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Designed control in an AC/AC Converter ForUsageIn Alow-powered Wind System

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ABSTRACT
Converting AC/ AC for industrial applications, it is required by the operating characteristics of the sources and loads. Alternating electrical sources are showing constant valuesof voltage, frequency, power and phases. They can be single or three-phase types, according to their classifications of power. The AC / AC converters used to vary the effective voltage across the constant electrical loadslike the frequencies, that are known as controllers or regulators AC voltage AC.
Keywords– AC/AC, Converter, controller, matrix, topologies

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I. INTRODUCTION

The power generation is one of the most basic of human activities, it can be materialized in many different ways and throughout different strategies, while the fail of the rotary motion generates direct current or alternate current will be able toenable to provide greater quantity and power of electricity.Alternative electrical sources are explained to have constant values of voltage, frequency, power and phase. They can be single or three-phase types according to their classifications of electrical power. The AC/AC converters are used to vary the effective voltage across the constant electrical loads, theknown frequency is controlled or regulated by the AC / AC voltage regulators. With the rapid advancement in the quick action of the fully controlled switches, the cycle-converter switched power (FCC) or recently developed matrix converters. Controlled-switches provide independent control of the magnitude and frequency of the output voltage, generating modulation as sinusoidal output voltage and current.

The matrix converters have been studied and proposed for different applications(Figure 1). There are two types of matrix converters called indirect and direct, each with its own advantages and disadvantages. For the indirect matrix converter, it has two modulators used, as it is composed of two clearly defined stages: a rectifier and a DC/AC converter. By contrasting, the direct matrix converter consists of a single step, is considered a single modulator or controller [1].

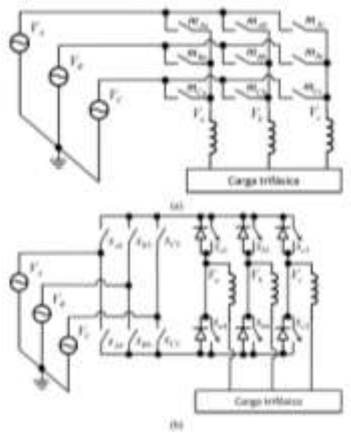

Figure 1.- Matrix Converter. (a) Direct, (b) Indirect

This work proposes an indirect modulator but for the direct matrix converter; that is, two virtual modulators that are used: one for the input stage or grinder and the other one for the output stage or inverter; both are linked so that the control signals for the matrix converter are generated in a single stage[1][2].

II. COMPARISON OF THREE-PHASED AC/AC CONVERTERS

Currently in the literature are several research papers in which comparisons were made with various aspects in the design and performance of different topologies of AC / AC converters, Figure 2 shows three general converter topologies AC/AC phase[3][4].

In the comparison of a direct matrix converter, compared to a two-level converter with a DC link back to back and a three-level converter with DC Link back to back with a synchronous 30 KW permanent magnet motor as an electrical filler and obtaining the following conclusions:

- Thematrixconverterprovideslowerweight and volumecomparedtotheothertwoconverters.
- Themainadvantageisthesmaller input filter.
- Forthematrixconverter input voltageisshapedlike a smooth sinusoidal wave, onlythe output voltageis in a PWM form.
- Thedisadvantageofthematrixconverteristhelacko fincrease in theoutput voltage.

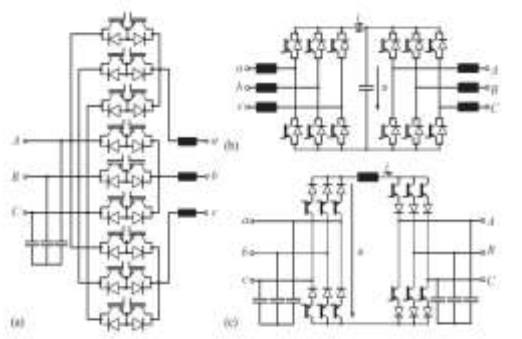

Figure 2.- Conventional Matrix Converter; AC-DC Converters Basic-AC: b)V-BBc; c)C-BBC

III. MODULATION BACKTO BACK

Traditionally, direct matrix converter is controlled as one single stage that is operated directly from AC/AC, i.e. not treated as two virtual converters with a CD virtual bus, i.e. a rectifier cascade with an inverter; the above is only for controlling purposes, because the actual converter still consists of a single step or stage[3][5][5][6]. The relationship between input and output of a matrix converter is given by the expression (4):

$$\begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} = \begin{bmatrix} m_{Aa} & m_{Ba} & m_{Ca} \\ m_{Ab} & m_{Bb} & m_{Cb} \\ m_{Ac} & m_{Bc} & m_{Cc} \end{bmatrix} \begin{bmatrix} V_A \\ V_B \\ V_C \end{bmatrix} \quad (3)$$

Nothing like the single inverter system, power conversion is AC / AC. This modulation has the ability to reduce harmonic distortion in the current, increasing the power factor and controlling bidirectionally the flow of active power and reactive power compensating the BTB structure (fig.3) converter is based on known converters as voltage source converters (VSC by its acronym) which use semiconductor devices as the IGBT or the MOSFET. The whole scheme consists of two converters pulsed with a modulator (PWM converters, for its acronym in English), coupled by a DC bus.

To make the virtual separation in two stages, the above equation is divided into two, so that the system is:

$$\begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} = \begin{bmatrix} S_{a1} & S_{a4} \\ S_{b3} & S_{b6} \\ S_{c5} & S_{c2} \end{bmatrix} \begin{bmatrix} S_{A1} & S_{B3} & S_{C5} \\ S_{A4} & S_{B6} & S_{C2} \end{bmatrix} \begin{bmatrix} v_A \\ v_B \\ v_C \end{bmatrix} \quad (4)$$

Where matrices to rectify and invert virtually; doing this division identifies a DC virtual bus, which can be found by multiplying the matrix corresponding to the rectifier with the input vector. In figure 5, the system considered, which is practically the same as the indirect matrix converter is shown. Equalization, the actual control signals of the matrix converter are shown in Figure 6.

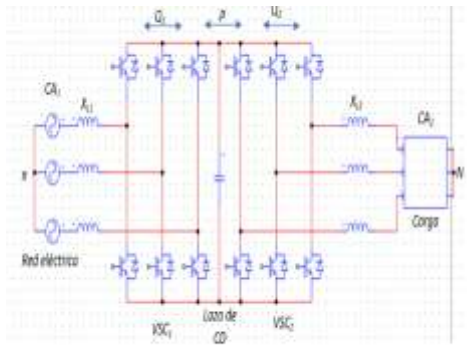

Figure 3.- Topology of a Back to Back Converter (BTB)

$$\begin{bmatrix} m_{Aa} & m_{Ba} & m_{Ca} \\ m_{Ab} & m_{Bb} & m_{Cb} \\ m_{Ac} & m_{Bc} & m_{Cc} \end{bmatrix} = \begin{bmatrix} S_{a1}S_{A1} + S_{a4}S_{A4} & S_{a1}S_{B3} + S_{a4}S_{B6} & S_{a1}S_{C5} + S_{a4}S_{C2} \\ S_{b3}S_{A1} + S_{b6}S_{A4} & S_{b3}S_{B3} + S_{b6}S_{B6} & S_{b3}S_{C5} + S_{b6}S_{C2} \\ S_{c5}S_{A1} + S_{c2}S_{A4} & S_{c5}S_{B3} + S_{c2}S_{B6} & S_{c5}S_{C5} + S_{c2}S_{C2} \end{bmatrix} \quad (5)$$

From this equation are the control signals of the switches of the direct matrix converter, simply an array of logic gates (figure 4), using the control signals of the switches of the rectifier and the inverter. Thus the control signals of the direct matrix converter can be found like one indirect[6]. The rectifier, for example, can be operated as if it was a simple diode array so that the DC bus is maximized and the inverter can be operated by PWM modulation, either sinusoidal signal, vector or harmonic injection. This mode of operation allows you to use the concepts previously known from the rectifiers and the inverters.

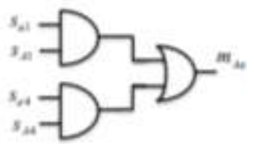

Figure 4.- Logic Gates for Combined Virtual Modulators

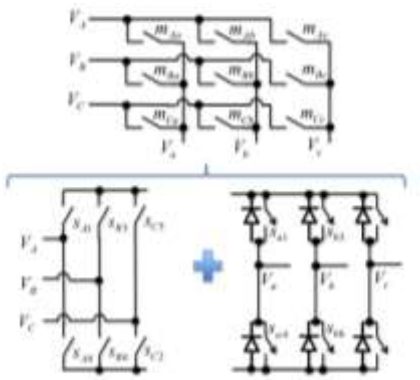

Figure 5.- Virtual Converter

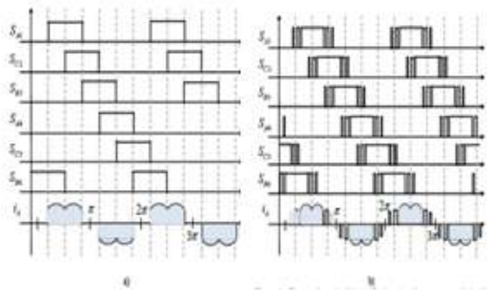

Figure 6.- Virtual RectifierWaveforms: a) Not Controlled, b) Controlled

IV. PI CONTROL

The control consists in measuring the value of a controlled variable and the manipulated variable applied to the system to correct or limit the deviation of the measured value compared to a desired value. In this context, the controlled variable is the amount or condition that is measured, while the manipulated variable is modifiedby the controller to affect the controlled variable.The Integral Control mode (Figure 6) is intended to reduce and eliminate the steady-state error, caused by the proportional mode. The Integral Control acts when there is a deviation between the variable and the setpoint, integrating this deviation over time and adding it to the proportional action. The integral control is used to obviate the disadvantage of the offsetproportional band, (permanent deviation of the variable with respect to the setpoint). The integral control formula is given as:

$$I = K_i \int_0^t e(\tau)d\tau$$

I. IMPLEMENTATION OF THE AC/AC CONTROL CONVERTER IN HARDWARE IN THE LOOP (HIL)

The final topology used in this paper for the AC/AC converter is shown in Figure 7, this converter is based on an IGBTsinverter. Which is connected as a BTB (back to back) converter, rectifying and inverting the signal, so the voltage signal is rectified and reverse out to an AC voltage.That this generates a maintenance of the frequency and amplitude of the input signal, this new design is a proposal that involves occupy less space and make a compact designof a plant card that allows to control more effectively the AC/AC converter.

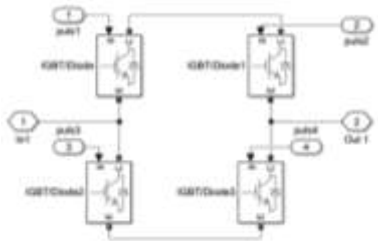

Figure 7.- Topology design of a single-phase converter for AC / AC converter connected as a BTB with IGBTs

To be more understandable this, the operation of the converter comprises a full wave bridge of two arms, where in the first branch are connected IGBT/Diode and IGBT/Diode2 by the common emitter and common collector respectively,it is injected through an inlet of AC voltage (INT1). Each branch has two switches that switch according to the control strategy, and control load hysteresis band. Each jumper switch comprises an IGBT/diode, IGBT/Diode1, IGBT/Diode2 and IGBT/Diode3. Switching is done by digital signals at the gates G as pulse1, pulse2, pulse3 and pulse4. The converter converts the voltage INT1 to an alternate current signal, injecting current at the output (OUT1) of the second branch connected IGBT/Diode1 and IGBT/Diode3 by the common emitter and common collector respectively, shown in Figure 9. OUT1 voltage flows into the electrical load where it is modeled by the capacitor and the inductance to resistance should supply the electrical load currents needed to meet their energy needs. Figure 10 shows the final topology of the AC/AC converter, which is constituted with the sum of three single-phase AC/ACconverters which are connected to a resistive load, wherein the sequence of firing the IGBTs of each inverter is activated,it is shown to convert at the same time to achieve appropriate conversion, input, three-phase phase output. OUT1 voltage flows into the load where it is modeled by the capacitor and the inductance to the resistance. Resistance should supply the load needed to meet their energy needs. The following figure 8, shows the final topology of the AC/AC converter, which is constituted with the sum of three single-phase converters AC/AC connected to a resistive load, wherein the sequence of firing of the IGBTs of each inverter is activated, it is shown to convert at the same time to achieve appropriate conversion, input, three-phase phase output. OUT1 voltage flows into the load where it is modeled by the capacitor and the inductance to resistance. Resistance should supply the loadneeded to meet their energy needs. The following Figure 8 shows the final topology of the AC/AC converter, which is constituted with the sum of three single-phase AC/AC converters connected to a resistive load, wherein the sequence of firing of the IGBTs of each inverter is activated are shown to convert at the same time to achieve appropriate conversion, input, three-phase phase output[7][8].

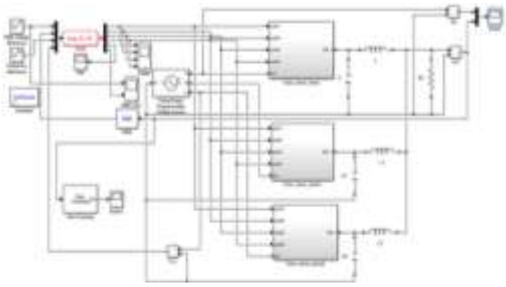

Figure 8.- Topology of AC/AC Control Converter, Closed Loop in Matlab

Table 1.- Switching state of the IGBTs

Shots	Ignitions switches
Puls1	IGBT / Diode, IGBT / Diode4 and IGBT / Diode8
Puls2	IGBT / Diode1, IGBT / Diode5 and IGBT / Diode9
Puls3	IGBT / Diode2, IGBT / Diode6 and IGBT / Diode10
Puls4	IGBT / Diode3, IGBT / Diode7 and IGBT / Diode11

The converter consists of 12 switches IGBTs, which are divided infull-wavethree-phase converters that have as input a three-phase source and an output connected to the same resistive load, thereby giving phase output, and the pulses are connected to each converter, managing to create a converter with three-phase input and a single-phase output.

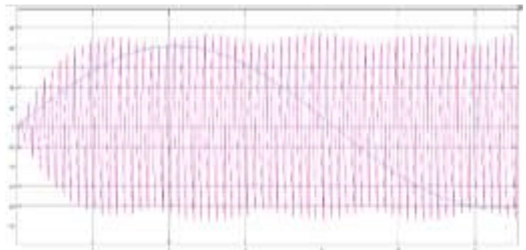

Figure 9.- Simulation of a AC/AC Converter, Open Loop in MATLAB

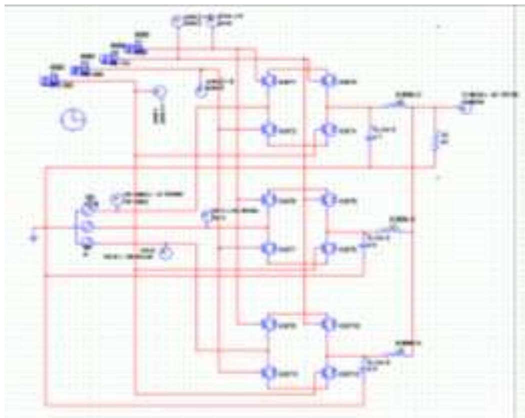

Figure 10.- Topology of AC/AC Converter, Open Loop in PSIM

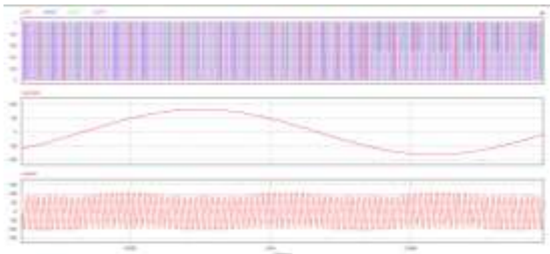

Figure 11.- Simulation of aAC/AC Converter, Open Loop in PSIM

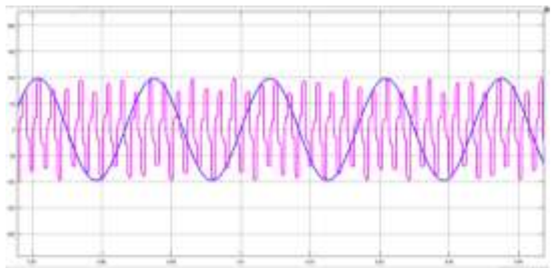

Figure 12.- Simulation of aAC/AC Converter, Closed Loop in MATLAB

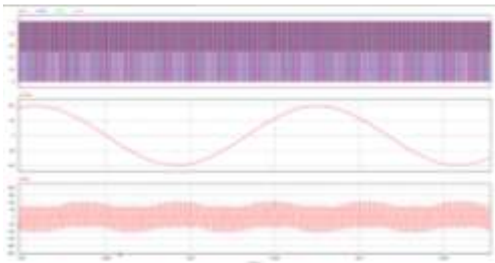

Figure 13.- Simulation of AC/AC Control Converter, Closed Loop in PSIM

It is noted that the box in the upper left (Figure 13) is showing the input of an AC / AC converter, with a 100v three-phase input; in the upper right box should display the output of the plant, but apparently there is no display of output voltage, indeed 0V; the remaining boxes (left and bottom right) show some control of the IGBTs in OFF mode, they were not yet lit to implement these controls.It is distinguished in Figure 14,management control is at the minimum that allows IGBTs to make the right shot control with the minimumvoltage and Figure 15 is shown as it reaches its maximum controllability viewing control operation of the plant.

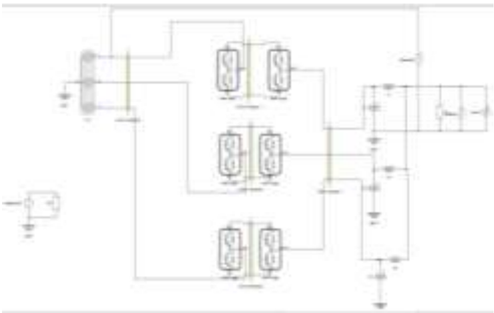

Figure 14.- Schematic Diagram of the Plant for Implementation in Hardware In the Loop.

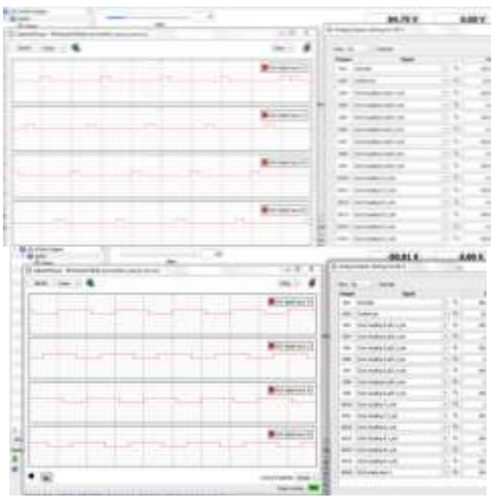

Figure 15.- simulation of the plant in the Typhoon HIL

V. RESULTS

By comparing the software used to implement the topology used in the construction of the AC / AC converter, one can say and understand that thisnew topology integrates new performance achieves, the function of converting an AC input signal to an AC output, it is shown that both open and closed loops in the software PSIM MATLAB andTYPHOON throw equal results even in PSIMsignalsthat are symmetrical, in the output of the AC / AC converter; using the controls on both platforms fail to perform their duties successfully by controlling the output voltage of the converter,is observed in the previous sub-chapter to do it with the results of the simulations.Extensive testing has managed to obtain similar results as they are constantly modified; after the modifications it is trying to find out what could the error be and advanced research is reached to see the control response of AC / AC converter platforms used (figure 16, figure 17 and figure 18):

Figure 16.- Control of shots AC / AC converter in PSIM

Figure 17.- Control of shots AC / AC converter in MATLAB

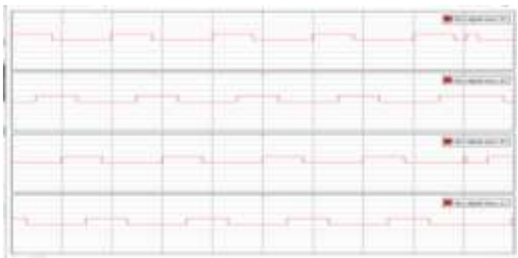

Figure 18.- Control of shots AC / AC converter in Typhoon HIL

The controls work properly, even if very noticeable differences exist between the lags of MATLAB, PSIM and Typhoon HIL software's. In MATLAB there is more order, whereas in PSIM and Typhoon HIL there is an order non-consequent with MATLAB, but if they fulfill the function of controlling the AC / AC converter, only that it is limited by not showing the output voltage when implement in hardware in the loops, as the Typhoon HIL, its software platform has limitations when performing the schematic diagram of the plant, where components have certain restrictions when wanted to modify a device.It is proceeded to a physically performance a single-phase AC/AC converter to find the problem that the platform could not detect.

Figure 19.- Shots Inverter Switches single phase AC/AC

It is worth mentioning that tests were performed with single-phase AC/AC converter in MATLAB and PSIM software, showing its versatility.

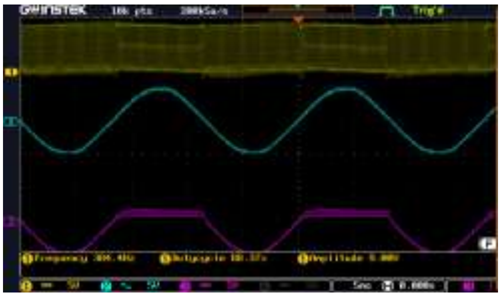

Figure 20.- Control Single-phase AC/AC Converter

In Figure 19 shows the shots that are similarly identical to the simulations in PSIM and Typhoon HIL corroborating that the control is operating properly, while in Figure 20areshown in the implemented control to phase converter AC/AC is the line 1 in yellow, resulting in the same result as the Typhoon HIL platform showing a total of 0v output, and it is seen that in the physical implementation also shows the 0v output (line 3 in purple) with a slight perturbation measured in millivolts (mV), thus doing a small modification in the control at that level, while the input is stable (line 2 in blue) with retaining 110v frequency 5KHz.

VI. CONCLUSIONS

In this paper a topology consisting of the sum of three single-phase inverters connected as three individual bridges full wave composed of 4 IGBTs, each giving a total of 12 IGBTs implemented where three of them make one shot while connected as a BTB (Back to Back) converter achieving the effect of converting the AC signal input to an AC output, as it is switching, as switches act differently with respect to the order in how they placed IGBTs making function an AC / AC converter, giving to discover a new kind of topology.The design of thisthree-phase converters for AC/AC was based ondifferent existing AC converterstopologies, comparing the characteristics, advantages and disadvantages of various semiconductor devices used in the design of power systems such as IGBTs, implementing an integrated control through a real-time embedded system, fulfilling part of the scopes that were established in this chapter,for a further analyze in performances, configurations and arrangements of the switches of the sum of single-phase AC/AC converters implemented in this topology for greater understanding and effectiveness.

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