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Hardware Implementation Of Three Phase To Two Phase Matrix Converter

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Abstract - *The paper describes design of micro-controller based three phase to two phase Matrix Converter prototype. Matrix Converter is an array of bidirectional switches which connects output phase to input phase. It is variable voltage, variable frequency converter. For three phase to two phase conversion, scott transformer may be used but, its cost and core loss are higher. Also, transformers used in scott connection are expensive, have losses and require large installation area, therefore Matrix Converter can replace scott transformer. In this paper, Triac is used as a bidirectional switch. Gate pulses are given to Triacs from Microcontroller using PWM technique. The proposed matrix converter provides sinusoidal output current/voltage waveforms with independently controlled magnitude and 90° phase angle to two-phase loads.*

***Key Words*: Scott transformer, Two phase voltage, Matrix Converter, Microcontroller etc.**

1. INTRODUCTION

This In many AC drive applications, it is desirable to use a compact voltage source converter to provide sinusoidal output voltages with varying amplitude and frequency, while drawing sinusoidal input currents with unity power factor from the AC source. The development of matrix converter started when *Alesina* and *Venturini* proposed the basic principles of operation in the early 1980's. Matrix Converter is increasingly becoming popular because it does not have any intermediate energy storage devices except small AC filters for the elimination of switching ripples. This converter fulfills all the requirements of the conventionally used rectifier/ DC link/ inverter structures and provides an efficient way to convert electric power. [1]

Since there is no DC link as in common converters, the matrix converter can be built as a full-silicon structure. However, a mains filter is necessary to smooth the pulsed currents on the input side of the matrix converter. Using a sufficiently high pulse frequency, the output voltage and input current both are shaped sinusoidal. The matrix converter is an alternative to an inverter drive for frequency control.

The Matrix Converter has several advantages over traditional rectifier-inverter type power frequency converters. It provides sinusoidal input and output waveforms, with minimal higher order harmonics and no sub harmonics; it has inherent bidirectional energy flow capability; the input power factor can be fully controlled. It has also minimal energy storage requirements, which allows to get rid of bulky and lifetime- limited energy-storing capacitors.

The Matrix Converter has also some disadvantages. First of all, it has a maximum input output voltage transfer ratio limited to 87 % for sinusoidal input and output waveforms. It requires more semiconductor devices than a conventional AC-AC indirect power frequency converter, since no monolithic bi-directional switches exist and consequently discrete unidirectional devices, variously arranged, have to be used for each bi-directional switch. Finally, it is particularly sensitive to the disturbances of the input voltage system [2].

The Matrix Converter is superior to the traditional VSI because of regeneration ability and sinusoidal input current. Therefore, it meets the stringent energy efficiency and power quality requirements of the new century. Matrix Converter can be considered to be a direct converter, in this respect similar to a cycloconverter, because it does not employ a DC link and the output waveforms are composed of switched segments of the input waveforms.

Indirect AC-AC converter (fig.1) is the most common approach for AC-AC power conversion. The distinctive feature of this converter topology is the need of energy storage element in the intermediate D.C link: a capacitor or an inductor. Due to these elements, this converter becomes bulky and also the converter is not usable in application requiring regenerative operation. This disadvantage of Indirect AC-AC converter has been removed by Direct AC-AC Converter. A direct AC-AC converter converts a fixed frequency fixed voltage into a variable frequency variable voltage. The basic AC-AC energy conversion described has three possible operations, namely (a) AC controller, (b) Decreased frequency operations and(c) Increased frequency operation.

Matrix Converter is a direct ac/ac frequency converter (fig.2) which does not require any energy storage element. When the Matrix Converter (MC) is compared with conventional DC link converter, it has some significant advantages. For instance, due to absence of components with significant wear-out characteristics (electrolytic capacitors), the MC can be potentially very robust and reliable [3].

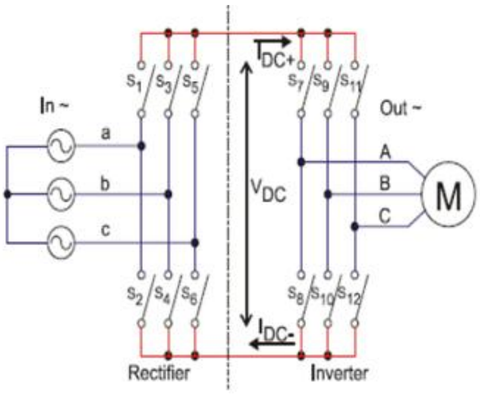

Fig.1 Three Phase To Three Phase Indirect Matrix Converter

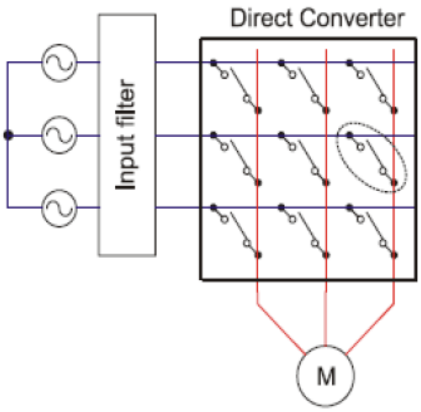

Fig.2 Three Phase To Three Phase Direct Matrix Converter

A Matrix Converter is a direct power conversion system that converters three-phase AC supply to variable-voltage variable frequency outputs. It is an ideal AC/AC converter, which meets all the requirements needed for converters, such as no energy storage requirement, sinusoidal input and output waveforms, bi-directional energy flow and controllable input power factor.

2.Three Phase To Two Phase Matrix Converter

Three-phase to two-phase MC is commonly used in electric furnace installation where it is desired to run two single-phase furnaces together and draw a balanced load from the three phase mains. In three phase to two phase Matrix Converter, mostly Scott transformers are used for industrial purposes. The transformer used have disadvantages such as ,they are expensive, have losses, require large installation area, Also, DC magnetising current and surge over voltages can result in control problems and their failure rate is much higher. These limitations are overcome in Matrix Converter. [6]

In Matrix Converters, the transformer has been omitted, which results in reduction of losses, installation area and cost. The MC is a direct ac/ac frequency converter which does not require any energy storage element. Lack of bulky reactive components in this structure results in reduced size and improved reliability compared to conventional multistage ac/dc/ac frequency converters. In the output voltages of three-phase to two-phase MC are symmetrical two-phase voltages with 90° shift.

Usually there are three types of three phase to two-phase MC topologies, four-leg, three-leg and two leg (fig.3) based on structures. In four-leg topology, MC is formed by two single phase outputs and the two output circuit is independent, which means the structure has more control freedom but it requires 12 switches which will bring more switch conduction losses. And in two leg topology, it just needs 6 switches but the load common joint is connected directly to the neutral point of the source which will cause interaction smaller switching devices between each other. The three-leg topology has less switches compared to four-leg topology and be more flexible compared to two-leg topology. Since the MC is supplied by the voltage source, the input phases must never be shorted, and due to the inductive nature of load, the output phases must not be left open [7].

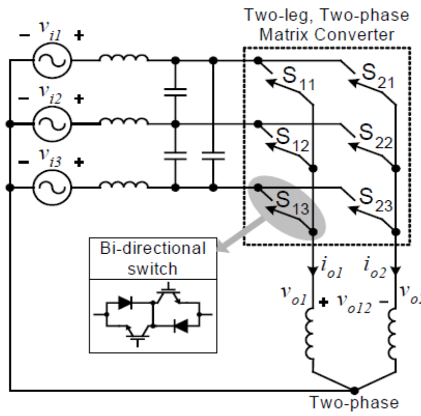

Fig.3 Two leg, Two phase Matrix Converter

Because the Matrix Converter has no dc-link capacitor, the two-phase structure with two legs in Fig. 3 is configured with the load neutral fed back to the supply neutral. Meanwhile, utilizing one leg to connect the load neutral results in the two-phase matrix converter based on three output legs. The three-leg configurations causes increased system cost and complexity. In this paper, two leg configuration is used.

3. Implementation Of Matrix Converter

3.1 Input Filter

Filters must be used at the input of the Matrix Converters to reduce the switching frequency harmonics present in the input current. The requirements for the filter are:

i. To have a cut-off frequency lower than the switching frequency of the converter.
ii. To minimise its reactive power at the grid frequency.
iii. To minimise the volume and weight for capacitors and chokes.
iv. To minimise the filter inductance voltage drop at rated current in order to avoid a reduction in the voltage transfer ratio.

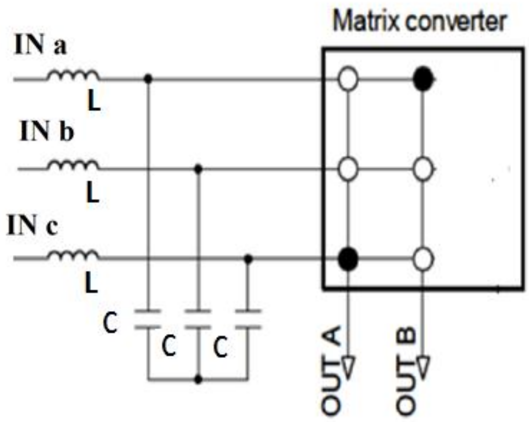

Fig.4 Three phase to Two phase MC with Input LC Filter

It must be noticed that this filter does not need to store energy coming from the load. It has been shown that simple LC filtering, as shown in figure4 is the best alternative considering cost and size.

Due to the LC configuration of the input filter, some problems appear during the power-up procedure of the Matrix Converter. It is well known that an LC circuit can create overvoltage during transient operation. The damping resistors to reduce overvoltage may be used.

3.2 Bidirectional Switch Realisation

Three possible ways to obtain a bi-directional power switch using low costs commercial IGBTs are shown in Fig.5.Another possibility to get a bi-directional switch is the use of two reverse blocking IGBTs in anti-parallel connection.

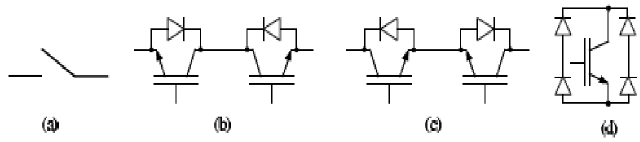

Fig.5 Bidirectional switch (a) Ideal switch (b) Common collector switch (c) Common emitter switch (d) Diode bridge switch

The topology based on Diodes Bridge, as shown in Fig.5 (d), causes higher conduction losses since the current path is formed by two diodes and one IGBT and this is the reason why it is less used than the other topologies. The gate drive circuitry is simple since there is one controlled component in each power bi-directional switch. On the other hand, the topologies based on common collector or common emitter connections of two IGBTs, as shown in Fig. 5(b) and 5(c) respectively, allow lower conduction losses and are commonly used in the matrix converter design, but the use of two IGBTs increases the complexity of the gate drive. So, the choice of bi-directional switch implementation will influence the hardware requirements to build the matrix converter. In this circuit, Triac is used as bidirectional switch.

Figure 6 shows hardware implementation of three phase to Two phase Matrix Converter with two phase output.

Fig. 6 Hardware implementation of Three phase to Two Phase Matrix Converter.

4. CONCLUSIONS

The matrix converter uses bidirectional fully controlled switches for direct conversion from ac to ac. The bidirectional switches are so arranged that any of input phase could be connected to any output phase through the switching matrix symbol. The Two phase voltage is produced by using Microcontroller ATmega328p using PWM technique.

The matrix converter has some advantages (1) inherent bidirectional power flow (2) sinusoidal input-output waveforms with moderate switching frequency (3) possibility of compact design due to absence of dc-link reactive components. However, the practical applications of the matrix converters are very limited due to following reasons (1) complex control of law implementation (2) an intrinsic limitation of the output-input voltage ratio (3) commutation protection of the switches. With space vector PWM control using over modulation the voltage transfer ratio may be increased to 1.05 the expense of more harmonics and large filter capacitors. The Matrix Converter topology used for universal power conversion such as: AC/DC, DC/AC, DC/DC, AC/AC without any change of topology is used. For AC/AC converter its equivalent circuits combining current source rectifier & voltage source inverter connected by dc link.

Future scope of work is to analyze the operation of a Matrix Converter for different loading conditions and synthesize the output voltage using various other modulation techniques and further this work can be extended to implement simulation approach.

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