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Modeling of Single Phase Matrix Converter Using Matlab

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ABSTRACT:This paper presents a modellingapproach for a single-phase matrix converter using Matlab/Simulink. Matrix converters have gained popularity in recent years as an alternative to traditional converters due to their ability to eliminate bulky DC-link capacitors and their high-frequency switching capabilities. However, the modelling of matrix converters can be complex due to their bidirectional power flow and the non-linear nature of the switches. In this study, the matrix converter is modelled using the space vector modulation technique, which simplifies the analysis and allows for efficient control of the converter. The simulation results show the effectiveness of the proposed model in generating sinusoidal output voltage and current with low total harmonic distortion. Furthermore, the model is validated experimentally using a prototype converter, and the results confirm the accuracy of the proposed simulation model. The proposed modelling approach can serve as a useful tool for designing and optimizing single-phase matrix converters in various applications.

KEYWORDS:- Single-phase matrix converter, Space vector modulation, Bidirectional power flow, High-frequency switching, Prototype converter, Simulation model, Experimental validation, Converter design

I. INTRODUCTION

A matrix converter is an electrical power converter that can convert AC power from one frequency to another and change the voltage and current level without the use of any bulky transformers. It uses a matrix of semiconductor switches to connect the input AC power to the output AC power in a controlled manner.

The matrix converter can perform bi-directional power flow, which means it can operate as an AC-to-AC converter and as an AC-to-DC converter. It can also operate at variable frequencies and voltages, making it a versatile power conversion solution for a wide range of applications.

The matrix converter is a relatively new technology and is still being researched and developed. It has the potential to provide more efficient, compact, and flexible power conversion solutions than traditional power converters, especially in applications where space and weight are critical factors, such as in aerospace and automotive industries.

However, the matrix converter has some challenges, such as complex control algorithms, high semiconductor switching losses, and low power factor. Despite these challenges, it is expected to play an important role in future power conversion systems.

A matrix converter typically consists of a matrix of semiconductor switches arranged in a specific configuration to allow for bidirectional power flow between the input and output. The switches are controlled by a complex algorithm to create the desired output waveform.

There are several circuit topologies for matrix converters, but one of the most common is the direct matrix converter. In a direct matrix converter, the input AC power is connected to the output AC power through a matrix of bidirectional switches, such as IGBTs or MOSFETs. The matrix consists of nine switches that are arranged in a three-phase bridge configuration, where each phase is connected to the input and output power.

The switching of the semiconductor devices is controlled by a complex algorithm that ensures the output voltage and frequency are controlled precisely. The control algorithm typically uses pulse width modulation (PWM) techniques to generate the desired output waveform.

The circuit diagram of a direct matrix converter consists of three sets of three-phase bridges, each set consisting of nine switches. The AC input power is connected to one set of switches, and the AC output power is connected to another set of switches. The third set of switches is used to control the flow of power between the input and output, depending on the required output waveform.

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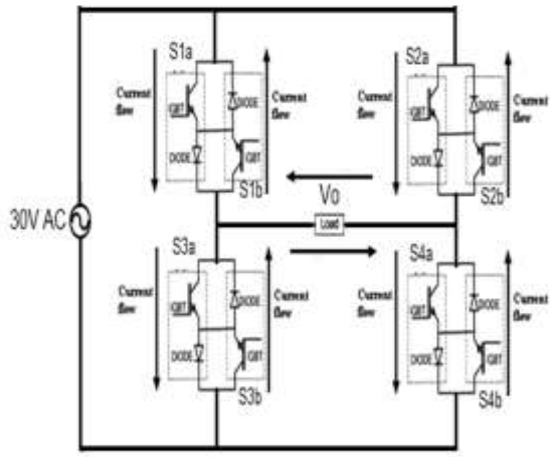
The circuit of a matrix converter consists of a matrix of semiconductor switches arranged in a specific configuration, controlled by a complex algorithm to create the desired output waveform. The circuit topology and the control algorithm depend on the specific requirements of the application.

TheSingle-Phase Matrix Converter consists of a matrix of input and output lines with four bidirectional switches connecting the single-phase input to the single-phase output at the intersections. Nowadays, there is no bidirectional switch semiconductor that has the capability of blocking voltage and conducting current in both directions available in the market that is required for the application of the matrix converter. However, as in Figure, in order to fulfill the requirement, two

Fig.1 Four Quadrant operation of Matrix Converter



Operation		
Switches	Positivecycle(State1)	Negativecycle (State2)
S1a	ON	OFF
S1b	OFF	ON
S2a	OFF	ON
S2b	ON	OFF
S3a	OFF	OFF
S3b	OFF	OFF
S4a	SPWM	OFF
S4b	OFF	SPWM

Fig.2 SEQUENCE OF SWITCHING CONTROL

II. SPMC AS AC VOLTAGE CONTROLLER

A matrix converter can be used as an AC voltage controller by controlling the output voltage

IGBTs are used back to back that functions as bidirectional switch for the matrix converter.

It is common emitter anti-parallel IGBTs with diode pair. Diodes are used to provide reverse blocking capability of the switch itself. The IGBT is popularly used since its high speed switching capabilities and high current carrying capacity desirable amongst researchers for high power application. In SPMC, there would be four bidirectional switches required. During positive cycle of the input source, S1a and S2b will be maintained in ON state. Here, S4a is the controlling switch to synthesize the PWM pattern. S1a to complete the loop for the SPWM return and act in conjunction with S2b to provide freewheel operation whenever S4a in turned OFF.

waveform. The matrix converter can provide a variable output voltage with a fixed frequency, making it suitable for applications where precise control of voltage is required.

To control the output voltage of a matrix converter, the switching pattern of the semiconductor switches in the matrix varies by changing the switching pattern, the shape of the output voltage waveform can be altered to produce the desired output voltage. This is typically achieved by using a complex control algorithm that generates a specific switching pattern for the semiconductor switches.

In AC voltage control applications, the matrix converter can provide several advantages over traditional voltage controllers, such as reduced size and weight, improved efficiency.

SNO.	PWMdutycycle	AC Voltage,Volts
1.	10%	2.3
2.	20%	6.3
3.	50%	13.4
4.	80%	23.7

Fig.3 Experimental results of SPMC as AC Voltage Controller

A matrix converter can be used as an AC voltage controller by controlling the output voltage waveform through the switching pattern of the semiconductor switches.

The use of a matrix converter as a rectifier can provide several advantages over traditional rectifiers, such as reduced size and weight, improved efficiency, and higher power density. However, the control algorithm for the matrix converter can be more complex than that of

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traditional rectifiers, and the semiconductor switches can have higher switching losses, leading to lower efficiency.

III. SPMC AS RECTIFIER

A matrix converter can also be used as a rectifier to convert AC power into DC power. In this application, the matrix converter can provide bi-directional power flow, allowing for energy storage and recovery.

To use a matrix converter as a rectifier, the input AC power is connected to one set of the semiconductor switches in the matrix, and the output DC power is connected to another set of switches. The control algorithm for the matrix converter is designed to generate the appropriate switching pattern to convert the AC input power into the desired DC output waveform.

The use of a matrix converter as a rectifier can provide several advantages over traditional rectifiers, such as reduced size and weight, improved efficiency, and higher power density. However, the control algorithm for the matrix converter can be more complex than that of traditional rectifiers, and the semiconductor switches can have higher switching losses, leading to lower efficiency.

Overall, a matrix converter can be used as a rectifier to convert AC power into DC power. This application can provide several advantages over traditional rectifiers, but it requires a complex control algorithm and can have higher switching losses.

S.No	PWM duty cycle	DC Voltage,V
1.	10%	1.6
2.	20%	5.2
3.	50%	10
4.	75%	16.6
5.	90%	21

Fig.4 Experimental results of SPMC as Rectifier

IV. SPMC AS CYCLO CONVERTER

A matrix converter can also be used as a cycloconverter to convert AC power of one frequency to AC power of another frequency. In this application, the matrix converter can provide bi-directional power flow, allowing for energy storage and recovery.

To use a matrix converter as a cyclo converter, the input AC power of one frequency is connected to one set of the semiconductor switches in the matrix, and the output AC power of another frequency is connected to another set of switches. The control algorithm for the matrix converter is designed to generate the appropriate switching pattern to convert the input AC power of one frequency into the desired output AC power of another frequency.

However, the control algorithm for the matrix converter can be more complex than that of traditional cyclo converters, and the semiconductor switches can have higher switching losses, leading to lower efficiency.

Overall, a matrix converter can be used as a cyclo converter to convert AC power of one frequency to AC power of another frequency. This application can provide several advantages over traditional cyclo converters, but it requires a complex control algorithm and can have higher switching losses.

S.No	PWMdutycycle	AC Voltage, Volts
1.	10%	2.17
2.	20%	5.47
3.	50%	12.8
4.	75%	19
5.	90%	24

Fig.5 Experimental results of SPMC as CycloConverter

V. SIMULATION CIRCUIT AND RESULTS

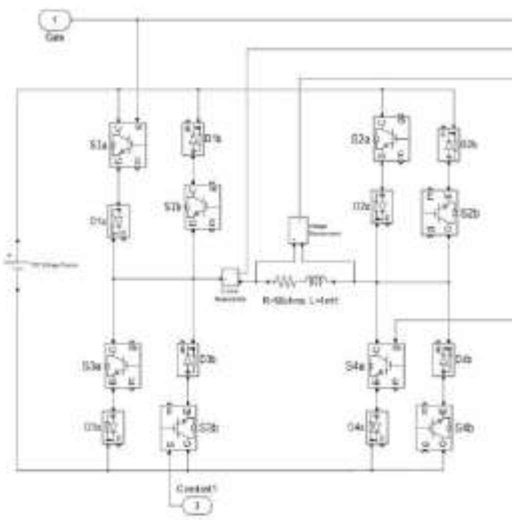

Fig 6.Simulation Circuit for SPMC in First Quadrant

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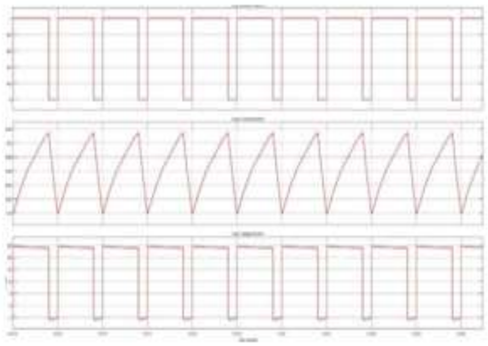

Fig 6a.Simulation output for SPMC in First Quadrant

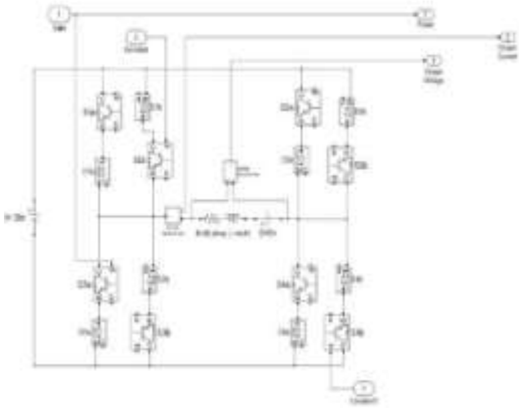

Fig 7.Simulation Circuit forSPMC inSecond Quadrant

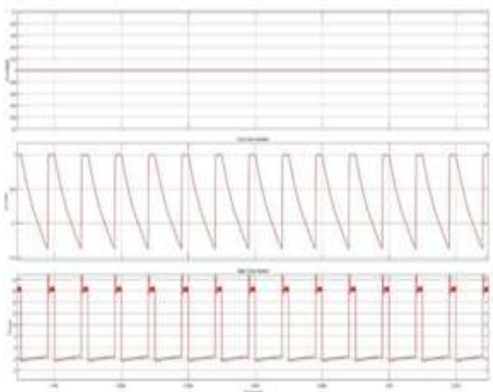

Fig 7a.Simulation output for SPMC in Second Quadrant

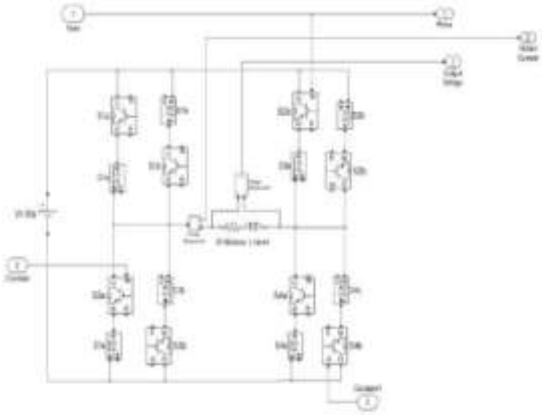

Fig 8.Simulation Circuit for SPMC in Third Quadrant

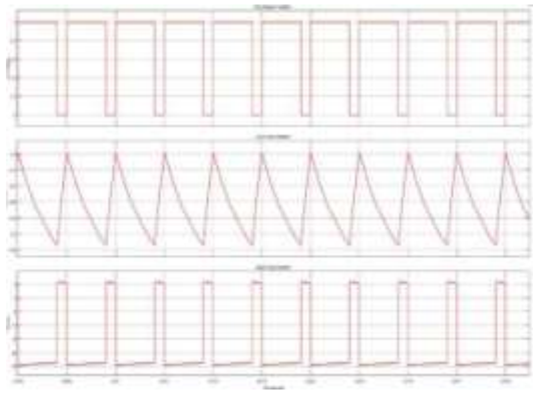

Fig 8a.Simulation output for SPMC in Third Quadrant

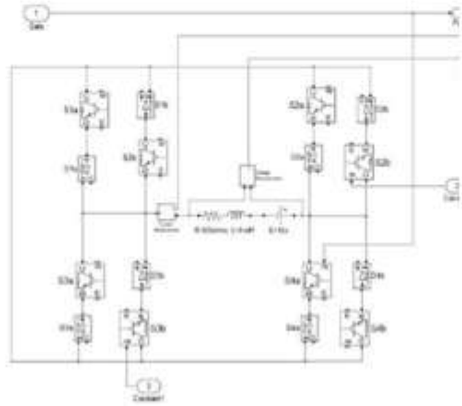

Fig 9.Simulation Circuit for SPMC in Fourth Quadrant

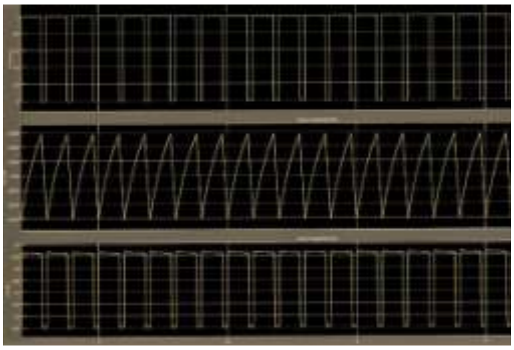

Fig 9a.Simulation output for SPMC in Fourth Quadrant

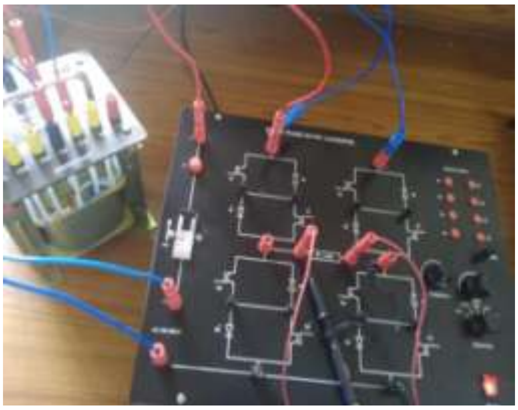

Fig 10. **Experimental Setup for SPMC**

VI. CONCLUSION

The single-phase matrix converter, the simulation model developed using MATLAB can be used to investigate the converter's behavior, analyze its performance, and optimize its design parameters. The results of the simulation can provide insights into the converter's efficiency, power quality, and harmonic distortion. Four quadrant operation of single phase matrix converter is tested practically and compared with simulation results obtained.

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