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COMPARATIVE ANALYSIS ON MATRIX CONVERTER FED INDUCTION MOTOR WITH NO LOAD AND LOAD CONDITION

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Abstract: Matrix converter is an important alternative to the traditional two-level voltage source inverter (VSI) in controlling 3-Phase motor drives. It has received more attention in recent decades since it has some noticeable advantages like bidirectional power flow, sinusoidal input output waveforms, unity input power factor etc. The device has a direct link structure and does not use bulky DC link capacitor for intermediate energy storage. Thus matrix converter can be made compact in size by integration of power devices into single structure and so have the advantages of extreme temperature operation. This paper presents, an open loop configuration of vector controlled matrix converter-fed induction motor drive simulation using the MATLAB/ SIMULINK Environment. The Proposed control method uses SVM (space vector modulation) technique to generate switching sequence for matrix converter. The Performance has been made for various Induction Parameter analyses like Stator Current, Torque and Speed for no load and Induction motor with 7 N-m load conditions. The analysis of the paper shows the utility of the high performance matrix converter drive system.
Keywords: Matrix Converter (MC), Induction Motor(IM), Simulation, MATLAB/SIMULINK

I. INTRODUCTION

In every industry there are industrial processes of some form that require adjustment for their normal operation or for their optimum performance. Such adjustments are usually accomplished with a variable speed drive system. Variable speed drive systems are an integral part of automation. They help to optimize the process and to reduce investment costs, energy consumption, and energy cost. There are three basic types of variable speed drive systems: electrical drives, hydraulic drives, and finally mechanical drives. Only electrical drives are focused here. A typical present day electric variable speed drive system consists of three basic components: the electric motor, the power converter, and the control system. The matrix converter topology was first proposed by Gyugyi and Pelly in 1976 [11]. They extended the principle of the cycloconverter to obtain an unrestricted output frequency by using controllable bidirectional switching devices. For the voltage source inverters, the output voltages of the variable voltage and variable frequency voltage sources is non sinusoidal Similarly the variable frequency current source for current source inverter is also non sinusoidal in nature. Whenever the induction motor is fed by using these inverters odd harmonics will be there in the input supply and due to inverters output voltage becomes non sinusoidal. However the harmonics do not contribute the output power of the motor and produce additional losses in the machine. This harmonics reduces the machine efficiency and also causes the derating of the motor. This limitations can be overcome by using matrix converter because of their unique feature is the sinusoidal as output. The matrix converter is better than inverter drives because of their regeneration ability and four-quadrant operation and hence it meets the stringent energy efficiency and power quality. The physical realization of the matrix converter is not straightforward, due to the fact that there are no freewheeling paths. In addition, the number of devices in the power circuit is high compared with that in the inverter. Consequently, the timing of the switch actuation signals is particularly critical, and protection of the circuit under fault conditions requires very careful consideration [7]. In [8], a highly compact converter using novel high-power 3-in-1 integrated power modules was used. In another aper, the integration of the matrix converter and the induction motor in a single unit was discussed [9]. The first matrix converter contained in a single power module using insulated gate bipolar transistor technology was presented in [10]. There is now competition between the matrix converter and the voltagesource inverter with a regenerative input rectifier. Only a few technical papers have dealt with the dynamic behaviour analysis of the field-oriented controlled matrix converter motor drive. In [11, 12], a simulation of the matrix converter feeding an induction motor was performed. and in [13], a control technique for compensating the effects of the input voltage variations on the matrix converter algorithms was described, but closed loop operation was not considered.

II. MATRIX CONVERTER

Matrix converter is a device which converts AC input supply to the required variable AC supply as output without any intermediate conversion process whereas in case of Inverter which converts AC - DC - AC which takes more extra components as diode rectifiers, filters, charge-up circuit but not needed those in case of matrix converters. Matrix converters are one-stage converters capable of providing simultaneous voltage and frequency transformation. They can be applied to any multi-phase system, but the most significant case is the 3-phase to 3-phase converter. This consists of nine 4-quadrant or bidirectional switches distributed in a 3x3 matrix form. These switches connect each input phase with the three output lines. There are no energy storage elements such as large capacitors and inductors. The inductive load and the input filter capacitors filter the high frequency current components produced by the high frequency switch commutations. There are several reasons why matrix converters remain very attractive for some applications and a very promising technology that contribute to the development of power electronics.

III. INDUCTION MOTOR

Ideally, a vector controlled IM drive operates like a separately excited DC motor drive, as mentioned above. The following figure explains this analogy.

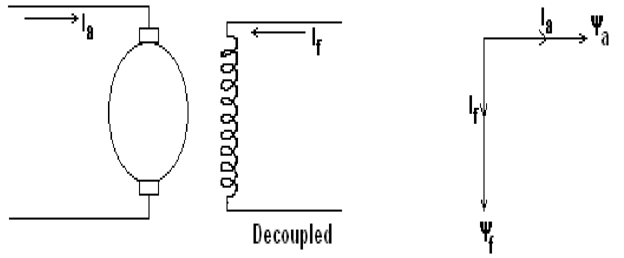

Fig 1.1 Separately Excited DC Motor

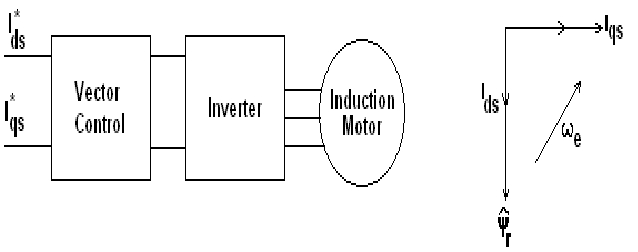

Fig 1.2 Vector-Controlled IM

In a dc machine, neglecting the armature reaction effect and field saturation, the developed torque is given by

$$T_e = k_t \Psi_f \Psi_a = k_t' I_a I_f \qquad 2.35$$

Where I_a =armature current also called torque component of current and I_f =field current also called field component of current.

The construction of a dc machine is such that the field flux Ψ_f produced by the current I_f is perpendicular to the armature flux Ψ_a, which is produced by the armature current I_a. These space vectors, which are stationary in space, are orthogonal or decoupled in nature. This means that when torque is controlled by controlling the current, I_a the flux Ψ_f is not affected and we get the fast transient response and high torque/ampere ratio with the rated Ψ_f. Because of decoupling, when the field current I_f is controlled, it affects the field flux Ψ_f only, but not the Ψ_a flux. Because of the inherent coupling problem, an IM cannot generally give such fast response i.e. it gives sluggish response and the system is easily prone to instability because of a high-order (fifth-order) system effect.

IV. SIMULINK MODEL:

The proposed method in the thesis has been investigated under system circuit level simulations given below under Matlab/Simulink environment. The below SIMULINK model shows the design of the open loop configuration for the matrix converter fed Induction drive.It has been used to calculate the performance of the Induction motor considering the stator current vs. time curve, the speed curve and the torque vs. time curve. The time constant for the simulations has been talken for the performance analysis with the PI and fuzzy based design of the Closed Loop configuration for the matrix Converter fed induction drive.

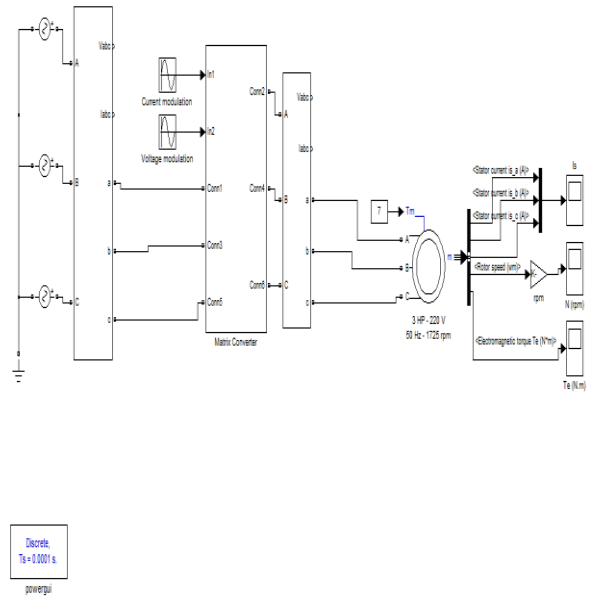

Fig 1.3 Simulink block diagram of proposed work

V. SIMULATION RESULT

The simulation work was carried out by using the tool MATLAB/SIMULINK. The simulation results will be verified the work of the thesis report. The aim of this project is to control the Stator current, speed and torque of vector controlled matrix converter fed 3 phase induction motor by the use of direct torque control (DTC) technique .The modeling of induction motor is done in the SIMULINK environment using the necessary equations. The Direct Torque Control (DTC) of the induction motor along with the Matrix converter based design is also modeled in the SIMULINK using the necessary equations.

Motor Parameters

Parameter	Value
Rated Power	3*786 = 2238 W
Nominal Voltage	220 V
Frequency	50 Hz
Pole pair	2

Stator resistance	0.924 Ω
Stator inductance	0.0089 H
Rotor resistance	0.9861 Ω
Rotor inductance	0.0038 H
Mutual Inductance	0.4 Ω
Rotational Inertia	0.04 Kg-m2
Speed	1725 rpm
Torque	10 N-m

This paper describes modeling the induction motor based on the matrix converter output and to investigate the results under no load and load condition.. The electromagnetic forces of induction motor based circuit have been calculated as the functions of stator current, speed and torque. The simulations have been carried out assuming the parameters given below.

A. Results with load 7 N-m:

The below simulation result shows the curve for the stator current, speed and torque under 7 N-m load. Figure 1.4, 1.5 and 1.6 are shown below of stator current, speed and torque waveforms corresponding to 7 N-m load having time constant 0.18 sec.

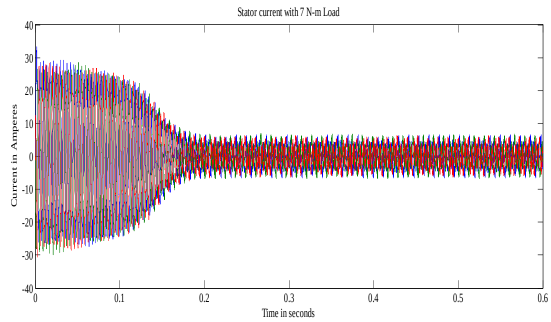

Fig 1.4 Stator current of IM with 7 N-m load

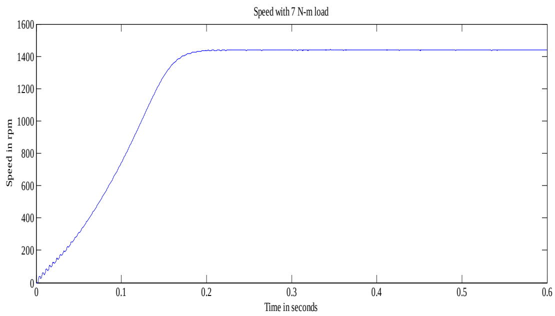

Fig 1.5 Speed of IM with 7 N-m load

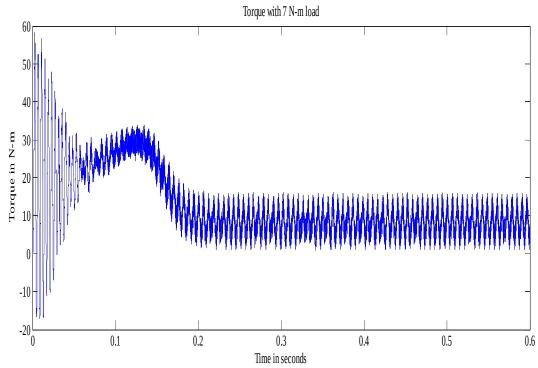

Fig 1.6 Torque of IM with 7 N-m load

B. Results with no load:

The below simulation result shows the curve for the stator current, speed and torque under no load. Figure 1.7, 1.8 and 1.9 are shown below of stator current, speed and torque waveforms corresponding to No load condition having time constant 0.06 sec.

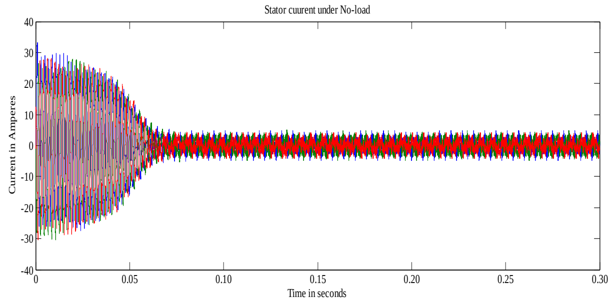

Fig 1.7 Stator current of IM with no load

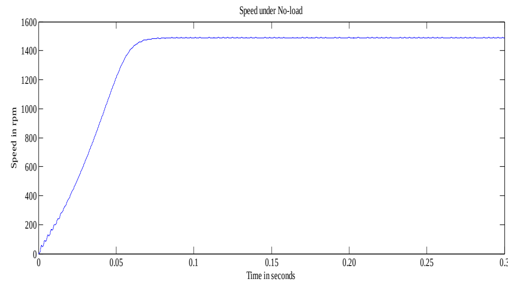

Fig 1.8 Speed of IM with no load

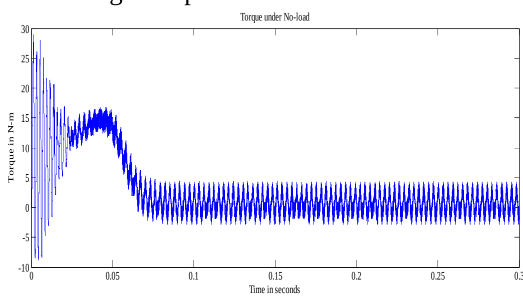

Fig 1.9 Torque of IM with no load

VI. CONCLUSION

In this paper, a comparative simulation study of the vector controlled matrix converter-fed three phase induction motor drive has been done under MATLAB/SIMULINK Environment. In both the analysis it is to be concluded that for same parameters Induction motor gives less time constant in case of light load or no load.

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