APPLICATION OF SINGLE PHASE MATRIX CONVERTER TOPOLOGY TO AN UNINTERRUPTIBLE POWER SUPPLY CIRCUIT

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Abstract

This paper presents the single phase matrix converter topology that will operate as an uninterruptible power supply circuit. A single circuit is developed that performs both the rectifier and inverter operation which also incorporate active power filter. Commutation strategies are also implemented with reduction in spikes, a common phenomenon in matrix converter topologies. Experimental setup and results are presented to verify that the proposed technique is feasible. This single phase matrix converter topology will be operating as an inverter and controlled rectifier in which H-bridge inverter transforms a DC input into an AC output. The pulses for single phase matrix converter are generated by using pulse width modulation technique. The various building blocks to the development of a new uninterruptible power supply circuit are developed centred on the use of a single phase matrix converter.

Keywords: *Pulse width modulation, matrix converter controlled rectifier, UPS, MOSFET – Metal oxide semiconductor field emitting transistors.*

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1. INTRODUCTION

A matrix converter is an array of controlled semiconductor switches that directly connect each input phase to each output phase, without any intermediate dc link. The matrix converter (mc) offers possible "all silicon" solution for AC-AC conversion removing the need for reactive energy storage components used in an conventional converter systems [1]. Its topology was first described in 1976 by Gyugyi[3] previous published studies deal with three-phase circuit topologies[2,4,5]. Matrix converter in the three phase circuit variant is widely researched while the single phase matrix converter has very little attention offering very wide application. The single phase matrix converter was first realized by Zuckerberger[6]. All previous works have focused attention to direct AC-AC single phase converter and DC chopper but none on inverter as well as rectifier operation.

This paper presents the single phase matrix converter topology that will operate as an inverter and controlled rectifier in which H-bridge inverter transforms a DC input into an AC output.

2. MATRIX CONVERTER

Basically, a matrix converter (MC) is composed of a bidirectional switches as shown in fig.1. Where each dot of the grid represents a connection between the output and input terminals [11]. The converter is usually fed at the input side by a three phase voltage source and it is connected to an inductive load at the output side.

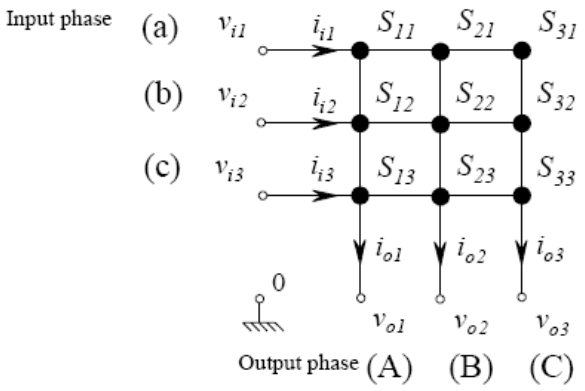

Fig.1. Basic Scheme of matrix converter

The most important characteristics of MCs are as follows [11], [12].

A simple and compact power circuit, Generation of load voltage with arbitrary amplifier and frequency, Sinusoidal input and -

Output current Operation with unity power factor, and Regeneration capability

Aim of this paper is overview solution of existing single phase matrix converter application possibilities. It describes switching scheme of each single phase matrix converter application solution. Compare it with conventional solution

and conclude how single phase matrix converter may be used. Matrix converter has more advanced potential as compared with conventional voltage source inverters [12].

3. SINGLE PHASE MATRIX CONVERTER

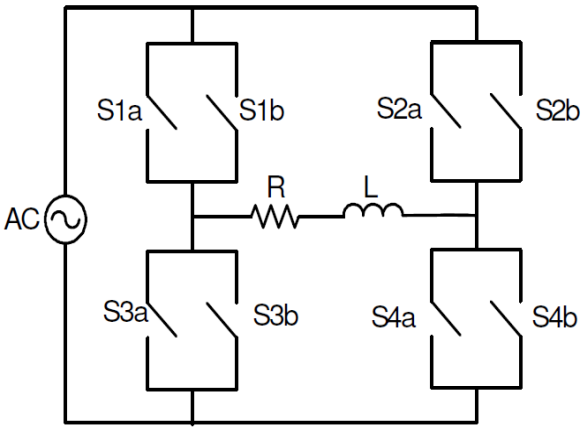

Fig.2 Basic Diagram of Single Phase Matrix Converter Topology

The SPMC requires 4 bi-directional switches as shown in fig.2. Each capable of conducting current in both directions, blocking forward and reverse voltages. It requires the use of bidirectional switches capable of blocking voltage and conducting current in both directions [4][13]. Unfortunately there is no discrete semiconductor device currently that could fulfil the needs and hence the use of metal oxide semiconductor field emitting transistor, MOSFET Ant parallel diode pair is used. The MOSFET were used due to its popularity amongst researcher that could lead to high power applications with reasonably fast switching frequency for fine control [8] [9]. MOSFET are used because voltage that can be applied to the gate must be reduced, to maintain reliability and to maintain performance.

4. BLOCK DIAGRAM

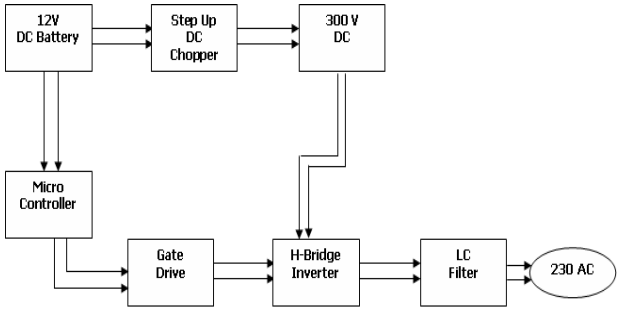

Fig.3 Block diagram

Fig.3 shows the block diagram of proposed single phase matrix converter topology to an uninterruptible power supply circuit. It consists of step-up dc chopper, H-bridge inverter, microcontroller, opt coupler and gate drives. The DC chopper which is boost converter also known as the step-up converter. This converter produces an output voltage greater than the source.

The most common single phase inverter is the H .Bridge inverter. Since most loads contain inductance, feedback rectifiers or ant parallel diodes are often connected across each semiconductor switch to provide a path for the peak inductive load current when the semiconductor is turned off. Microcontroller is used to obtain the gate signal of the booster switch and to drive the inverter switches using SPWM. 8051 microcontroller is used to perform a single set of functions which provides high performance and reliability. MOSFETs are preferred in this work because it has applications with high frequency (<50Hz), zero voltage switch (ZVS) circuit (>200 KHz), wide line or load variations, low voltage applications (<250V) and lower output power (<500W).

The general purpose opt couplers consist of a gallium arsenide infrared emitting diode driving a silicon photo transistor in a 4 pin dual in line. The opto coupler used to isolate between high voltage of the inverter and low voltage of the micro controller. There are many situations where signals and data need to be transferred from one subsystem to another within a piece of electronics equipment. Often this is because of source and destination are at very different voltage levels, like a microcontroller operating at 5V dc but being used to control power inverter switching at 300V dc. In such situation the link between the two must be an isolated one to protect the microcontroller from over voltage damage. We use opto coupler for isolating between the H .bridge inverter gates and the PWM output from the microcontroller. Gate drive is required to supply the switch such as MOSFETs with required voltages and currents.

5. PROPOSED UPS USING SINGLE PHASE MATRIX CONVERTER

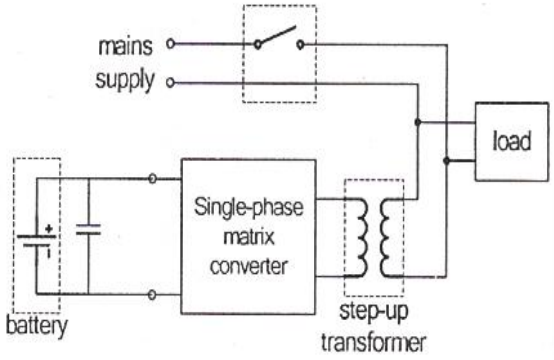

Fig.4 Proposed UPS using SPMC

Using single phase matrix converter the proposed circuit diagram is as shown in Fig.4. Since single phase matrix converter is characterized by pure controllable switching function, the need for the blocking switch is eliminated a may be replaced by sophisticated control algorithm that could be developed in the future. A transformer is used step down voltage during rectification operation.

Critical loads such as data storage and computer systems, life support equipment, process equipment controllers, telecommunications equipment and emergency systems require continuous operation when there is a power failure. Other sensitive equipments are less tolerable to nuisances caused by harmonics penetration such as poor overall power factor, heating effects; device malfunction and destruction of other equipment caused by nonlinear loads have been recorded. Therefore the demand for high quality and availability of power supply has shown an upward increase in recent years. This trend reflects in the increase use of single phase matrix converter to an uninterruptible power supply (UPS) to provide uninterruptible and reliable power supply with the provision of unity supply power factor.

6. INVERTER OPERATION

Inverter Operation

The DC to single-phase AC matrix converter will be designed and controlled in such a manner that the fundamental of the output voltage is;

$$V_{out} = V_{in} \cos w_0 t$$

The matrix switch‘s’ follows;

$$S = \begin{bmatrix} S_1 & S_2 \\ S_3 & S_4 \end{bmatrix}$$

The sampling time T_s will be divided to 2 time intervals t_1 & t_2 as follows;

$$T_s = t_1^n + t_2^n$$

By this approach

At $t_1 : S_1 \& S_4$ will be on

$S_2 \& S_3$ Will be off

At $t_2 : S_2 \& S_3$ will be on

$S_1 \& S_4$ Will be off

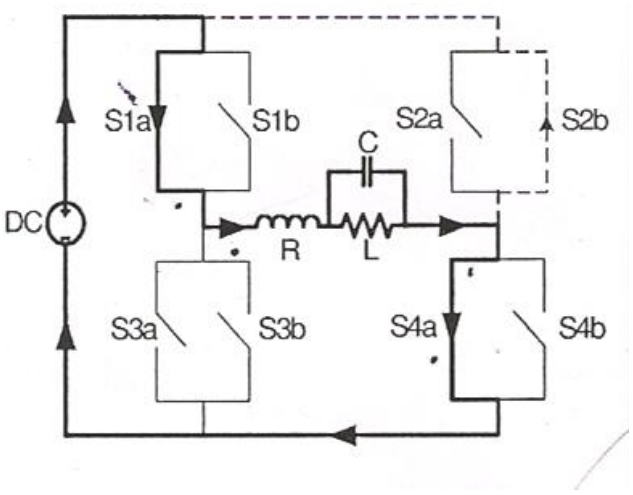

Fig.5 Inverter Operation for Positive Cycle

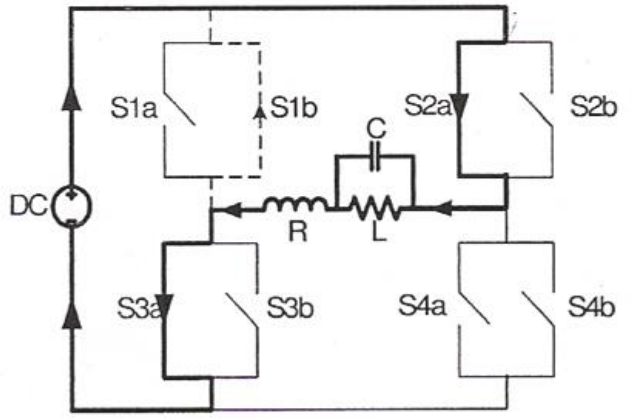

Fig.6 Inverter Operation for Negative Cycle

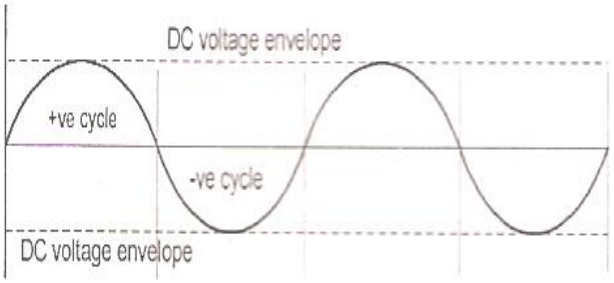

Fig.7 Sinusoidal Output Voltage

7. EXPERIMENTAL SETUPS AND RESULTS

The hardware developed is setup and tested on 1-ϕ, 230v, 50Hz AC supply on the load of 300 watt which has the ratings as given below; in power electronics laboratory. Results for different loads and speeds are shown in the following tables.

Table.1 Specifications

1.	Type of load	300 watt Tungsten Bulb
2.	Phase	Single
3.	Frequency	50 Hz
4.	Power	100 x 3 WATT
5.	Voltage	230 Volts
6.	Manufactured By	Philips

Inverter circuit is made up of four power MOSFETs each having snobber circuit to avoid the losses during on/off. This circuit is driven by driver circuit with an isolation circuit. Isolation circuit is necessary to make isolation between high voltage circuit (the inverter) and low voltage circuit (the control circuit)

Table.2 Experimental results for variable load

Battery Voltage (VBAT)	Load in Watts	Output Voltage (VOUT)	Output Current (IOUT) mA
11.0 V	100 W 200 W 300 W	200 V 190 V 180 V	260 mA 500 mA 790 mA
11.5 V	100 W 200 W 300 W	210 V 200 V 190 V	270 mA 520 mA 810 mA
12.0 V	100 W 200 W 300 W	220 V 219 V 215 V	280 mA 550 mA 830 mA

Gate Drives Output:

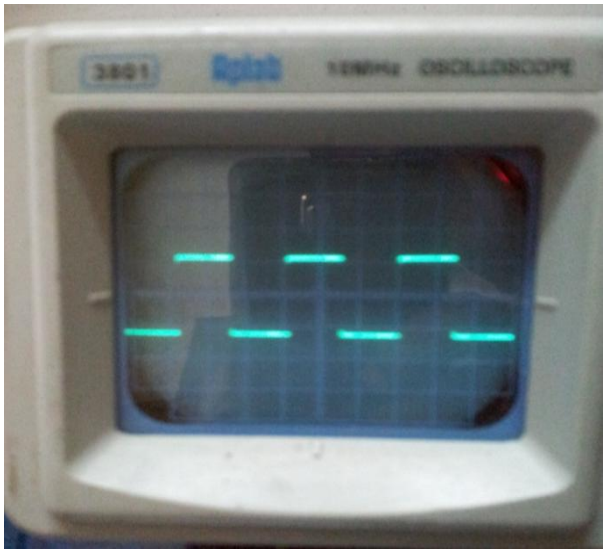

Fig.8 Gate Drive Output

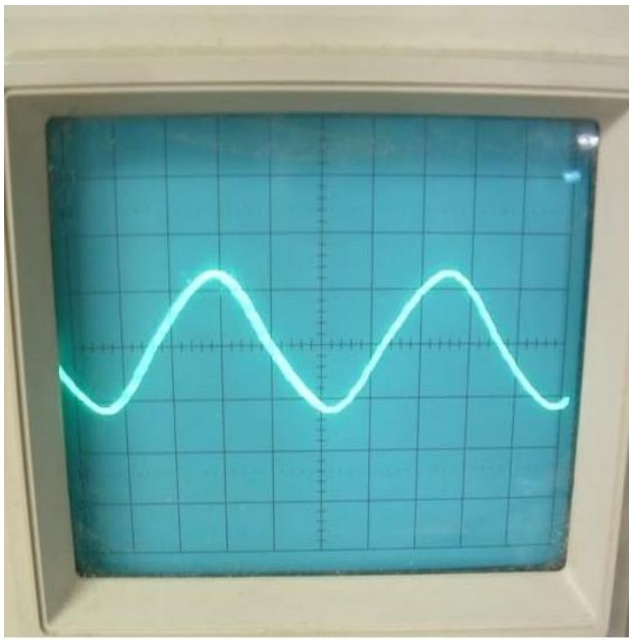

Fig.9 Equivalent Sinusoidal Output

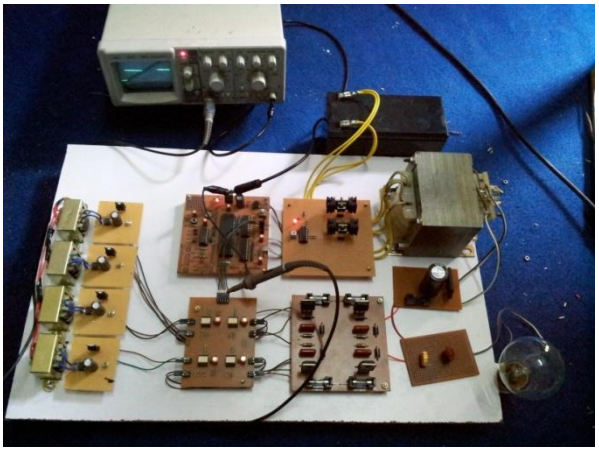

Fig.10 Photograph of Project Setup

8. CONCLUSIONS

The single phase matrix converter topology has been presented to operate as an uninterruptible power supply circuit. A single circuit is developed that perform both the rectifier and inverter operation which also incorporate active power filter. Selected experimental results are presented to verify that the proposed technique is feasible.

The H-bridge inverter transforms a dc input into an ac output. The pulses for the single phase matrix converter are generated using pulse width modulation technique. The proposed single matrix converter topology uses MOSFETs as a switching device. Single phase matrix converter topology is applied to maintain reliability and performance, good input power quality

as well as bidirectional energy flow. The various building blocks to the development of single phase matrix converter to an uninterruptible power supply circuit are presented. Hence, it has been verified with prominent results with different loads and speed, in which the load can be varied up to 300 Watts. Moreover the new topologies of matrix converter can be developed using sparse converter and z-source converter.

REFERENCES

[1] Venturini.M, "A New Sine Wave In Sine Wave Out Conversion Technique which Eliminates Reactive Elements", Proceedings Powercon 7, PP.E3-1-E3-15, 1980.

[2] Oyama, J., Higuchi, T., Yamada, E.Koga, T, and Lipo, T., "New Control Strategies of Matrix Converter", IEEE Power Electron Spec Conf. Rec., 1989, PP.360-367.

[3] Gyugyi, L and Pelly, B.R., "Static Power Chargers Theory, Perforemance and Application", John Wiley & Son Inc., 1976.

[4] Sobczyk, T, "Numerical Study of Control Strategies for Frequency Conversion with a Matrix Converter", Proceedings of Conference on Power Electronics and Motion Control, Warsaw, Poland, 1994, PP.497-502.

[5] Cho, J.G., and Cho. G.Hm "Soft-switched Matrix Converter for High Frequency Direct AC-to-AC Power Conversion", Int., J.Electron, 1992, 72, (4), pp.669-240.

[6] Zuckerberger, A., Weinstock, D., Alexandrovitz A, "Single Phase Matrix Converter", IEEE Proc., Electric Power App., Vol.144(4), Inl 1997, pp.235-240.

[7] Hosseini, S.H; Babari, E., "A New Generalized Direct Matrix Converter", Industrial Electronics, 2001., Proc. ISIE 2001, Vol.(2), 2001, pp.1071-1076.

[8] ZahiruddinIdris, Mustafar Kamal Hamzah& Ahmad Maliki Omar, "Implementation of Single Phase Matrix Converter as a Direct AC-AC Converter Synthesized using Sinusoidal Pulse Width Modulation Width Passive Load Condition", IEEE SixthInternational Conference PEDS 2005, Kaula Lumpur, Malaysia.

[9] SitiZaleha Mohammad Noor, Mastafar Kamal Hamzah& Ahmad FaridAbidin, "Modeling and Simulation of a DC Chopper using Single Phase Matrix Converter Topology", IEEE Sixth International Conference PEDS 2005, Kaula Lumpur, Malaysia.

[10] W.Edward Reid, "Power Quality Issues Standards and Guidelines", IEEE Pulp and Industry Technical Conference, Jun 1994.

[11] Jose Rodriguez, Marco Rivera, Johan W.Kolar and Patrick W.Wheeler, "A Review of Control and Modulation Methods forMatrixConverters", IEEE Transactions on IndustrialElectronics, Vol.59, NO.1, Jan 2012.

[12] Hong-Hee Lee and Hoang M.Nguyen, "A new Study on Indirect Vector AC Current Control Method using a Matrix Converter Fed Induction Motor",Journal of Power Electronics, Vol.6, No.1, Jan 2006.

[13] R.Dhivya, V.J.Sudhakar and R.Thilepa, "Single Phase Matrix Converter as a Frequency Changer with Sinusoidal Pulse Width Modulation using MATLAB", Int. Journal of Electronic & Electrical Engineering ISSN 0974-2174 Vol.4, No.2 (2011), pp.135-143.

[14] R.M. Anusuya& R.Saravanakumar, "Modeling and Simulation of aSinglePhase MatrixConverterwithReduce Switch Count as a Buck/boost Rectifier with Close Loop Control", Special Issue of Intl.Journal of Power Electronics, ISSN: 2231-0371., Vol.3, ISSN: 0975-7449.

[15] GennadilyZinoview and Leonid Zotov, "Matrix Converter with Voltage Transfer Ratio Greater than One", 17th Int.Conference on Electrical Drives and Power Electronics, The High Tatras, Slovakia, 28-30 Sept., 2011.

[16] G.N.Surya, Prof.S.Dutt, Dr.Valsson Varghese, "Matrix Converter", An Understanding (A Modular Approach to Design a Converter Suitable for Variable Frequency Power Supply Applications, Lokavishkar International E-Journal, ISSN: 2277-727X, Vol.1, Issue-1, Jan-2012.

[17] Wheeler, P.W.,Clare, J.C., Empringham, L., Bland M., Kerris, K.G., Matrix Converter",IEEEIndustryApplications Magazine, Vol.10, Jan-Feb. 2004, pp.59-65