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MODULATON AND CONTROL STRATEGIES OF MATRIX CONVERTER

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Abstract —*This paper presents the different kinds of power electronic converters are introduced and then modulation and control strategies of matrix converter. The matrix converter is an array of controlled semiconductorswitches that connects directly the three-phase source to the three-phase load. The main element of Matrix converter is the fully controlled four quadrant bidirectional switch, which allows high-frequency operation. And also the desirable features of matrix converter is generation of load voltage with arbitrary amplitude and frequency; sinusoidal input and output currents; operation with unity power factor for any load; regeneration capability. This paper presents the state-of-the-art view in the development of this converter, starting with a brief historical review. Some new control methods of power bidirectional switches integrated in a single module are also presented. The results shows some practical issues related to the practical application of this technology, like overvoltage protection, use of filters, and ride-through capability.*

Keywords- *AC–AC power conversion, converters, matrix converters.*

I. INTRODUCTION

The matrix converter is a forced commutated converter which uses an array of controlled bidirectional switches as the main power elements to create a variable output voltage system with unrestricted frequency. The presentation of the power circuit of the converter as a matrix bidirectional power switches is named as "matrix converter."

One of their main contributions IS to describe the low-frequency behavior of the converter. In modulation method, also known as the direct transfer function approach, the output voltages are obtained by the multiplication of the modulation (also called transfer) matrix with the input voltages.

The matrix converter demands large-power, high-speed switching devices with bi-directional voltage blocking ability and self-turn **off** capability. Higher speed switching devices are desirable because the size of the input filters decreases with increased carrier frequency. The second reason is that the switches are subjected to current spikes and voltage spikes during commutation interval. The spikes increase **as** the current increases and the inductance of the load increases and eventually destroy the devices.

A conceptually different control technique based on the "fictitious dc link" In this method, the switching is arranged so that each output line is switched between the most positive and most negative input lines using a pulsewidth modulation (PWM) technique, as conventionally used in standard voltage-source inverters (VSIs).

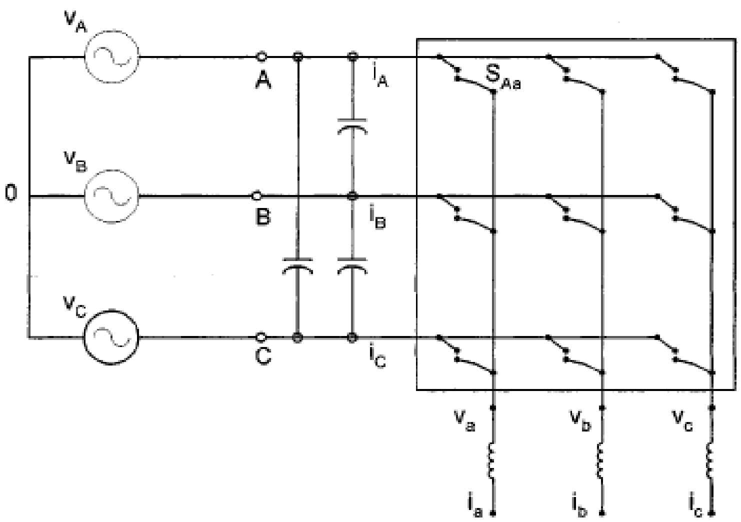

Fig .1. **Matrix converter in simplified form**

II. COMPARISION OF MATRIX CONVERTER WITH CONVENTIONAL CONVERTER

A Matrix Converter has nine bi-directional switches as shown in Figure 2.2. It is an attractive topology because it has potential advantages of reduced size and weight compared to controlled rectifier/inverter configuration in Fig 2.1. Substantial space and weight savings can be made due to the absence of a relatively bulky DC-link capacitor. The input filter inductors and capacitors are also small and light compared with the input filter. This is because the input filter only needs to remove high switching frequency harmonics (typically at least 10 kHz).

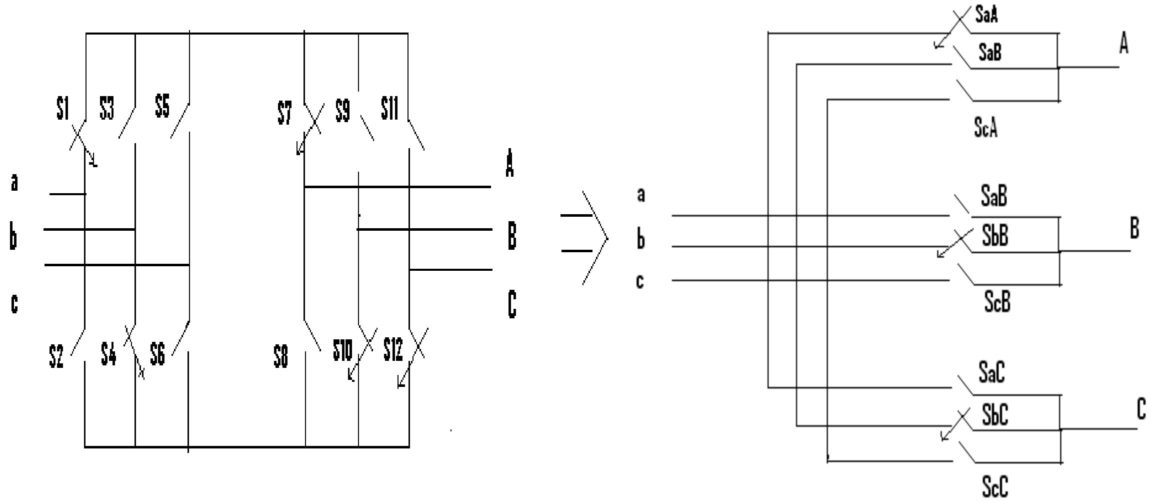

Figure 2.2. Matrix Converter relation with conventional converter.

III . Switching technique

$$S_{Kj} = \begin{cases} 1, & \text{switch } S_{Kj} \text{ closed} \\ 0, & \text{switch } S_{Kj} \text{ open} \end{cases} \quad K = \{A, B, C\}$$
$$j = \{a, b, c\}.$$

The relationship between load and input voltages can be expressed as

$$\left.\begin{aligned} \begin{bmatrix} v_a(t) \\ v_b(t) \\ v_c(t) \end{bmatrix} = \begin{bmatrix} S_{Aa}(t) & S_{Ba}(t) & S_{Ca}(t) \\ S_{Ab}(t) & S_{Bb}(t) & S_{Cb}(t) \\ S_{Ac}(t) & S_{Bc}(t) & S_{Cc}(t) \end{bmatrix} \begin{bmatrix} v_A(t) \\ v_B(t) \\ v_C(t) \end{bmatrix} \\ \mathbf{v_o} = \mathbf{T} \cdot \mathbf{v_i} \end{aligned}\right\} \quad (4)$$

$$\mathbf{v_o} = \begin{bmatrix} v_a(t) \\ v_b(t) \\ v_c(t) \end{bmatrix} \quad \mathbf{v_i} = \begin{bmatrix} v_A(t) \\ v_B(t) \\ v_C(t) \end{bmatrix}.$$

$$\mathbf{i_i} = \begin{bmatrix} i_a(t) \\ i_b(t) \\ i_c(t) \end{bmatrix} \quad \mathbf{i_o} = \begin{bmatrix} i_A(t) \\ i_B(t) \\ i_C(t) \end{bmatrix}$$

$$\mathbf{i_i} = \mathbf{T}^T \cdot \mathbf{i_o}$$

***IV*. Basic modulation method**

$$\mathbf{v_o} = qV_{im} \begin{bmatrix} \cos(\omega_o t) \\ \cos(\omega_o t + 2\pi/3) \\ \cos(\omega_o t + 4\pi/3) \end{bmatrix}$$

$$\mathbf{i_i} = q\cos(\phi_o)I_{om} \begin{bmatrix} \cos(\omega_i t + \phi_i) \\ \cos(\omega_i t + \phi_i + 2\pi/3) \\ \cos(\omega_i t + \phi_i + 4\pi/3) \end{bmatrix}$$

q is the voltage gain between the output and input voltages There are two basic solutions, When Φi= Φo, giving the same phase displacement at input and output ports, where Φi= -Φo,giving reversed phase displacement.

V. Alesina-Venturini method:

In the first method calculating the switch timings directly from those equations is cumbersome for a practical implementation. More conveniently expressed directly in terms of input voltages and the target output voltages assuming unity displacement factor as

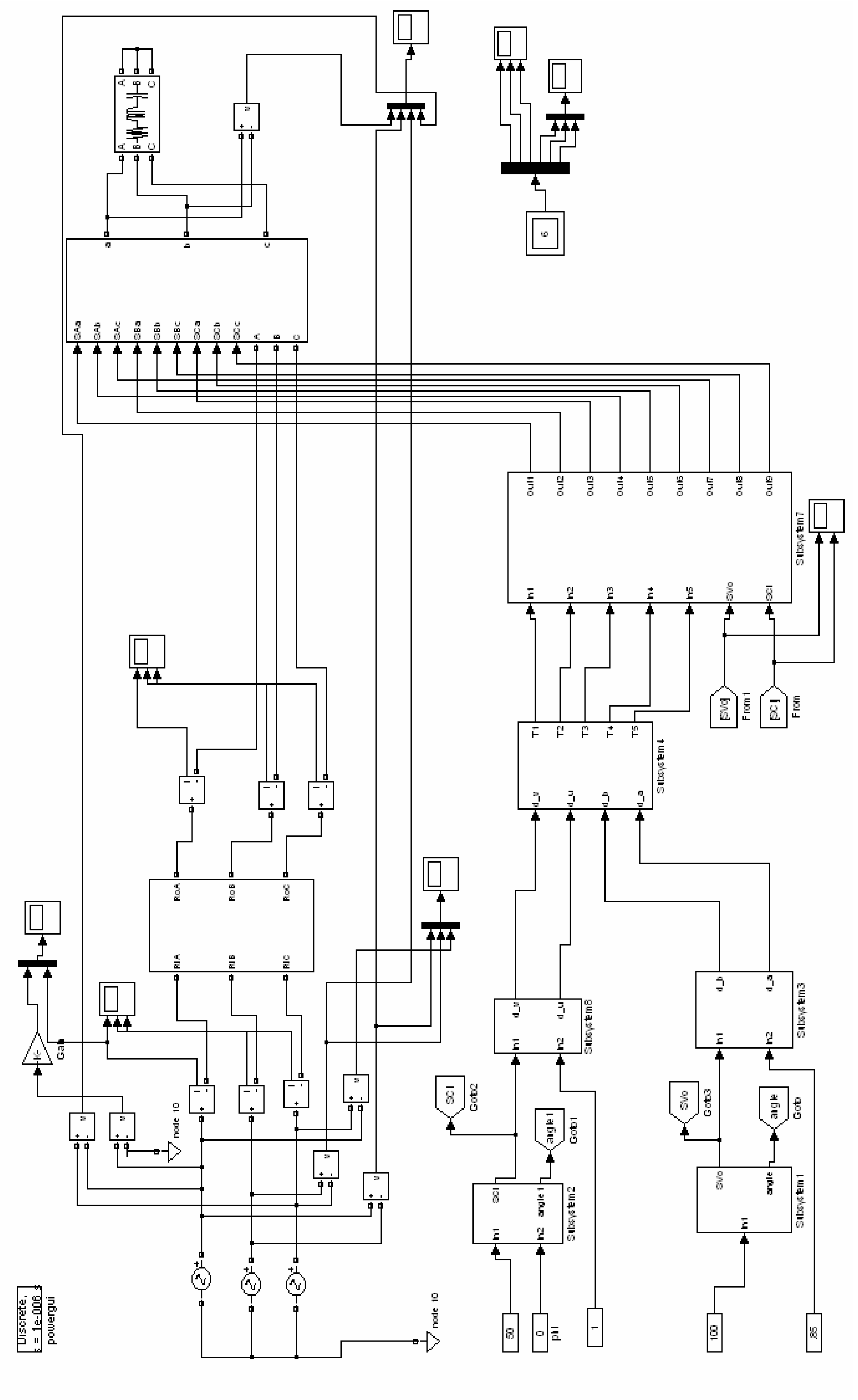

Figure 3. SVM complete block Representation.

VI . RESULTS

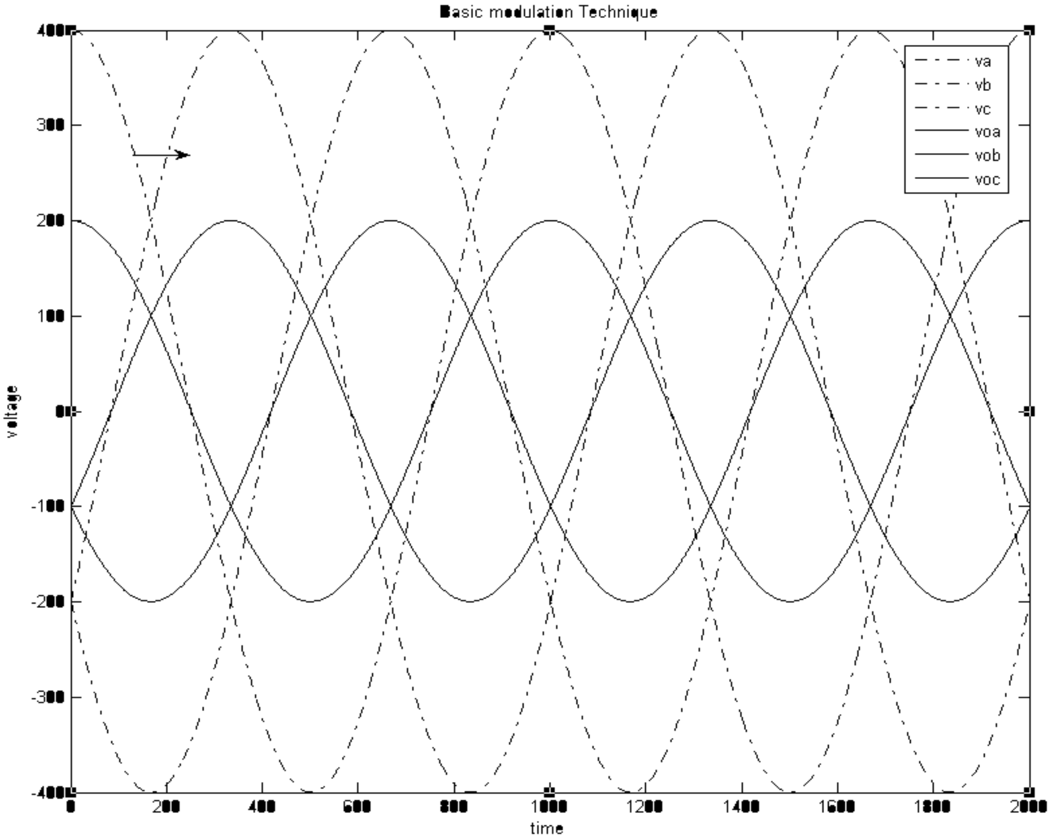

Fig. 4 output voltage and current waveforms for basic modulation technique.

Relation of Basic, Venturini & SVM techniques

For the SVM method, due to three zero configurations are used to complete the switching cycle, different ways exist to place and distribute zero vectors. Different distributions yield different SVM method. Normally, identical duty-cycles are symmetrically distributed in each switching period.

In this paper, the asymmetrical distribution will be implemented and duty-cycles of the three zero configurations will be calculated to establish the equivalent SVM method to the basic/optimum AV methods. Two different AV methods are well-established, the method without the common mode injection and the method with the injection. The input and output triple harmonics are inserted to expend the linear modulation range from 50% to 86%. Corresponding to each method, two different SVM methods are derived.

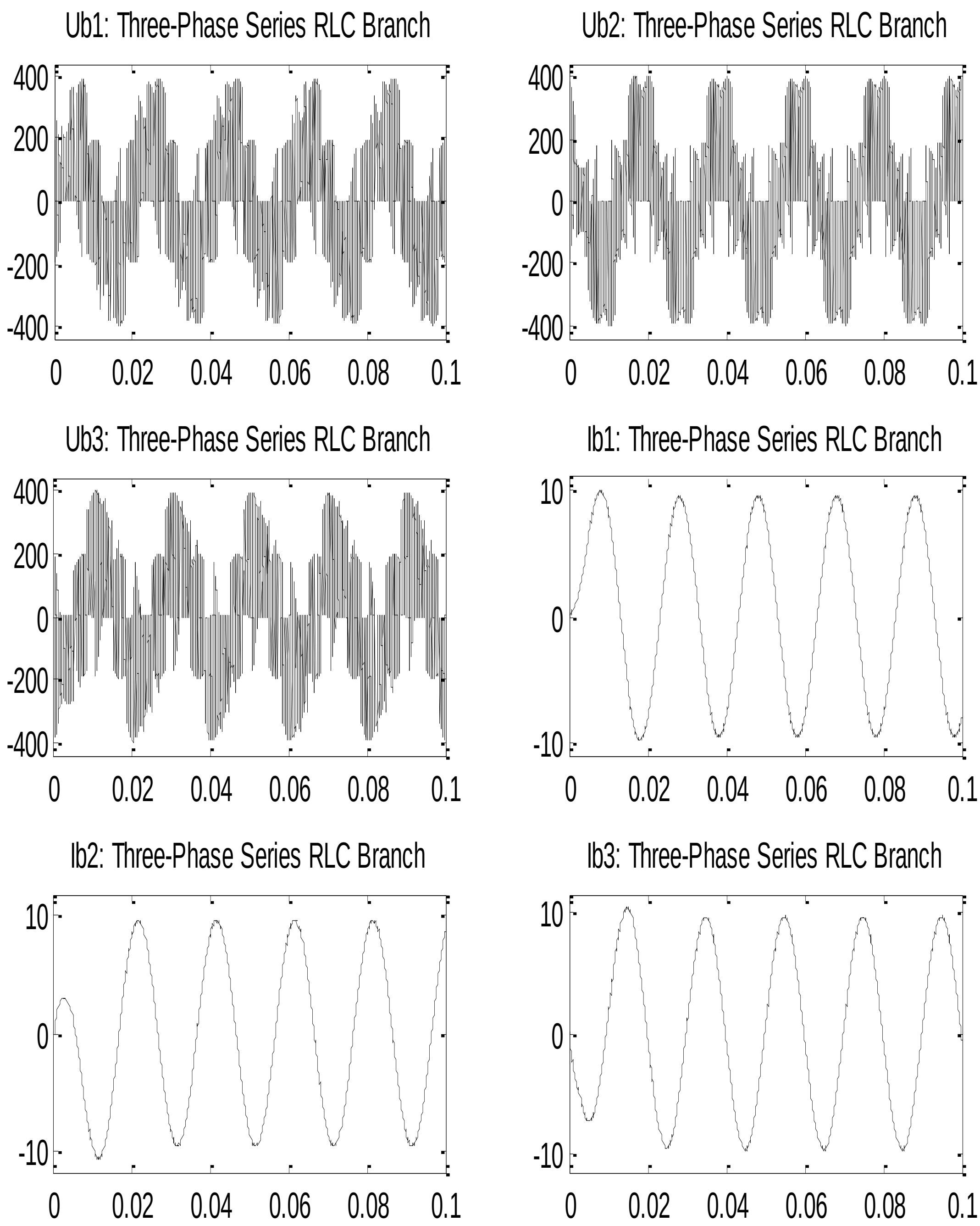

Figure 5. Simulated Output Voltage and Current of Alesina-Venturini Strategy.

VI. CONCLUTION

This project reviews some well known modulation technologies: basic/optimum AV method and space vector method. Two SVM approaches are reported in literature, indirect and direct SVM. Simulation for Basic, Alesina-Venturini, Scalar modulation techniques is done and also Space vector modulation technique simulation has been done for direct modulation method. In theory both methods are equivalent to each other. Apparently different, direct and indirect space vector schemes can be viewed as one unified SVM method. We also had the relation of the above methods.

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