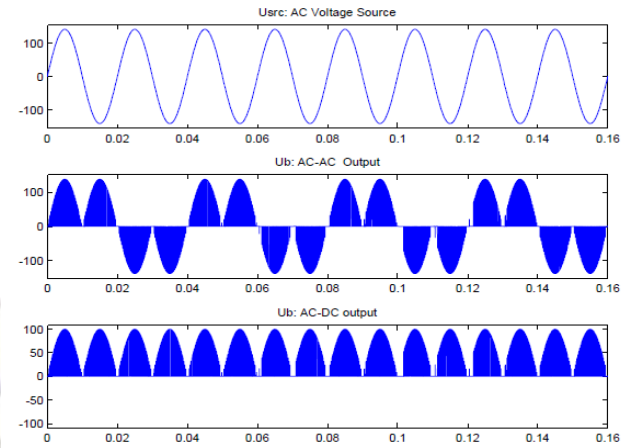

Figure 9: AC-AC converter Variable frequency Output 25 Hz

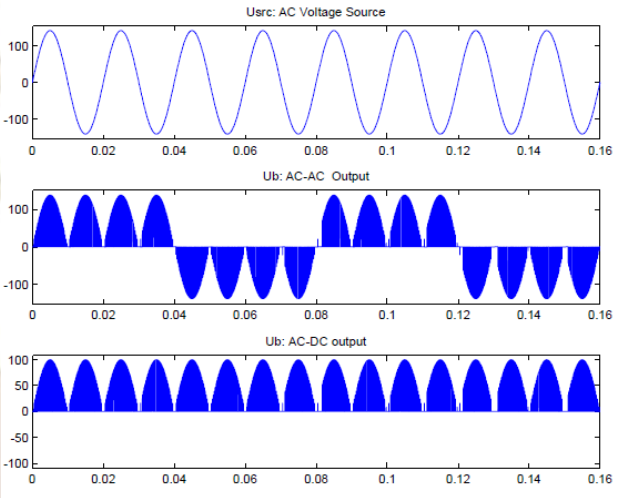

Figure 10: AC-AC converter Variable frequency Output
12.5 Hz

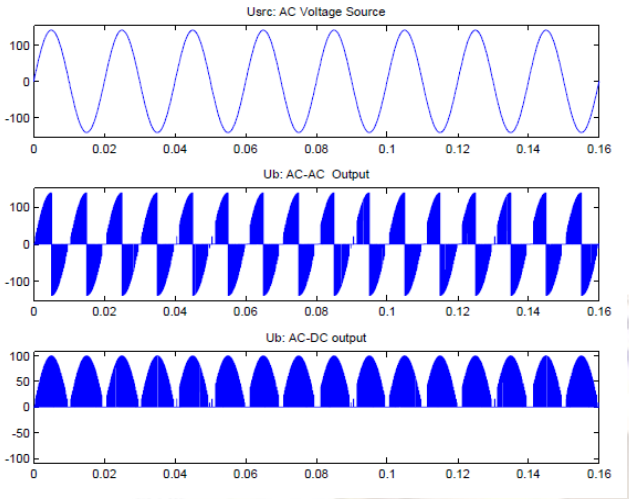

Figure 11: AC-AC converter Variable frequency Output 100Hz

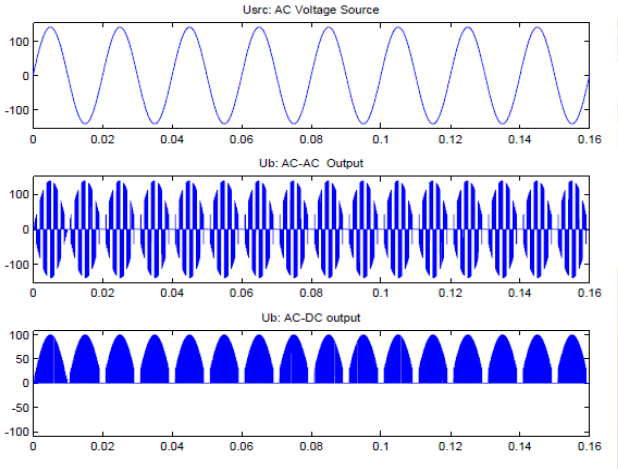

Figure 12: AC-AC converter Variable frequency Output 500Hz

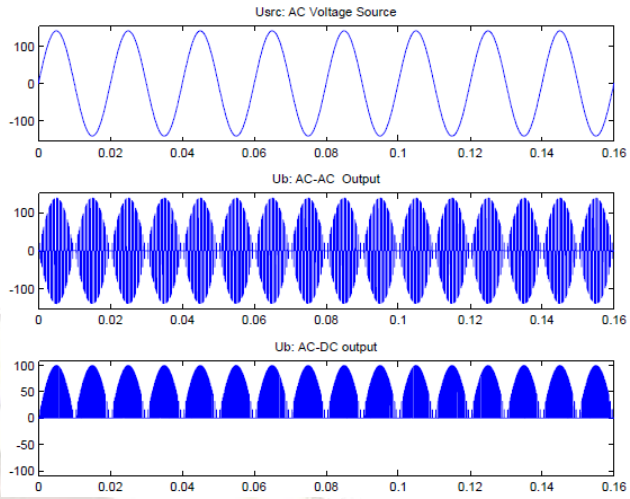

Figure 13 AC-AC converter Variable frequency Output 1000Hz

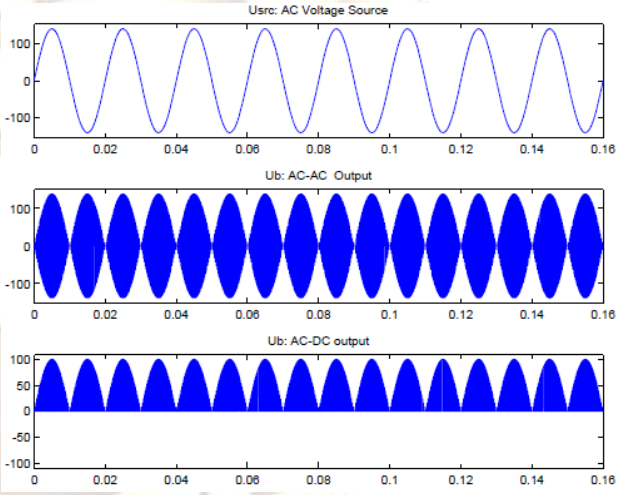

Figure 14: AC-AC converter Variable frequency Output 10000Hz

Figure 10, 11 and figure 12 shows low frequency output across load 25 Hz,100Hzand 500Hz respectively along with AC-AC and AC-DC output.Figure 13,14 shows high frequency output across load at 1000Hz and 10000Hz.

V .CONCLUSIONS

The simulation model of multiple Matrix Converter using MATLAB/Simulink Software package has been presented. The Results are presented for three modes of operation with Variable frequency operation for AC-AC Mode, Variable voltage for AC-AC mode and AC-DC conversion mode. The new multiple matrix converter topology for AC-AC conversion and AC-DC conversion using the single circuit is presented with SPWM Strategy to synthesize the AC output and DC output for a given AC input.

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