Single Phase Matrix Converter with Harmonic Injection PWM Technique

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Abstract- Power Electronics is the art of converting electrical energy from one form to another in an Efficient, clean, compact, and robust manner for convenient utilisation Efficient power conversion is one of the important areas of research in power electronics. There are various power converters that perform the required Power conversion namely rectifiers, inverters, voltage regulators, choppers and cyclo-converters. The various converters require different configuration to achieve the desired power. This paper describes the application of single – phase matrix converter that performs all the above stated power conversions using a single circuit. Different modulation techniques can be employed to a single phase matrix converter for generating the required pulses. The objective of this paper is to implement and compare trapezoidal pulse width modulation technique (TPWM) and sinusoidal pulse width modulation techniques (SPWM) to a single phase matrix converter in order to achieve required power conversion. Simulation is carried out using Matlab/Simulink.

Keywords – SPMC, PWM, PWM, TPWM, SPWM

I. INTRODUCTION

The task of a power converter is to process and control the flow of electric energy by supplying voltages and currents in a form that is optimally suited for the user loads. The term “Converters” is used to refer a system which transforms one form of electrical energy into another form of electrical energy. The power conversion systems can be classified according to the type of the input and output power. Mainly converters are classified as ac voltage regulators, rectifiers, inverters, choppers, step-up cyclo-converter and step-down cyclo inverters, these converters finds industrial applications. Pulse width modulation (PWM) is one of the techniques used in power electronic converters. This is the most preferred method since PWM offers many advantages PWM techniques are characterized by constant amplitude pulses. The width of these pulses is however modulated to obtain output voltage control and to reduce its harmonic content. The different PWM techniques are Single-pulse modulation, multiple pulse modulation and Sinusoidal pulse width modulation, Trapezoidal pulse width Modulation, Staircase pulse width Modulation, Stepped Modulation, Harmonic Injected Modulation, Delta Modulation.

II. SINGLE PHASE MATRIX CONVERTER

The application of single- phase matrix converter that performs all the above stated power conversions using a single circuit which uses four bidirectional switches, each capable of conducting current in both directions, blocking forward and reverse voltages and are so arranged such that input terminals can be connected to output terminals in a matrix manner. To block the voltage and conduct current in both directions, common emitter anti-parallel IGBT is used. The basic circuit of single phase matrix converter that requires four bi-directional switches as shown below fig.1.

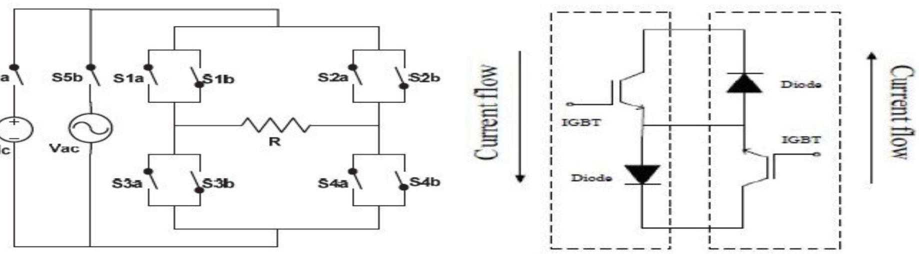

Fig. 1. Basic circuit of single phase matrix converter and Diode Pair

Unfortunately there is no discrete semiconductor device currently that could fulfil the needs and hence we use common emitter anti-parallel IGBT, diode pair as shown in Fig.1.

SPMC AS AC VOLTAGE REGULATOR

These converter circuits convert fixed ac voltage directly to a variable ac voltage at the same frequency Output voltage is controlled by varying the firing angle delay During positive half cycle switches S1a and S4a turn ON to give positive output voltage, during negative half cycle switches S1b and S4b turn ON to give negative output voltage

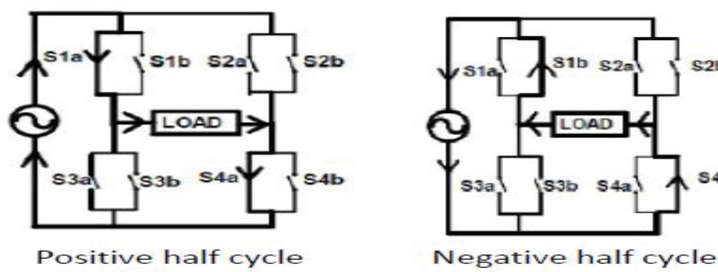

Fig. 2. SMPC as AC Voltage Regulator

SPMC AS RECTIFIER

Rectifier, converts constant AC voltage to variable dc voltage by controlling switches. During positive half cycle switches S1a and S4a turn ON to give positive output voltage, during negative half cycle switches S2b and S3b turn ON to give positive output voltage respectively

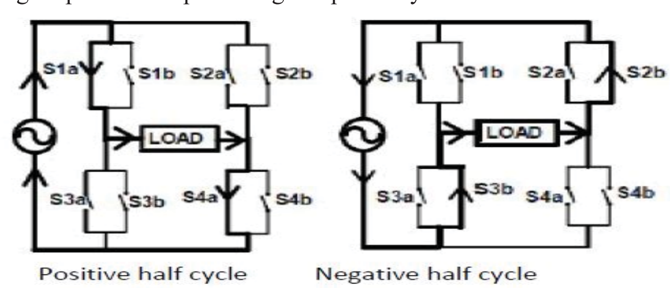

Fig. 3. SMPC as Rectifier

SPMC AS INVERTER

Inverter converts constant DC voltage into AC voltage of required frequency by controlling switches**.** During positive half cycle switches S1a and S4a turn ON to give positive output voltage, during negative half cycle switches S2a and S3a turn ON to give negative output voltage respectively as shown in the fig below

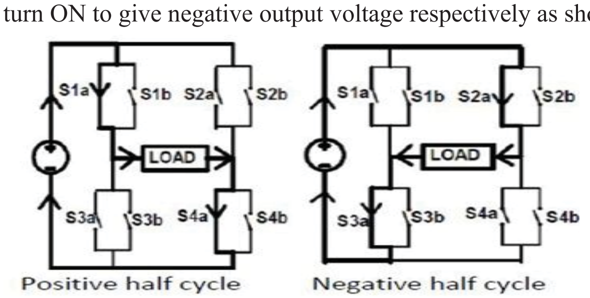

Fig. 4. SMPC as Inverter

SPMC AS STEPDOWN CYCLOCONVERTER

Step down Cycloconverter converts constant frequency AC to variable frequency AC of a lower frequency by synthesizing the output waveform from segments of the AC supply. During positive input cycle to obtain positive output voltage switches S1a, S4a turn ON, during negative input cycle to obtain positive output voltage switches S2b, S3b turn on, during positive input cycle to obtain negative output voltage switches S2a, S3a turn ON, during negative input cycle to obtain negative output voltage switches S1b,S4b turn ON

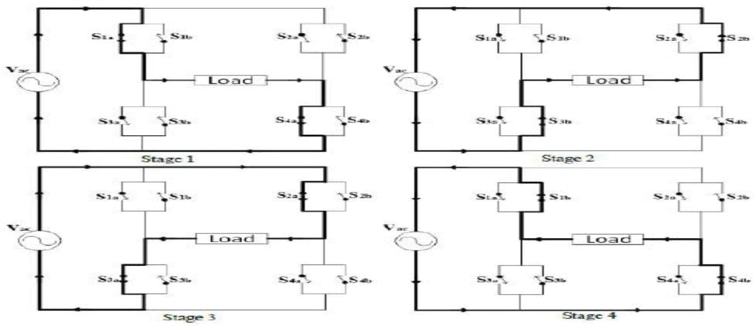

Fig. 5. SMPC as Cyclo Converter

SPMC AS STEPUP CYCLOCONVERTER

Step up cycloconverter converts constant frequency AC to variable frequency AC of a higher frequency by synthesizing the output waveform from segments of the AC supplyDuring positive input cycle to obtain positive output voltage switches S1a, S4a turn ON, during positive input cycle to obtain negative output voltage switches S2b, S3b turn on, during negative input cycle to obtain negative output voltage switches S2a, S3a turn ON, during negative input cycle to obtain negative output voltage switches S1b,S4b turn ON

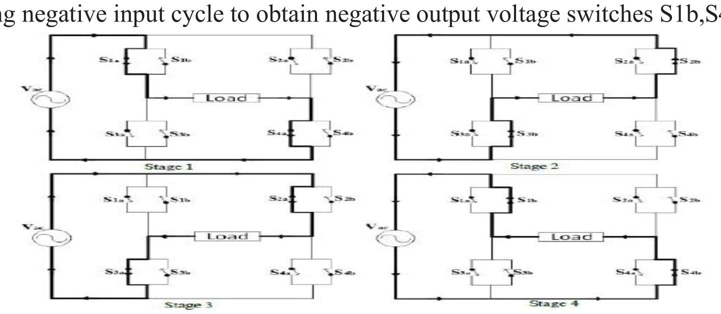

Fig. 6. SMPC as Step Up Cyclo Converter

SPMC AS CHOPPER

Chopper converts a constant DC voltage to variable DC voltageIn the chopper operation output is synthesizing by using MPWM scheme.The required voltage can be obtained by controlling duty cycle. Positive output switches S1a and S4a turn ON respectively

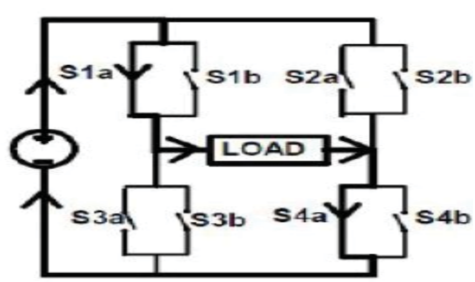

Fig. 6. SMPC as Chopper

III. SPMC AS ALL IN ONE CONVERTER

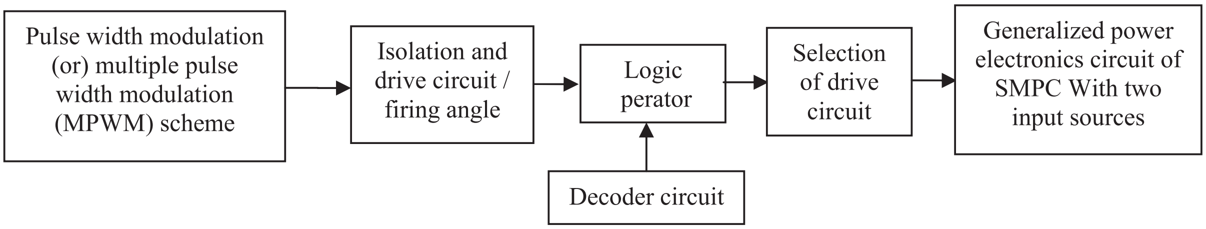

Fig. 7. Block Diagram of SMPC as all in one converter

DECODER CIRCUIT

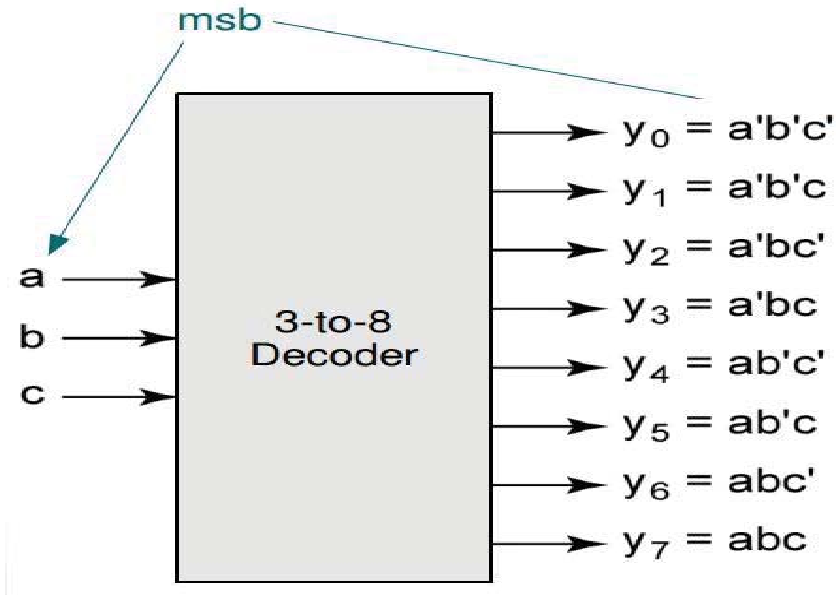

Fig. 8. Decoder Circuit

IV. SWITCHING TECHNIQUES

1. SINUSOIDAL PULSE WIDTH MODULATION

By comparing a triangular carrier wave (Vc) with a reference sinusoidal wave (Vr), the switching instance to semiconductor devices are generated. If Vr>VC positive pulses are generated and if Vr<VC negative pulses are generated as shown in the fig below

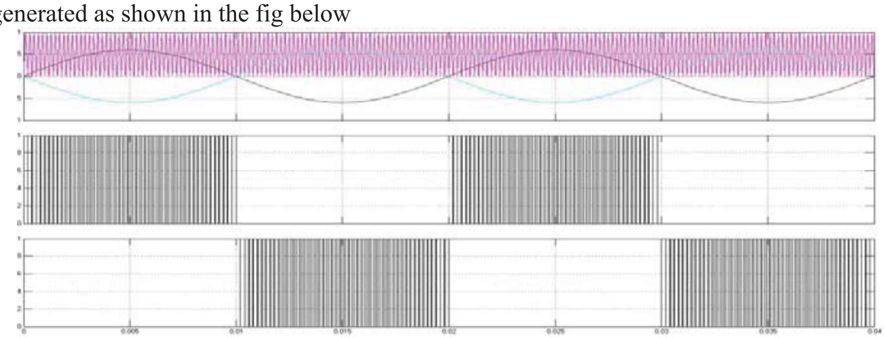

Fig. 9. Wave form of Sinusoidal Pulse Width Modulation

2. HARMONIC INJECTION PULSE WIDTH MODULATION

By comparing a triangular carrier wave (Vc) with a reference third harmonic injection wave (Vr), the switching instance to semiconductor devices are generated. If Vr>VC positive pulses are generated and if Vr<VC negative pulses are generated as shown in the fig below

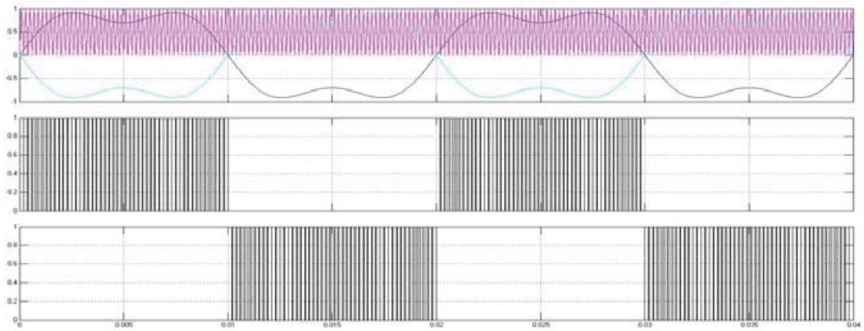

Fig.10. Wave form of Harmonic Injection Pulse Width Modulation

Table.1. INPUT PARAMETERS

Input source	50Hz, 230V,230V DC
Carrier frequence	5kHz
Modulation index	0.5
Load	R = 50 0hm

Table.2. THD ANALYSIS FOR DIFFERNT KINDS OF PWM TECHNIQUES

CONVERTER OPERATION	SINUSOIDAL PWM	Harmonic injection
AC VOLTAGE REGULATOR	20.13	11.08
INVERTER	45.91	10.16
STEPUP CYCLOCONVERTER	31.33	32.71
STEPDOWN CYCLOCONVERTER	78.66	64.72

V. SIMULATION RESULTS

1. OUTPUT WAVEFORM FOR AC VOLTAGE REGULATOR FOR FIRING ANGLE ZERO & 30^0

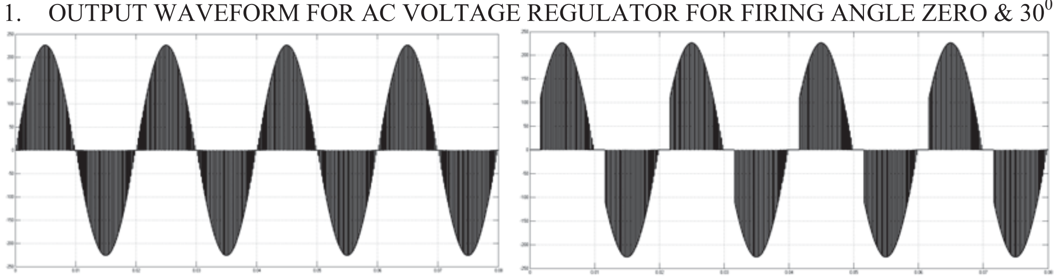

Fig. 11. Output Waveforms of AC Voltage Regulator for 00 and 300 firing angles

2. OUTPUT WAVEFORM FOR RECTIFIER FOR FIRING ANGLE ZERO & 30^0

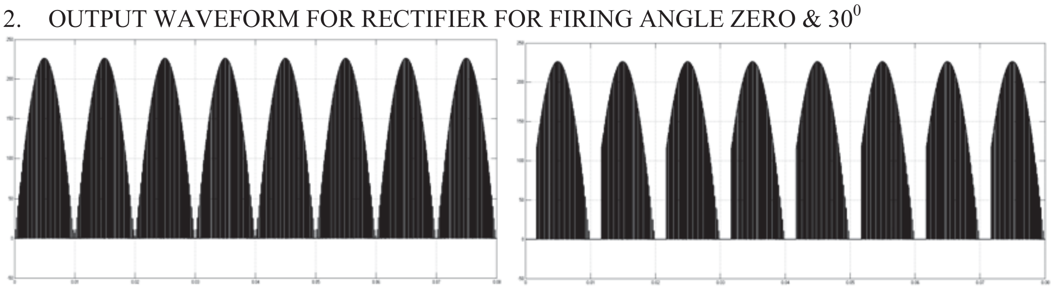

Fig. 12. Output Waveforms of Rectifier for 00 and 300 firing angles

3. OUTPUT WAVEFORM FOR INVRTER FOR FIRING ANGLE ZERO & 30^0

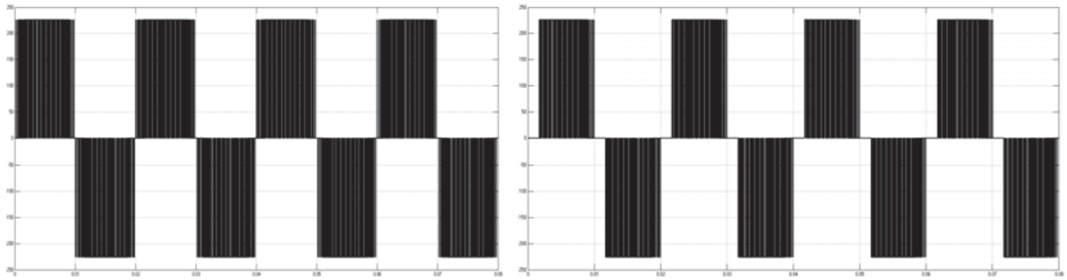

Fig. 13. Output Waveforms of Inverter for 00 and 300 firing angles

4. OUTPUT WAVEFORM FOR STEP DOWN CYCLOCONVERTER FOR FIRING ANGLE ZERO & 30^0

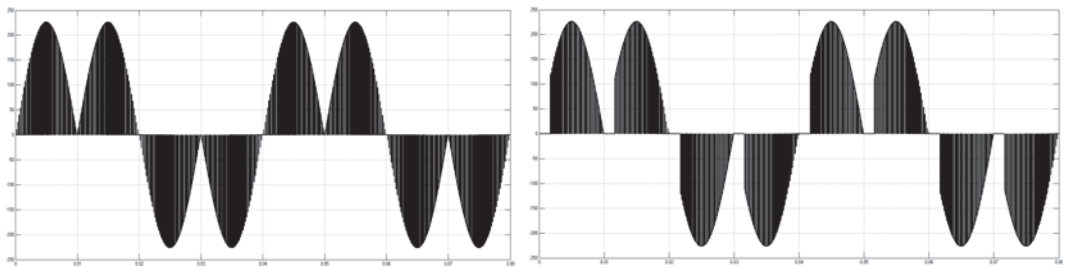

Fig. 14. Output Waveforms of Step Down CycloConverter for 00 and 300 firing angles

5. OUTPUT WAVEFORM FOR STEP UP CYCLOCONVERTER FOR FIRING ANGLE ZERO & 30^0

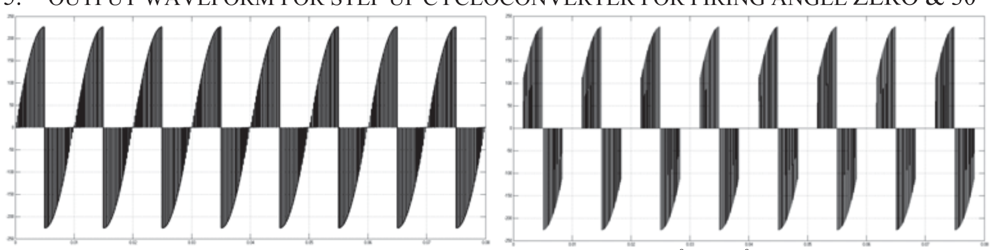

Fig. 15. Output Waveforms of Step Up Cycloconverter for 0^0 and 30^0 firing angles

6. OUTPUT WAVEFORM FOR STEP CHOPPER ONE QUADRANT OPERATION

Fig. 16. Output Waveforms of Step Chopper one Quadrant Operation

VI. FFT ANALYSIS

STEPUP CYCLOCONVERTER STEPDOWN CYCLO CONVERTER

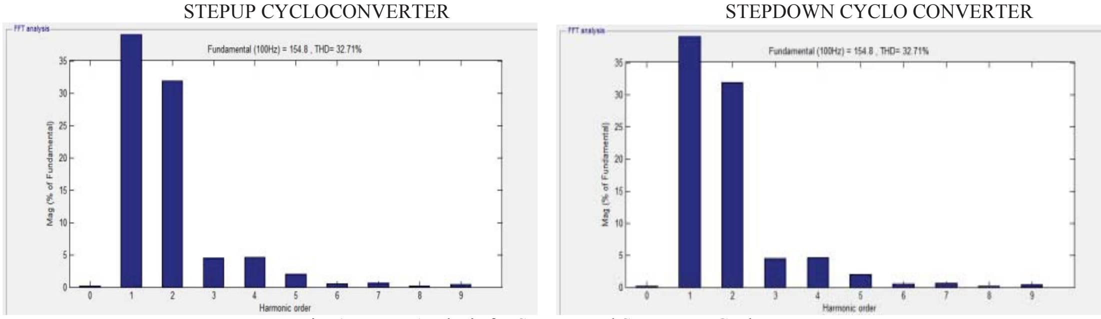

Fig. 17. THD Analysis for Step Up and Step Down Cycloconverter

INVERTER AC VOLTAGE REGULATOR

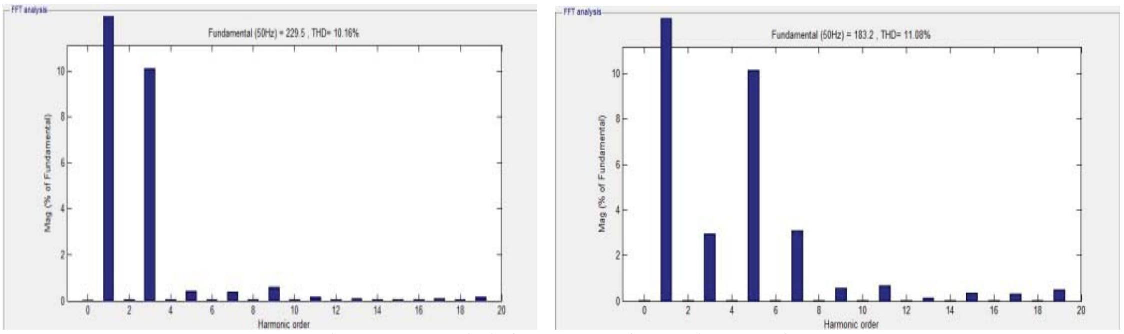

Fig. 18. THD Analysis for Inverter and AC Voltage Regulator

VII. CONCLUSION

By using single phase matrix converter conversions like rectification, inversion, voltage regulation and dc-dc are employed in single circuit. A comparison is done between sinusoidal pulse width modulation and harmonic injection pulse width modulation. Simulation results clearly indicate that peak output voltage obtained is more in harmonic injection PWM when compared with SPWM.

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