Middle-East Journal of Scientific Research 20 (11): 1484-1488, 2014
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2014.20.11.918

Steady State Performance and Simulation of Matrix Converter for Various Load

T. Saravanan, G. Saritha and V. Srinivasan

Department of ETC,
Bharath University, Chennai, India

Abstract: The matrix converter is superior to the PWM inverter drive, because of regeneration ability, sinusoidal input, sinusoidal output and highest limit of the voltage transfer ratio. This paper describes the basic operating principle with various load conditions. The matrix converter has received considerable attention due to the following advantages. A large capacity and compact converter system can be designed because the system does not have any dc-link circuit and, as a result, does not need any energy storage component, such as a smoothing inductor or a smoothing capacitor. The system has high efficiency, because the number of devices connected in series is less in this system than in the conventional rectifier– inverter system. Four-quadrant operation is very easy. The theory of the three-phase to three phase matrix converter is dealt with and its switching angle equations are presented. Matrix converter operation is based on the calculated switching angles. Modeling and numerical simulations of converter loaded with passive (R. L) and active (induction motor) loads are performed. Simulation results are presented.

Key words: Space Vector Modulation (SVM)

INTRODUCTION

The matrix converter is an alternative to an inverter for 3-phase frequency control. The converter consists of nine bidirectional switches arranged as three sets of three so that any of the three input phases can be connected to any of the three output lines (Figure 1). With suitable control strategies, the matrix converter is able to perform frequency and voltage conversion without the need for an intermediate DC link [1, 2]. Control of the output voltage is achieved by switching between the allowed switching states using a modulation strategy such that the average value of the output voltage follows the desired waveform.

The main potential advantages of a matrix converter solution over the traditional rectifier-DC link approach can be summarized as follows 4-quadrant operation, [3] direct frequency conversion with no intermediate DC link and High supply side power quality. Various modulation strategies can be applied to the AC – AC matrix converter to achieve sinusoidal output voltages and input currents. An optimal modulation strategy should minimize the input current and output voltage harmonic distortion and device power loss [4]. This paper uses the space vector modulation (SVM) method to simulate various load conditions. Switching angles of nine bidirectional switches will be calculated with the following rules. At any time‘t’ at least two of the switches will be ‘ON’ state. This will assure that there is no short circuit at the input terminals. At any time‘t’, at least two of the switches will be in ‘ON’ state. This condition guarantees closed – path for the load current. Switching frequency is much higher than the input and output frequencies.

Space Vector Modulation and Switching Sequence: All Space Vector Modulation (SVM) techniques use a set of vectors that are defined as instantaneous space-vectors of the voltage and currents at the input and output of the converter. These vectors are created by the various different switching states that the converter is capable of generating. For the standard 3x3 matrix converter there are 27 (33) switching states [2, 3]. However with the extra output leg this obviously extends the total number of switching states of the converter to 81 (34), all of which are shown in Table 1. The only useful states for most SVM techniques are those that use either a single input phase (Zero Vectors) or 2 input phases. Switching sequence is shown in Table 1.

Corresponding Author: T. Saravanan, Department of ETC, Bharath University, Chennai, India.

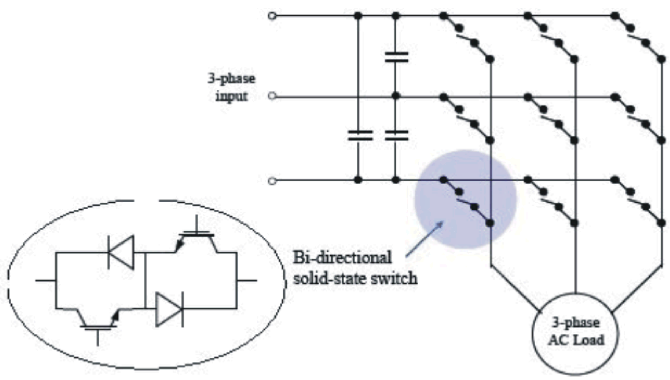

Fig. 1: Basic structure of Matrix Converter

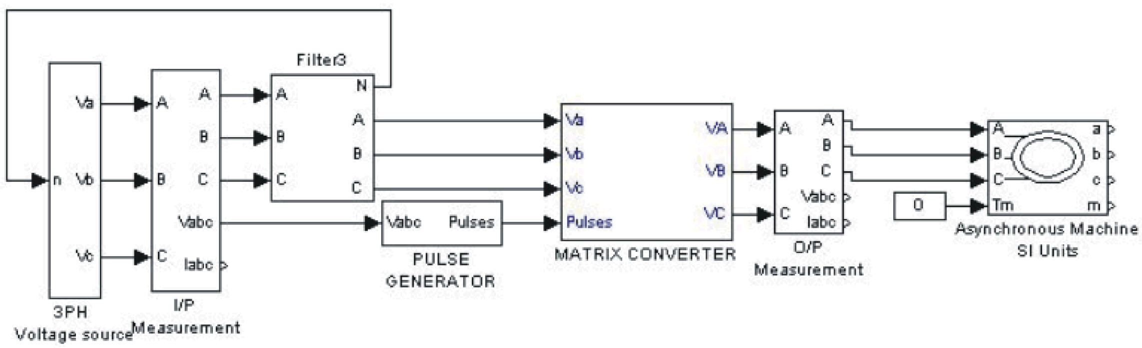

Fig. 2: Matrix Converter with 3phase Induction Motor

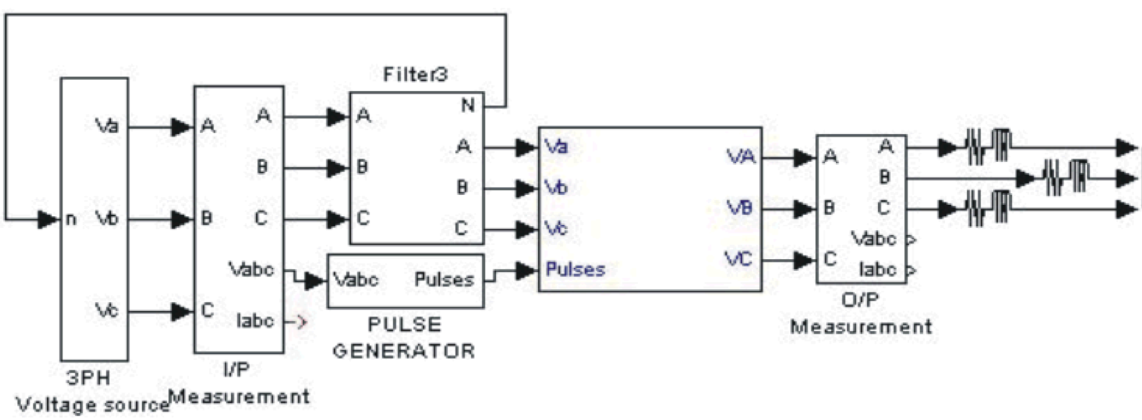

Fig. 3: Matrix Converter with RL Load

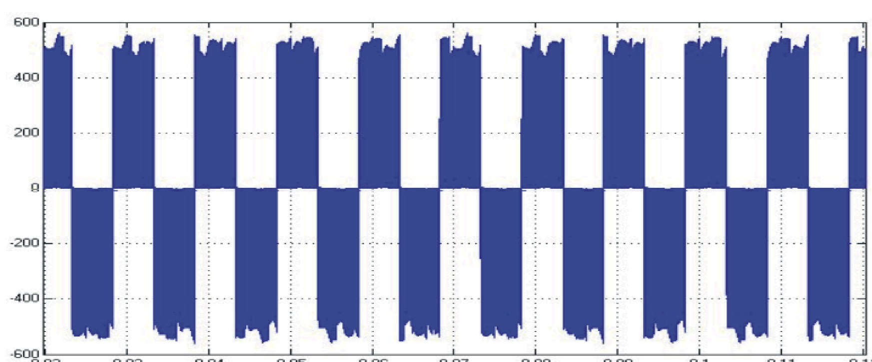

Fig. 4: Output voltage

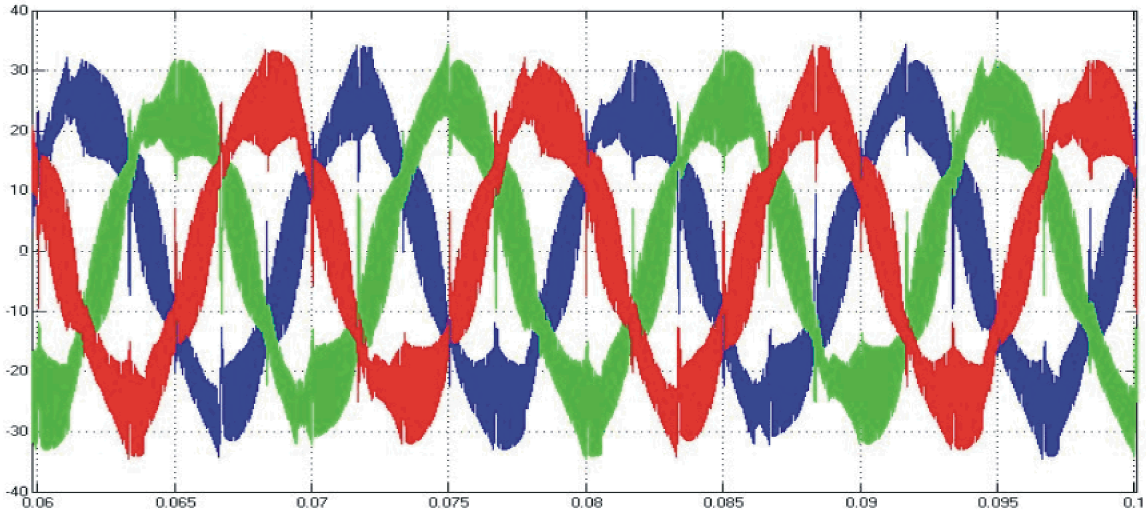

Fig. 5: Output current

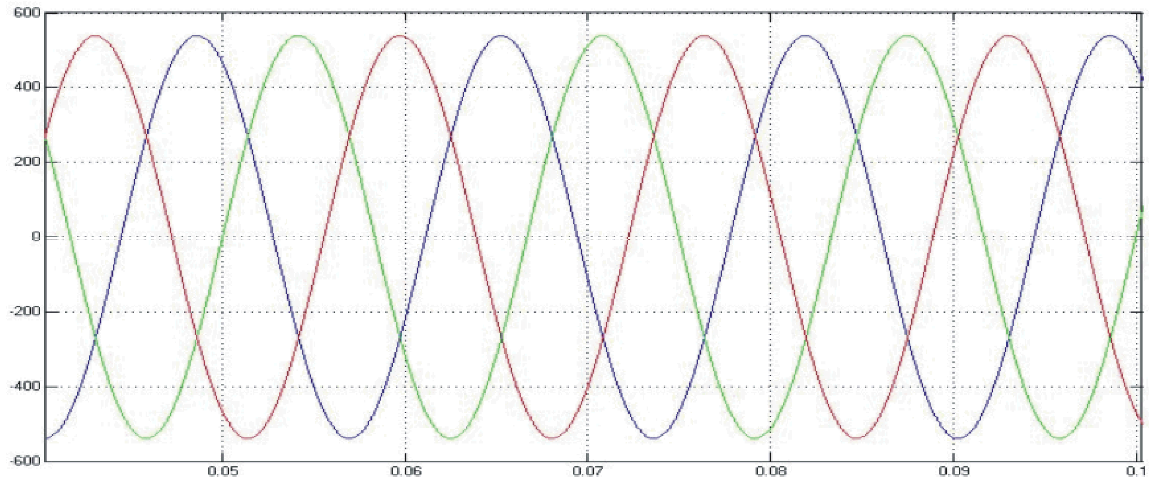

Fig. 6: Input voltage

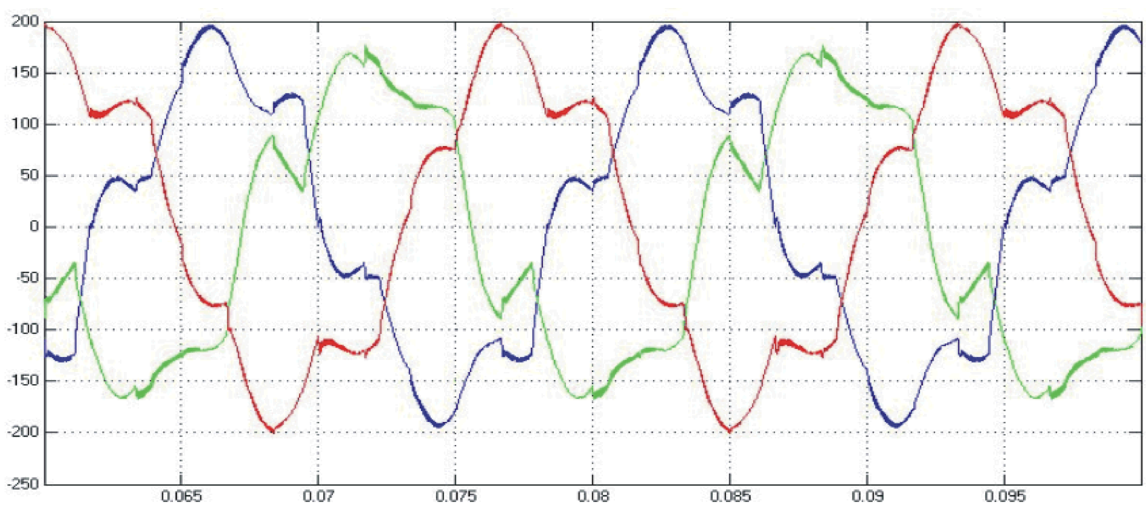

Fig. 7: Input current

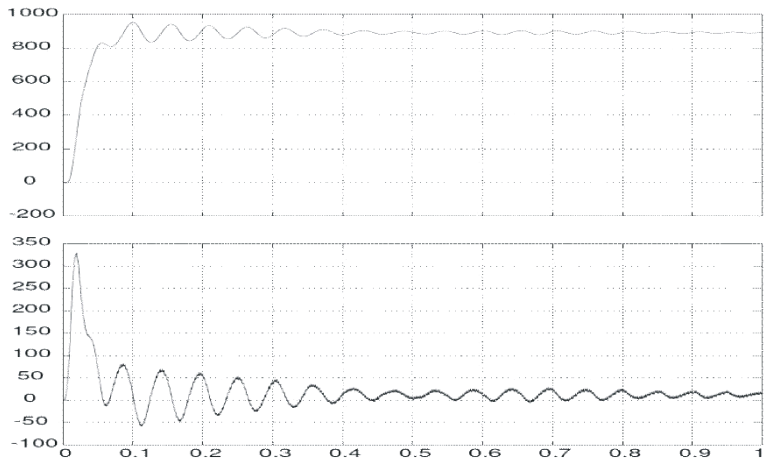

Fig. 8: Speed and Torque Responses for 60/30 Hz

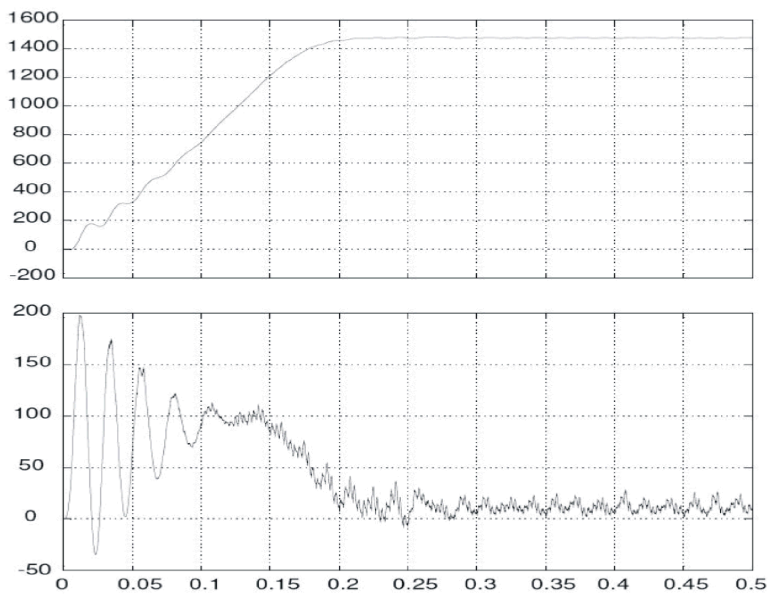

Fig. 9: Speed and Torque Responses for 60/50 Hz

System Configuration: The matrix converter is direct frequency conversion device that generates variable magnitude variable frequency output voltage from the ac utility line. The main control block diagram of the experimental MC drive system is shown in Figure. Since it does not involve an intermediate dc voltage link and the associated large capacitive filter, an MC drive has higher power density than a PWM inverter drive. The MC includes the LC input filters and nine bidirectional switches. The LC input filters are for filtering the carrier frequency components. Each bidirectional switch consists of two anti parallel IGBTs and diodes [3, 4]. The MC drive is connected to an induction motor with shaft encoder. The reference voltages are processed in MC controller that generates the pulse pattern for the MC switches. The input displacement angle control is implemented in the main controller. Experimental setup for RL and motor load shown in Figure 2 and Figure 3.

Experimental Result: To validate the correctness and effectiveness of direct transform control scheme, a three phase matrix converter fed to an induction motor and RL load has been simulated by using MATLAB/SIMULINK software package.

In particular, the influence of input line voltage disturbances on both the load side performance and the input current is significant and undesirable. This paper addresses the ac line voltage disturbance related performance issues of the MC drive. Above figure shows input and output phase current, electro magnetic

Table 1: Matrix Converter Switching Sequence

v_{pn}	θ_{an} B_{bn} θ_{cn} $S(\omega_r)$	Region	B_{al}	B_{bl}	B_{cl}	V_k		S_{aa}	S_{ab}	S_{ac}	S_{ba}	S_{bb}	S_{bc}	S_{ca}	S_{cb}	S_{cc}
	1 0 0 1 or 1 1 0 0	I	1	0	0	V_1		1	0	0	0	1	1	0	0	0
			1	1	0	V_2		1	1	0	0	0	1	0	0	0
			other cases			V_0	or	1	1	1	0	0	0	0	0	0
								0	0	0	1	1	1	0	0	0
	1 1 0 1 or 0 1 0 0	II	1	1	0	V_2		1	1	0	0	0	1	0	0	0
			0	1	0	V_3		0	1	0	1	0	1	0	0	0
			other cases			V_0	or	1	1	1	0	0	0	0	0	0
								0	0	0	1	1	1	0	0	0
	0 1 0 1 or 0 1 1 0	III	0	1	0	V_3		0	1	0	1	0	1	0	0	0
			0	1	1	V_4		0	1	1	1	0	0	0	0	0
			other cases			V_0	or	1	1	1	0	0	0	0	0	0
								0	0	0	1	1	1	0	0	0
e_{sw}	0 1 1 1 or 0 0 1 0	IV	0	1	1	V_4		0	1	1	1	0	0	0	0	0
			0	0	1	V_5		0	0	1	1	1	0	0	0	0
			other cases			V_0	or	1	1	1	0	0	0	0	0	0
								0	0	0	1	1	1	0	0	0
	0 0 1 1 or 1 0 1 0	V	0	0	1	V_5		0	0	1	1	1	0	0	0	0
			1	0	1	V_6		1	0	1	0	1	0	0	0	0
			other cases			V_0	or	1	1	1	0	0	0	0	0	0
								0	0	0	1	1	1	0	0	0
	1 0 1 1 or 1 0 0 0	VI	1	0	1	V_6		1	0	1	0	1	0	0	0	0
			1	0	0	V_1		1	0	0	0	1	1	0	0	0
			other cases			V_0	or	1	1	1	0	0	0	0	0	0
								0	0	0	1	1	1	0	0	0

toque – speed of induction motor in start up process. To eliminate harmonics and assure the input phase currents to be sinusoidal, a high frequency filter is necessary in the configuration. It should be noted from the figures that the input voltage and current are sinusoidal and the displacement angle between each other approximately equals to zero. Results obtained also present SPWM output line voltage sinusoidal output line current which are all ideality without any low frequency harmonics. The fundamental component of input phase currents and output line voltages is the main component absolutely. All these figures illustrate that the modeling and control algorithm studied in the paper are effective and the matrix converter is quite suitable to be served as an ideal power supply input AC excited power generation system.

CONCLUSION

Space Vector modulation control of induction machine fed from a three phase matrix converter modeling and simulation has been described. The main topics discussed in the paper were: review of matrix converter for various load conditions; switching angles calculation; converter modeling and simulation. To our knowledge, this is the first time that the matrix converter has been simulated for various load based on Space Vector modulation, this being the main contribution of the paper. According to the simulation results obtained, the control algorithm presented is advisable for the establishment in the industry. The next step of this research will be the realization of the motor drive with closed loop control.

Appendix: Induction Motor Load: 3HP, 220 V $_{ll}$, Rs= 0.435Ohms, L= 2.0mH, Rr= 0.816, Lr= 2.0 mH.

REFERENCES

1. Klumpner, C., P. Nielsen, I. Boldea and F. Blaabjerg, A New MatrixConverter-Motor (MCM) for Industry Applications; Proc. IAS '00 Conf., 3: 1394-1402.
2. Klumpner, C., P. Nielsen, I. Boldea and F. Blaabjerg, 2002. New solutions fora low-cost power electronic building block for matrix converters, IEEE Trans. Ind. Electron., 49(2): 336-344.
3. Wheeler, P.W., J. Rodrigez, J.C. Clare, L. Empingham and A. Weinstemi, April 2002. Matrix Converters. A Teclhology Review, IEEE Transactions on Industrial Electronics, 49(2): 276-288.
4. Alesina and M. Venturini, 1989. Analysis and design of optimum-amplitude nine-switch direct AC-AC converters, IEE Transactions on PowerElectronics, 4(1): 101-112.