Modeling, Design and Analysis of Three Phase Matrix Converter for Different Loads

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***Abstract*—Matrix converter is a single-stage converter which directly connects a three-phase voltage source to a three-phase load without dc-link components. Therefore, any harmonic distortion and imbalance in input voltage directly reflect to the output of the converter. Recently, many researchers have made an effort to cope with this problem. In this paper, a matrix converter (MC) which makes directly AC-AC power conversion is modeled using Matlab and Simulink and its working with different load is analyzed. The gate signals of the power switches of MC are produced using Optimum Amplitude-Venturini Modulation (OAVM) method.**

***Keywords*— Matrix converter, AC-AC power convesion, Matlab and Simulink, Venturini Modulation.**

I. INTRODUCTION

Matrix converter is an array of controlled semiconductor switches that converts directly three phase source to three phase load. This converter has several attractive features that have been investigated in the last two decades. In the last few years, an increase in research work has been observed, bringing this topology closer to the industrial application. Recently there has been considerable interest in the use of matrix converter technology. For motor drive application, with particular interest being shown by companies like Siemens, Rockwell and yaskawa. The potential advantages of matrix converter technology are explained and the factors that have so far prevented commercial exploitation.

Matrix converter has been recognized to have many disadvantages due to its compact technology. It is believed that matrix counter can have significant advantage over the traditional DC link convention in many areas since it is possible to eliminate the DC link capacitor. This counter provides a sinusoidal input and output waveform, bidirectional power flow, controllable input power factor, and linearly modulated output voltage, filtered design issues are complex and decoupling between input and output distortion is to some extent limited due to the absence of the DC link capacitor.

Matrix converter is a direct AC to AC converter, for converting one frequency AC supply to another frequency AC supply without involving DC link capacitor. Generation of controlled switching pulses has attracted much attention of scientist and engineers. Two modulation schemes, the venturini modulation or direct method and the space vector modulation or indirect method are well known. Both the scheme has different design approaches and has different performances.

This paper analysis the three phase to three phase matrix converter using venturini modulation for different application. The main problem encountered in this method was for commutation of switches. This methods works well for known input and output condition. Three phase to three phase matrix converter modeling and design has been described and done mathematically for different loads with the ever improving silicon device technology available to drives engineers, especially in the area of device packaging.

II. FUNDAMENTALS OF MATRIX CONVERTER

The Matrix Converter is a single stage converter which has an array of mxn bidirectional power switches to connect, directly, an m-phase voltage source to an n-phase load. The Matrix Converter of 3x3 switches, shown in figure 1, has the highest practical interest because it connects a three-phase voltage source with a three-phase load.

Normally, the Matrix Converter is fed by a voltage source and for this reason, the input terminals should not be short-circuited. On the other hand, the load has typically an inductive nature and for this reason an output phase must never be opened.

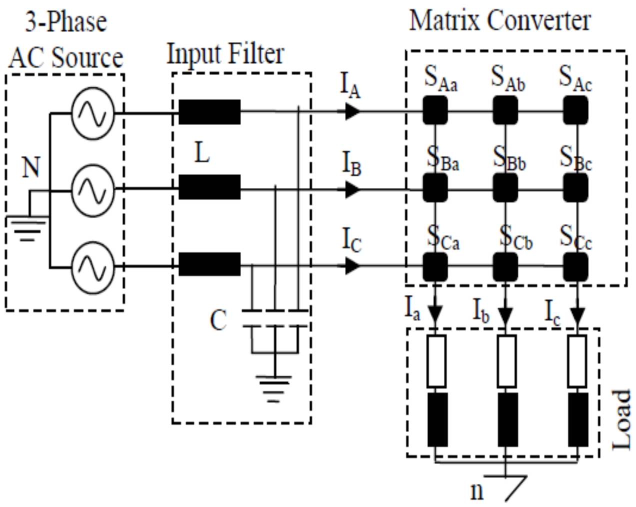


Figure 1. Simplified circuit of a 3*3 matrix converter

Each switch is characterized by a switching function, defined as follows and can connect or disconnect phase K of input stage of phase j of the load

$$S_{Kj}(t) = \begin{cases} 0 & Switch,\ S_{Kj}\ is\ open \\ 1 & Switch,\ S_{Kj}\ is\ closed \end{cases}$$

K = {A, B, C}, j = {a, b, c}

Output voltages can be synthesized by switching according to a proper combination of these switches.

Control of matrix converter must comply with basic two rules. Firstly, any two terminals should never be connected same output line to prevent short circuit, because MC is fed by voltage source. The other is that, any output phase must never be open circuited, owing to the absence of a path for a inductive load current which leads to over-voltages.

The above two constraints can be expressed by:

$$m_{Aa}(t) + m_{Ba}(t) + m_{Ca}(t) = 1$$
$$m_{Ab}(t) + m_{Bb}(t) + m_{Cb}(t) = 1$$
$$m_{Ac}(t) + m_{Bc}(t) + m_{Cc}(t) = 1$$

The load and source voltages are referenced to the supply neutral, '0' in figure 1, and can be expressed as vectors defined by:

$$V_o = \begin{bmatrix} V_a(t) \\ V_b(t) \\ V_c(t) \end{bmatrix} \qquad V_i = \begin{bmatrix} V_A(t) \\ V_B(t) \\ V_C(t) \end{bmatrix}$$

The relationship between load and input voltages can be expressed as:

$$\begin{bmatrix} V_a(t) \\ V_b(t) \\ V_c(t) \end{bmatrix} = \begin{bmatrix} m_{Aa}(t) & m_{Ba}(t) & m_{Ca}(t) \\ m_{Ab}(t) & m_{Bb}(t) & m_{Cb}(t) \\ m_{Ac}(t) & m_{Bc}(t) & m_{Cc}(t) \end{bmatrix} \begin{bmatrix} V_A(t) \\ V_B(t) \\ V_C(t) \end{bmatrix}$$

$$V_o = T\ V_i$$

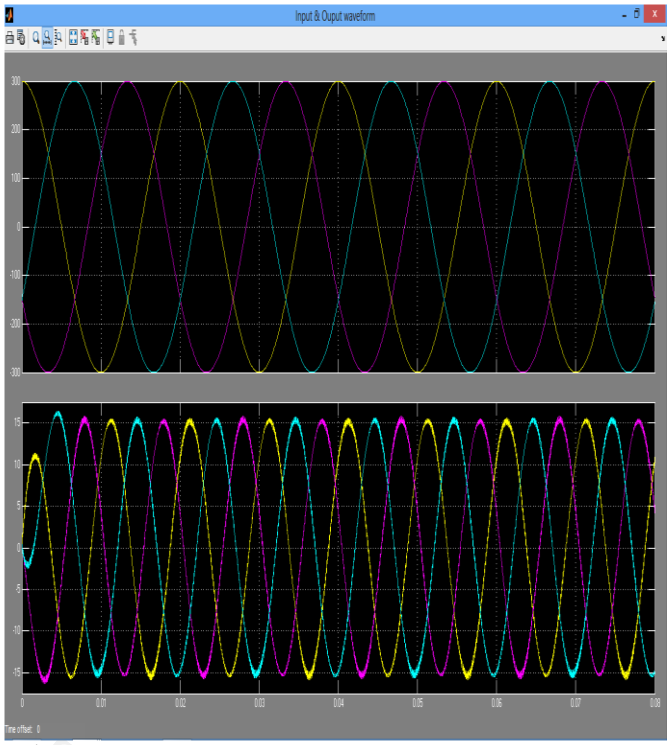
Where **T** is the instantaneous transfer matrix.

The above relationship gives the instantaneous relationships between input and output quantities.

III. MODELING OF MATRIX CONVERTER

Modeling of Matrix converter is done in Matlab for Converting one frequency to another frequency, here 50 Hz frequency is converted to 100 Hz frequency using Matrix Converter. Nine bidirectional switches are used, three for each phase. Gate pulses are generated and are given to nine switches. To drive modulation rules, it is also necessary to consider the switching pattern that is employed.

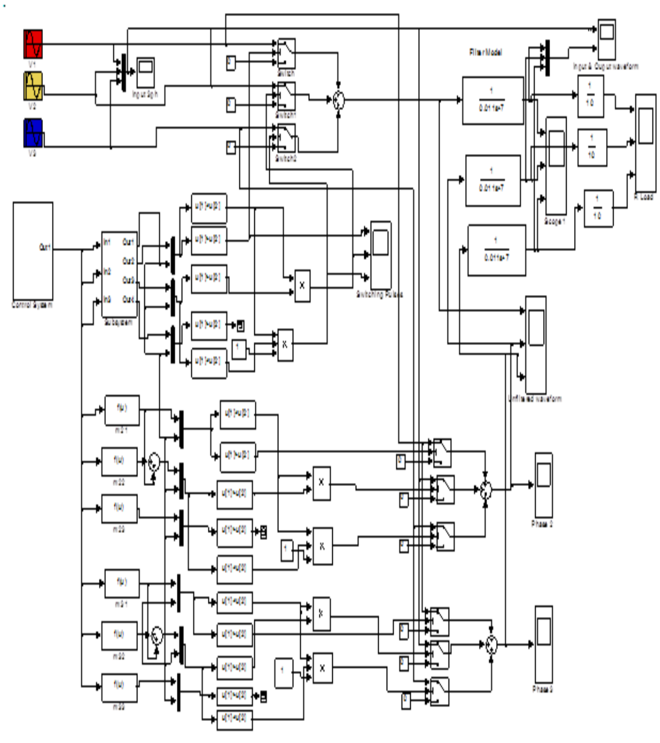
- Simulation Result of Matrix converter



Input and Output waveform of Matrix converter

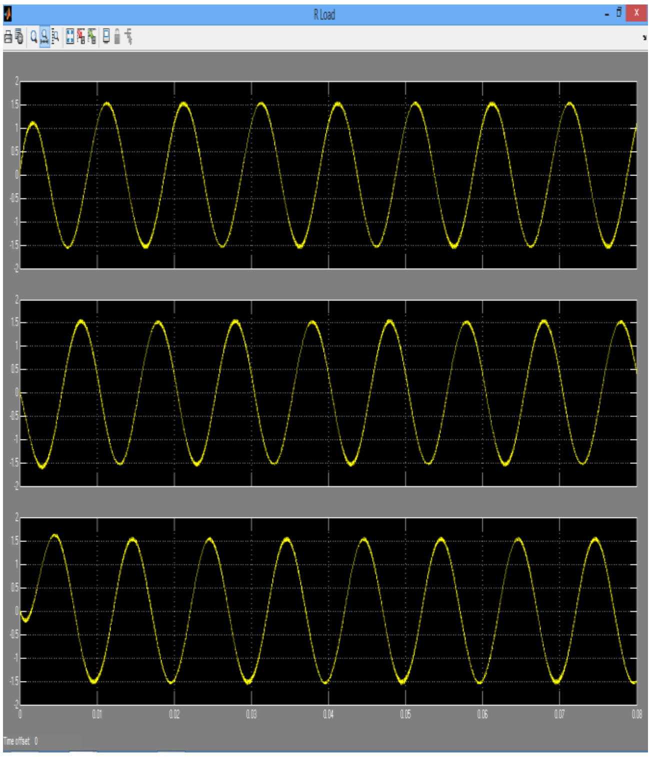
A. *Main Model designed for R Load*

The designing of matrix converter is done in Matlab according to venturini methods with R Load connected to its output, the designed model is then simulated and different waveforms are formed.



Three Phase Matrix Converter with Resistive Load

- Simulation results of R Load

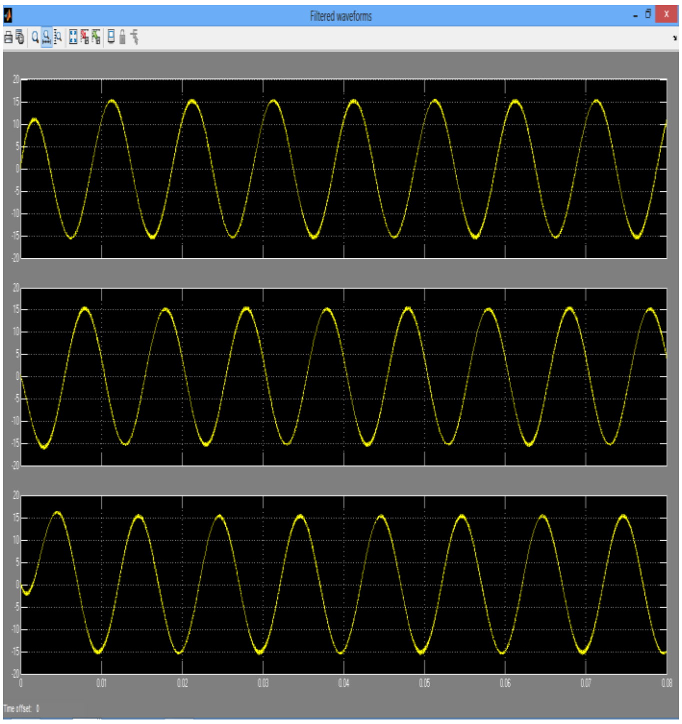


All three phases filtered output waveform with R Load

B. Main Model designed for RL Load

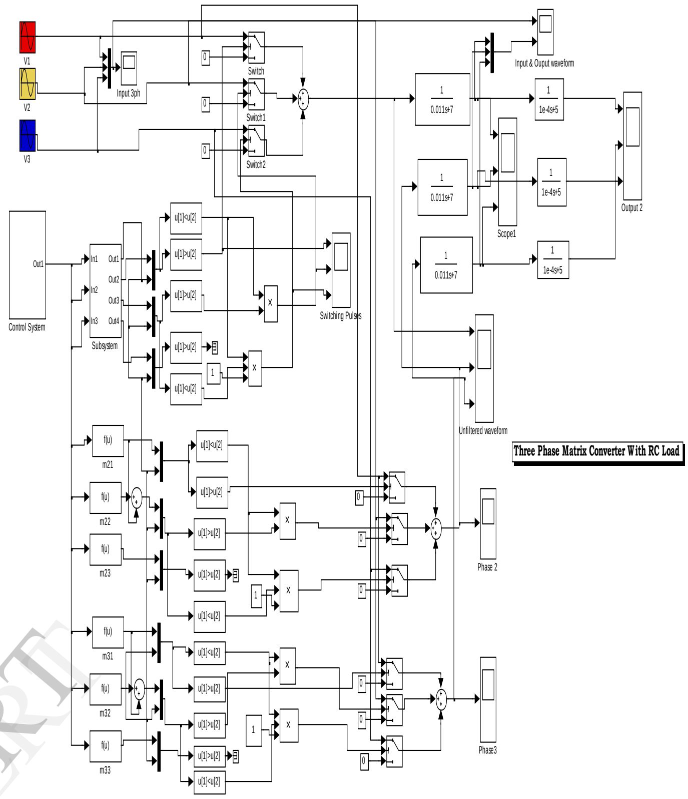
Matrix converter designing is done by using RL load. Here R=7 Ω and L=11μH and the analysis is done. Here again Optimum Amplitude-Venturini Modulation (OAVM) method is used for generating the gate pulses.

- Simulation results of RL Load

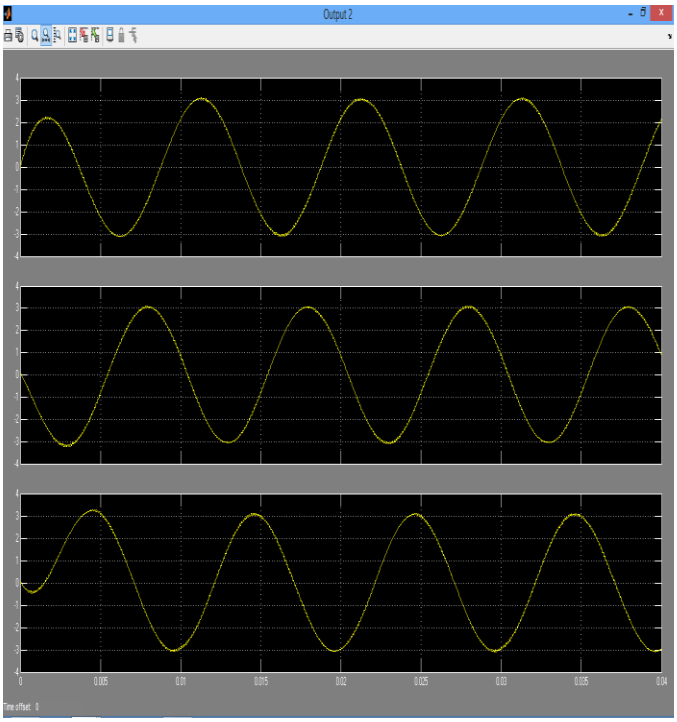


C. Main Model designed for RC Load

This designing of matrix converter is done in Matlab according to venturini methods with RC Load connected to its output, the designed model is then simulated and different waveforms are formed.



- Simulation results of RC Load



IV. ADVANTAGE AND DISADVANTAGE OF USINF MATRIX CONVERTER OVER CONVENTIONAL CONVERTER

Usually PWM inverters have been employed in variable speed motor drive applications due to their superior drive performance and energy saving characteristics. But which needs dc-link circuit that slows down the transient response of the circuit. This is the major drawback of the PWM inverters. To overcome this limitation, direct frequency changers can be constructed in the form of cycloconverter. More number of pulses is needed to achieve waveform quality with unrestricted output frequency in Forced commutated cycloconverter. So cost is more. To overcome this limitation and to minimize the number of switches used has resulted three pulse forced Commutated cycloconverter. This circuit consists of only nine bi-directional switches and is known as the Matrix Converter (MC). It is a direct ac-ac energy conversion device that converts the ac line voltage into variable voltage arbitrary amplitude, unrestricted frequency without using an intermediate dc-link circuit. Compared with other ac-ac converters matrix converter provides sinusoidal input and output waveform with minimum higher order harmonics, its input current wave form is pure sinusoidal and the input power factor is unity, bi-directional energy flow capability, four-quadrant operation and High reliability and long life due to the lack of energy storage reactive components, which allows a compact design.

V. CONCLUSION

After studying and evaluating the drawbacks of normal AC to AC converter that it has two conversion stages, its efficiency is low, it is bulky as it requires storage element and also it is costly. In this research paper AC to AC conversion is done but using matrix converter and then analysis is done by using different loads and following results in the form of waveform are shown

VI. REFERENCES

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