

A High Power Factor Matrix AC to DC Converter

Using Atmega 32 as the Signal Generator

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Abstract - The matrix converter is a power converter which uses an array of bidirectional switches for power conversion. The single phase matrix converter consists of 2*2 array of switches and a three phase matrix converter consists of 3*3 array of switches. The rectifier mode of operation of matrix converter for RC load has been proposed earlier[1]. In the present work a simplified control strategy for a matrix converter using AVR controller as signal generator is explained. The simulation has been done in both MATLAB and PROTEUS and a complete hardware set up was also made to verify the operation. Finally a new switching strategy is being proposed to meet the RL load requirement.

Keywords - matrix converter, bidirectional switch, ATMEGA 32, unity power factor.

I. INTRODUCTION

The paper describes about a matrix converter which is operating at high power factor. For obtaining this power factor there should be a particular switching strategy. This switching algorithm is generated by using the advanced virtual RISC controller ATMEGA 32. The main feature of a matrix converter is the fully controllable four quadrant bidirectional switches. The main features that should be possessed by a power converter include fully controllable operation, high power factor operation and high frequency operation. All the features can be obtained by Matrix converters and so a large number of researches are being carried out in matrix converters. The matrix converters are used in so many applications including aerospace applications.

II. POWER FACTOR

While designing a power converter the important thing that should be considered is that it should operate in a high power factor. True power is the product of the rms values of voltages and currents in an ac circuit with a purely resistive load. But in case the circuit contains any inductive or capacitive components the actual power delivered by the circuit will be different from the true power. If the circuit contains inductive or capacitive components there will be a voltage drop across it, and it will withdraw some current also. So there will be energy absorption across the reactive components. Power factor

is the ratio of true power and apparent power. If the energy absorbed by the components is more than the apparent power (which is the sum of true power and reactive power) will be high and so the power factor will be low. So a low power factor means the circuit is withdrawing more current or the circuit's wiring has to carry more current. So power factor should be high at any cost. Here in both RL and RC load the care has to be taken to obtain high power factor operation [3].

III. MATRIX CONVERTER

The matrix converter consists of an array of bidirectional switches. Depends on the switching algorithm used the matrix converter can be used as an ac to ac converter or as an ac to dc converter. The main attractions of matrix converters are simple and compact power circuit, the possibility of obtaining unity power factor operation etc. The diagram for a matrix converter is shown in fig 1.

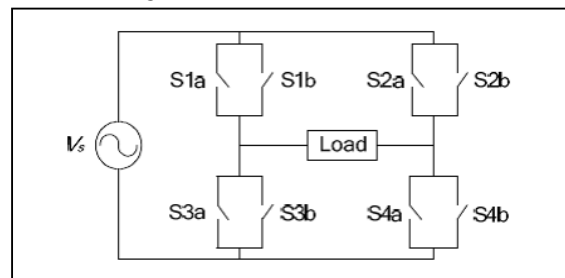


Fig.1

IV. ATMEGA32 CONTROLLER

Here the microcontroller which is used for controlling the switching algorithm is Atmega 32. It is a high performance 8 bit AVR microcontroller. It has advanced RISC architecture. It has two 8 bit timers with separate prescalars and compares modes. It has an internal calibrated RC oscillator. The operating voltage for Atmega 32 is 4.5 v to 5.5 v. The speed grade is in the range of 0 -16 MHz. The pin diagram of the microcontroller is shown in fig 2.

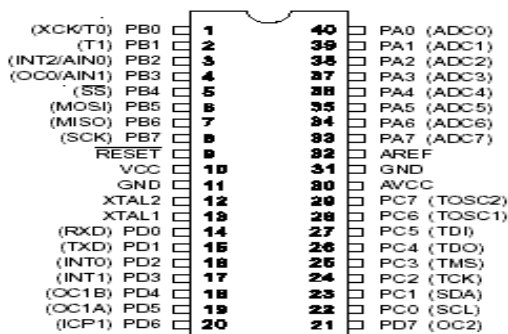


Fig. 2

V. RECTIFIER MODE OF OPERATION

a. RC load

The operation of the matrix converter as a rectifier is explained below. First RC load is considered. The switching algorithm is controlled by using avr controller Atmega 32. Refer the diagrams below[4].

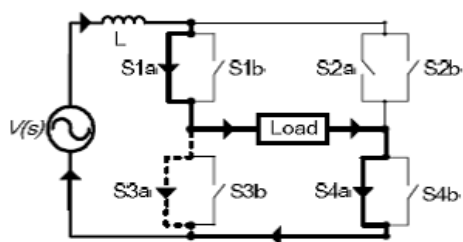


Fig. 3

The switches s1a and s3a will be turned on, then energy will be stored in the inductor. Then in positive cycle only s3a will be turned off and s4a will be turned on. Now the energy stored in the inductor gets discharged across the load. As phase detector output is given to s1a and s4a the charging and discharging of inductor occurs simultaneously with the start of each cycle. That is the input voltage will be in phase with the input current. Again in negative half cycle the same procedure repeats with s2b s4b and s3b. This switching

strategy is adopted from the reference paper only, but control method is modified by using AVR controller instead of pic microcontroller.

This type of switching can be used for RC load for obtaining high power factor. The new proposed strategy is for RL load. Most of the industrial loads which will affect the input power factor is of RL type. So considering a load of RL type will be very helpful.

A NEW SWITCHING STRATEGY

b. RL load

The new switching strategy for obtaining unity power factor operation in case of RL load is explained.

At first in the positive half cycle s1a and s3a will be turned on. Then s3a will be turned off and s4a will be turned on. Then as it is an inductive load even though s4a is turned off there will be some current which can cause damage if not treated properly. So in next step turn off s1a and s3 b will be turned on. The excess current will free wheel through s3b and s4a and will come to zero at the end of positive cycle. In negative cycle now turn on s1b as s3 b is already in on energy will be stored in the inductor through s3b and s1b. Now s1b is turned off and s2 b will be turned on so that the stored energy get discharged across the load. Next s3 b will be turned off and s1a will be turned on so that the excess current will freewheel through s1a and s2b. Again the same switching strategy will be repeated in next positive half cycle and so on.

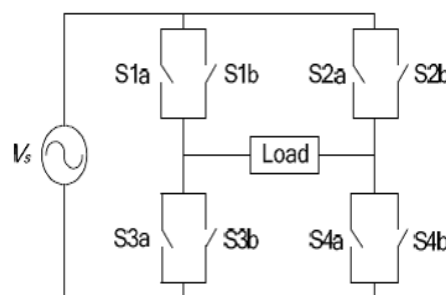


Fig. 4

The detailed switching sequence and pulse diagram is given below.

• POSITIVE HALF CYCLE

SWITCH	S1A	S1B	S2A	S2B	S3A	S3B	S4A	S4B
MODE 1	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF
MODE 2	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF
MODE 3	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF

NEGATIVE HALF CYCLE

SWITCH	S1A	S1B	S2A	S2B	S3A	S3B	S4A	S4B
MODE 1	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF
MODE 2	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF
MODE 3	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF

VI. SIMULATION ,HARDWARE SET UP AND RESULTS

The existing switching strategy is verified using MATLAB software and also a hardware prototype was developed to verify the performance using Atmega 32 microcontroller.

Hardware prototype picture

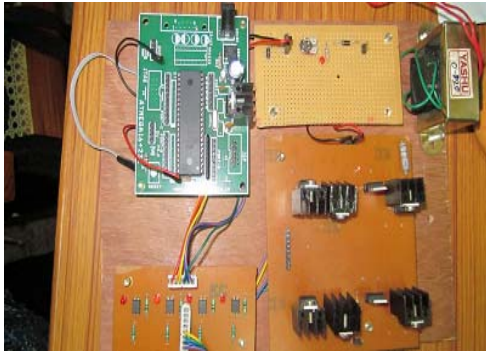


Fig. 5

By using this hardware set up, a dc voltage across the load was obtained. Also the input voltage and current will be in phase.

Simulation circuit

The simulation is done in MATLAB software and given below. In the scope a dc voltage is obtained across the load.

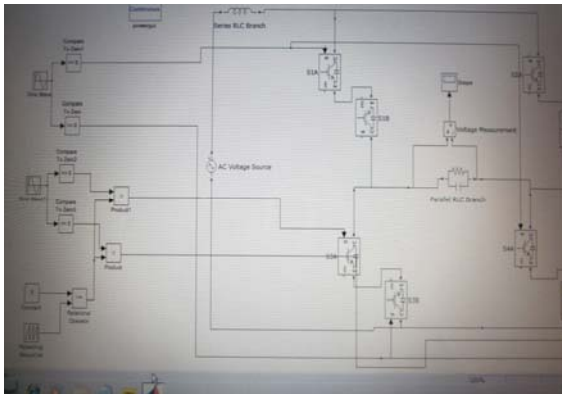


Fig. 6

RESULTS OBTAINED

Input voltage AC	20 v
Output voltage DC	39.6 v
Switching frequency	5 kHz
Boost Inductor	3 mH
MOSFET	STP55NF06

VII.CONCLUSION

From the above discussion it is clear that a high power factor matrix ac to dc converter for RC load can be easily made by using ATMEGA 32 controller .Further verifications are required in the new proposed switching strategy for RL load as hardware prototype is yet to be done. In future the work may be extended by confirming the switching strategy for RL load both by simulation and hardware prototype. More attention has to be given in developing more powerful bidirectional switches.

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