Single Phase Cycloconverter Based on Matrix Converter Topology

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Abstract— This paper presents a new strategy single-phase Cycloconverter. In this strategy, Single phase cycloconverter generates half, one third and one fourth times of the input frequency using matrix converter topology. A cycloconverter is a device that converts AC, power at one frequency into AC power of an adjustable but lower frequency without any direct current, or DC, stage in between. It can also be considered as a static frequency changer. Single-phase Cycloconverters are used for AC-AC power conversion particular for speed control of AC drives. In this work the Single-phase matrix converter (SPMC) topology is used for cycloconverter operation are proposed. IGBTs are used for the power switches. The well-known sinusoidal pulse width modulation (SPWM) scheme is used in this instance.

Key words: Cycloconverter, Single Phase matrix converter, sinusoidal pulse width modulation (SPWM), Matlab /Simulink

I. INTRODUCTION

In a cycloconverter, the ac power at one frequency is converted directly to another frequency generally lower than the input supply frequency without any intermediate dc stage. In the 1970's, various aspects of the cycloconverter theory and practice were discussed In the late 1980's (1986) implementations on cycloconverter, experienced growth in usage due to the development of microprocessor based control systems. Thyristor controlled cycloconverter today, has found its way in higher power applications such as in electric traction, rolling mills, variable frequency speed control for AC machines, constant frequency power supply and controllable reactive drives where the frequency of the output voltage is lower than the frequency of the mains network voltage[2].

Cycloconverter are a historical class of power converters based on SCRs. They are used to generate AC output (single- phase or three-phase) from a single-phase or three-phase input. A typical cycloconverter consists of one or more pairs of back-to-back connected controlled rectifiers as shown in Fig 1. Cycloconverter uses two separate converters called the P-converter and the N-converter; each performing similar to an H-bridge inverter [1].

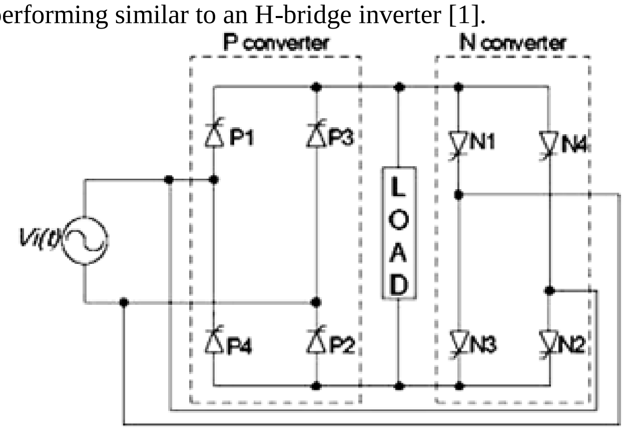

Fig. 1: single-phase cycloconverter

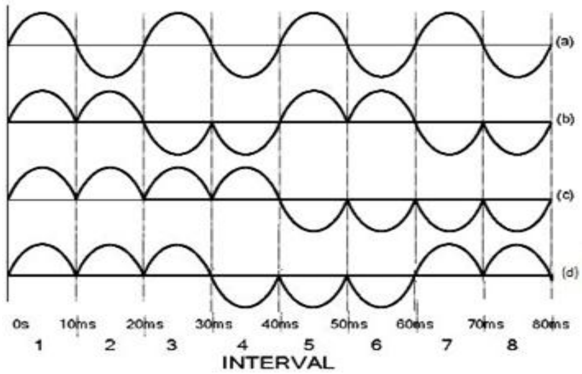

Fig. 2: Cycloconverter Operation (a) input 50 Hz (b) output 25Hz (c) output 12.5 Hz (d) output 16.66 Hz

II. SINGLE PHASE MATRIX CONVERTER (SPMC)

The matrix converter (MC) offers possible "all silicon" solution for AC-AC conversion, removing the need for reactive energy storage components used in conventional rectifier-inverter based system.

The SPMC topology with its 4 bi-directional switches and its individual power switches; used in this work is as shown in Figs. 3 and 4 respectively; In comparison the SPMC requires 4 bi-directional switches as illustrated in above Fig.4. For its cycloconverter implementation. It requires the use of bidirectional switches capable of blocking voltage and conducting current in both directions. Unfortunately there is no discrete semiconductor device currently that could fulfil the needs and hence the use of common emitter anti-parallel IGBT, diode pair as shown in Fig. Diodes are in place to provide reverse blocking capability to the switch module. The IGBT were used due its high switching capabilities and high current carrying capacities desirable amongst researchers for high-power applications

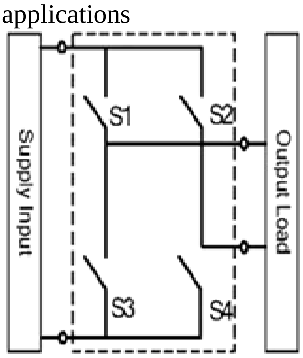

Fig. 3: Schematic of SPMC

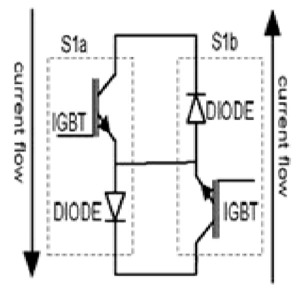

Fig. 4: Bidirectional Switch

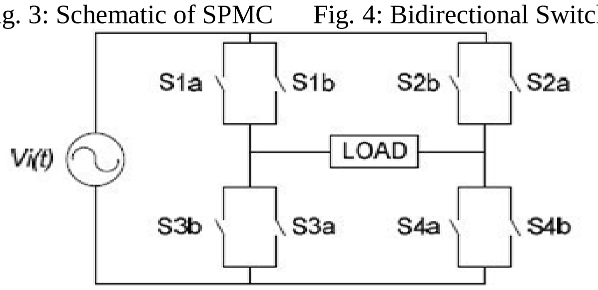

Fig. 5: Circuit Diagram

III. SINUSOIDAL PULSE WIDTH MODULATION (SPWM)

The well-known SPWM used in power electronics are as illustrated in Fig.5. A high frequency triangular carrier signal, Vc, is compared with a sinusoidal reference signal, Vref, of the desired frequency. The crossover points are used to determine the switching instants. The magnitude ratio of the reference signal (Vref) to that of the triangular signal (Vc) is known as the modulation index (mi). The magnitude of fundamental component of output voltage is proportional to mi. The amplitude Vc of the triangular signal is generally kept constant. By varying the modulation index, the output voltage could be controlled.

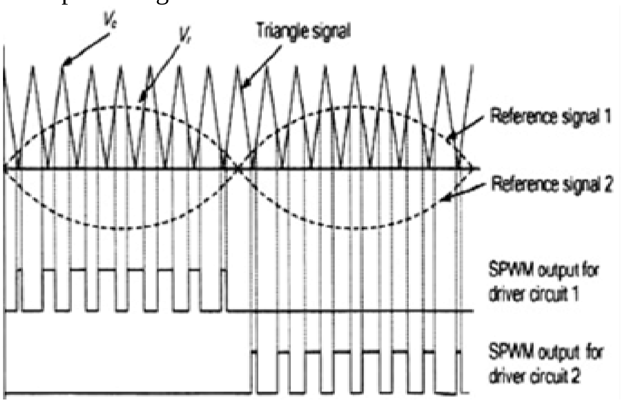

Fig. 6: Typical SPWM

IV. CONTROL STRATEGY

Implementation of SPMC as a cycloconverter requires different bi-directional switching arrangements depending on the desired output frequency. The magnitude of the output voltage is controlled by SPWM, but the frequency of the output depends on the switching algorithm. In this work the input frequency of power supply used is set at 50 Hz and desired output frequency synthesized at the 25 Hz ,12.5 and 16.66 Hz The switching sequences are dependent on the state of the driver circuit following table 1 (for one cycle).

The switching angle of the 4 bi-directional switches S_{ij} (i = 1,2,3,4 and j = a,b) where ‘a’ and ‘b’ represent driver one and two respectively following the rules below;

At any time‘t’, any two switches S_{ij} below will be ON;

- (i = 1, 4 and j = a) will conduct the current flow during positive cycle of input source. (state 1)
- (i = 1, 4 and j = b) will conduct the current flow during negative cycle of input source. (state 2)
- (i = 2, 3 and j = b) will conduct the current flow during positive cycle of input source. (state 3)
- (i = 2, 3 and j = a) will conduct the current flow during negative cycle of input source. (state 4)

Input Frequency	Desired Output Frequency	Time Interval	State	“ON” Switch
50Hz	25Hz	1	1	S1a and S4a
		2	4	S2a and S3a
		3	3	S2b and S3b
		4	2	S1b and S4b
	12.5Hz	1	1	S1a and S4a
		2	4	S2a and S3a
		3	1	S1a and S4a
		4	4	S2a and S3a
		5	3	S2b and S3b
		6	2	S1b and S4b
		7	3	S2b and S3b
		8	2	S1b and S4b
	16.66Hz	1	1	S1a and S4a
		2	2	S1b and S4b
		3	1	S1a and S4a
		4	4	S2a and S3a
		5	3	S2b and S3b
		6	4	S2a and S3a

Table 1: Sequence of Switching Control

V. SIMULATION AND RESULTS

A. *SPWM Subsystem:*

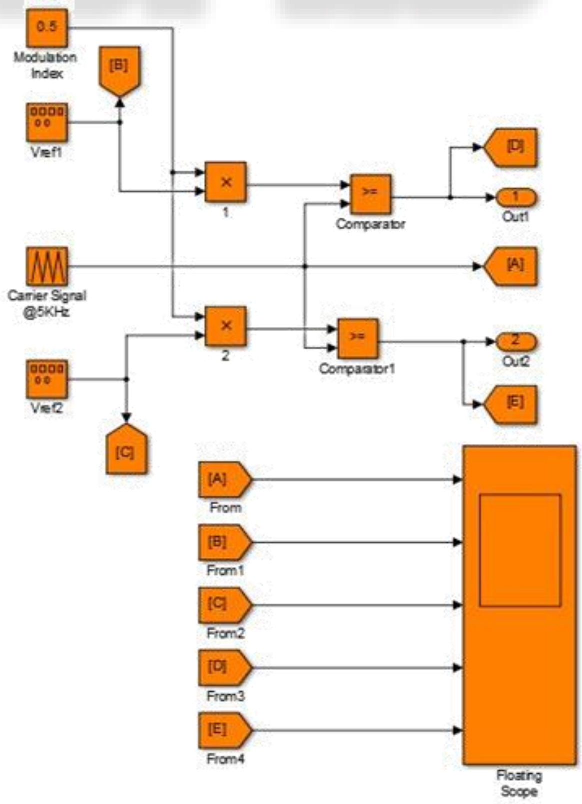

Fig. 7: Simulink Diagram for SPWM Generation

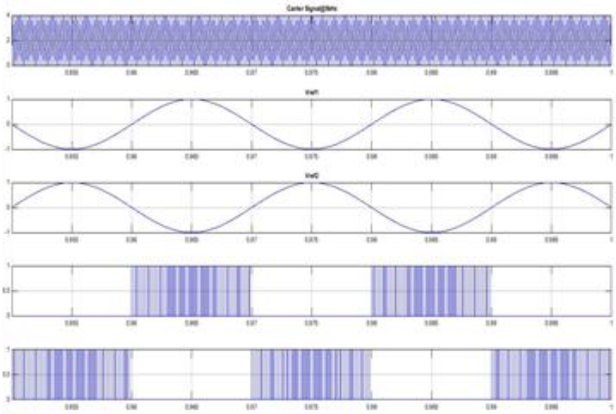

Fig. 8: Spwm Pattern

B. *Main Circuit Model:*

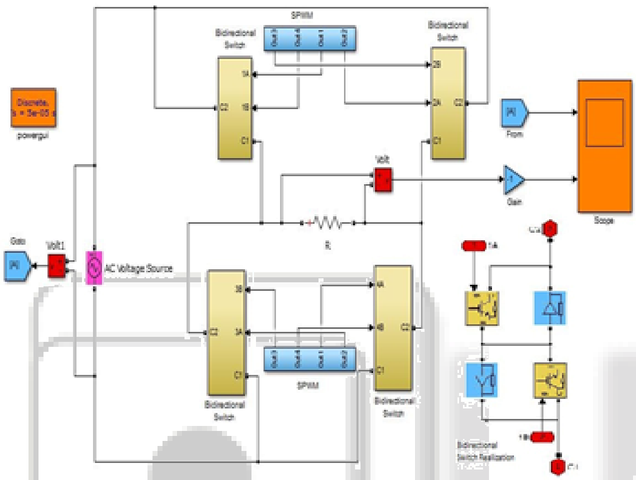

Fig. 9: Simulink Circuit Model

C. *Results*

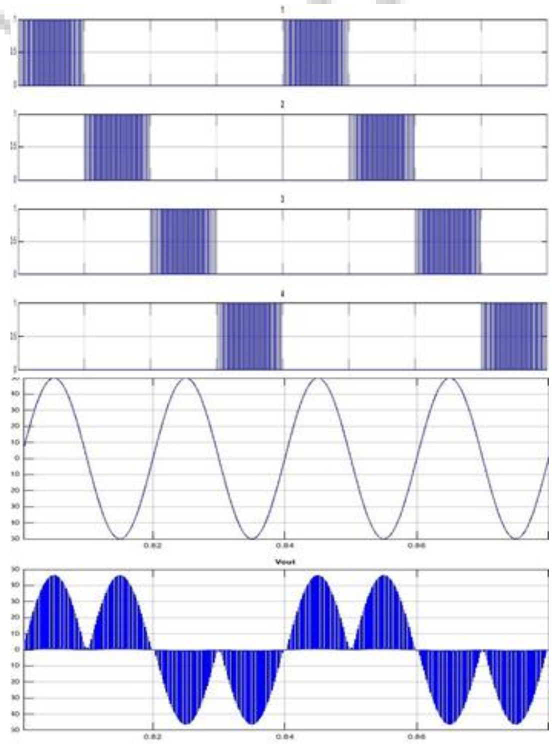

Fig. 10: Gate signals and I/P,O/P Voltages for f=25Hz

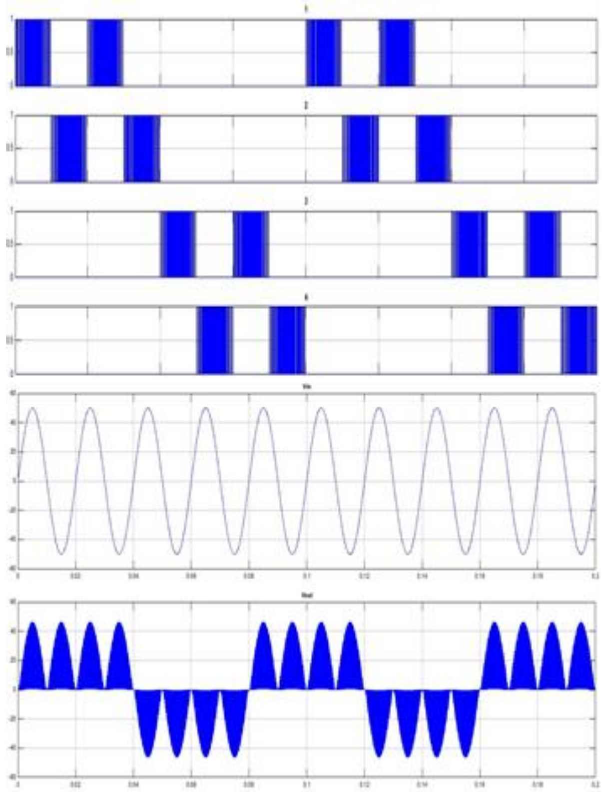

Fig. 11 Gate signals and I/P,O/P Voltages for f=12.5Hz

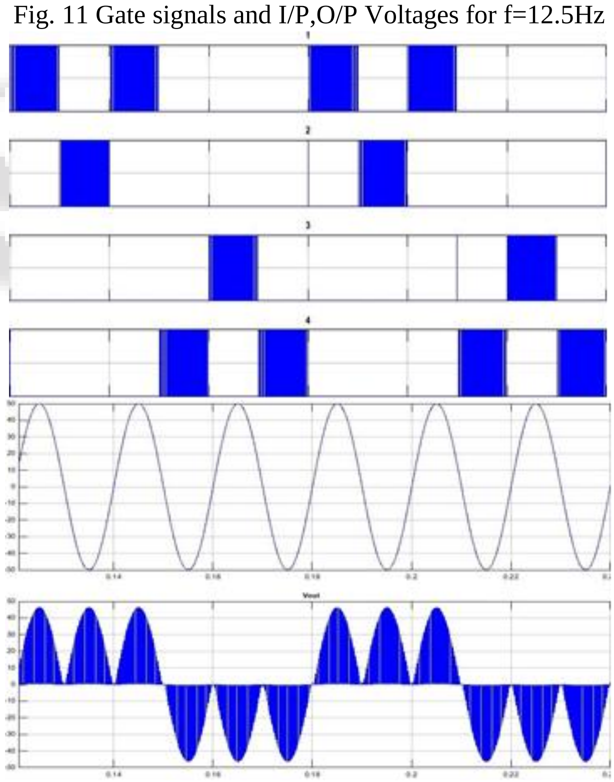

Fig. 12: Gate signals and I/P,O/P Voltages for f=16.66Hz

VI. CONCLUSION

This paper presented a more efficient and effective new strategy for single phase Cycloconverter and The matrix converter (MC) eliminates the need for reactive energy storage components used in conventional rectifier-inverter based system. Simulation model on SPMC for cycloconverter operation using MATLAB/Simulink (MLS) software package had been presented. It includes the implementation of SPWM to control the AC output supply for a given AC input. Safe-commutation strategy was implemented to solve switching transients.

REFERENCES

[1] Modern Power Electronics and AC Drives - B.K.Bose.
[2] Z. Idris, M.K. Hamzah, A. Saparon, N.R.Hamzah & N.Y. Dahlan "FPGA Design of Single-phase Matrix Converter Operating as Cycloconverter", IEEE PEPS 2007.
[3] Ajay Kumar Gola and Vineeta Agarwal "Implementation of an Efficient Algorithm for a Single Phase Matrix Converter", Journal of Power Electronics, Vol. 9, No. 2, March 2009.
[4] G.N. Surya, Subroto Dutt, "A Simplified Switch Modulation Strategy for Matrix Converter", IJEIT, Volume-1, March 2012.
[5] Abhishek Pratap Singh, V. K. Giri "Modeling and Simulation of Single Phase Cycloconverter", IJESAT, Feb 2012.
[6] DivyaAhirrao,BhagyashriGaware, PrajaktaKakade, PratikshaKharade "Analysis of Single Phase Matrix Converter", IJERA, March 2014.

