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Simulation Based Comparative Analysis of Matrix and Bridge Converter Fed Single Phase Induction Motor Drive Using DTC With PV Input

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Abstract: **This paper presents a Comprehensive analysis of Matrix and Bridge converter fed single phase induction motor drive. Direct Torque Control is one of the most suitable control techniques of torque control in case of induction machines. In this paper, Direct Torque Control (DTC) is proposed for induction motor drive with PV input which reduces torque triples and calculation ensure fixed frequency of 50 Hz. A separate simulation model for Matrix converter and bridge converter is presented. Maximum Power Point Tracing (MPPT) is an important issue in PV system to extract maximum power. The result shows that Matrix converter fed induction motor drive has smoother torque characteristics. Components of induction machines, simulated I/P & O/P parameters of converters are presented using MATLAB/Simulink software. The result shows that Matrix converter fed induction motor drive has smoother torque characteristics and Torque Controls as per requirement of load.**

Index Terms: **Direct Torque Control (DTC), Matrix and Bridge converters, MPPT, Induction motor.**

I. Introduction

One of the most outstanding control techniques in induction machines is Direct Torque Control (DTC), Which has become an alternative to the well-known vector control Strategy (Abdul Wahab and Sanusi H.,2008) Minimization of the torque ripple of MC fed PMSM drives using direct torque control that reduces torque ripples and does not require motor drive duty cycles calculations by using the algorithm space vector modulation, this scheme improves steady state response with smoother torque characteristics as well as reduces THD (Kannan S.,et al.,2008). A predictive control strategy applied to the MC based induction motor which results in high quality control torque, flux as well as power factor with quick dynamic response for AC-to-AC power conversion (Vargas R.,2015). The MPPT system is used for wind turbines with IMC powered DFIG (Double Fed Induction Generators) system (Dabour S. M.,2017). Predictive control techniques for predictive control of matrix converter applications have newly emerged as a promising alternative to more conventional control and modulation power converting techniques (Double fed induction generator is the most popular because of its variable speed for wind energy applications due to their performance, such as lower cost and control flexibility(Shamsher A.,2017).Various control techniques are available for converter of power for one form to another form, the AC motor drives also use as renewable energy sources (Dhumal C.D.,2017; Mohamad k,2018) .DTC for matrix converter fed velocity sensor less IM drive increases the IM input power efficiency. Via space vector modulation, DTC helps to gain fast control over AC machine torque & flux also (Tabish Nazir Miret al.,2018). It is useful for torque reduction, monitoring the speed, switching losses algorithm complexity and parameter sensitivity, DTC is excellent control strategies available to control the torque of induction machines (Najib EL Quanjli, et al.,2019). While comparatively studied in the total harmonic distortion of output and data of induction motor drives, venturing and indirect space vector modulation technique to find better efficiency for induction motor drive (Jati M. P.et al.,2020). Advance model predictive current control for induction drives gives sinusoidal output current, a unity power factor and good steady state response with dynamic performances (Yang Mei.,2020).

I. IMPLEMENTATION OF SYSTEM

A. Block Diagram

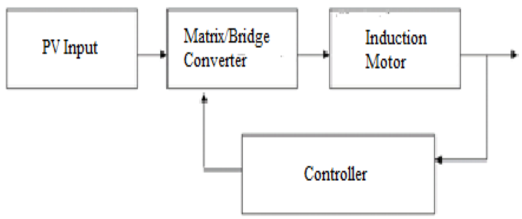

Fig. 1 Block diagram of system

1) Solar PV array

The PV array consists of 4 series of connected modules per string, which generates maximum amount power, and a power point tracking system that use an appropriate algorithm to extract maximum power from the PV array

2) Electrical Energy Converters

The proposed system simulated using two separate converters such as Single-phase Matrix Converter and Bridge converter.

a) Matrix Converter

MC is one of the powerful converters used because of is dynamic characteristics such as bidirectional energy capability, all types of energy conversion such as DC-AC, AC-AC etc. therefore single-phase Matrix Converter in DC to AC inverter mode is applied to IM.

b) Bridge Converter

The converter is modelled by a switching function whose having controlled by firing pulses which produced by PWM generator. The O/P of solar PV system gives to the bridge converter with device on-state resistance ie-3 snubber resistance i.e., ohm and snubber capacitance in farad.

C) Single phase Induction Motor

Here a single-phase asynchronous machine used in d-q stator reference frame where main and auxiliary winding are in quadrature. Same input parameters of induction motor used in both cases.

Input Parameters of single-phase IM For simulation: -

Nominal power = 5*750 VA.

Voltage = 230 volt.

Frequency = 50 Hz.

Main winding stator,

R_s = 1.8180-ohm. L_s = 0.0067 Henry.

Main winding rotor is,

R_r = 3.7080 ohm.

Main winding mutual induction is,

0.1595

Auxiliary winding stator,

R_s = 6.4260 ohm. L_s = 0.0077 Henry.

Inertia = 0.0146 gm.m^2.

Turn ratio = axillary = 1.15.

Main

Pole pair = 02.

Initial speed = 0 rpm.

B. Direct Torque Control

The DTC block developed on the basis of following structure and the torque control of DC to AC converter fed single phase induction motor is carried out.

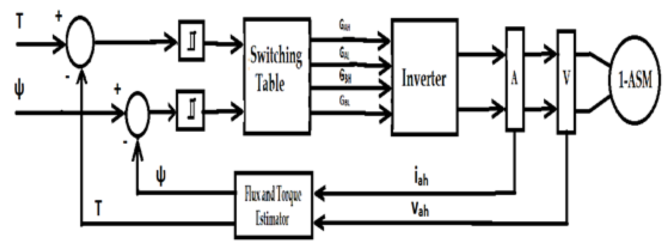

Fig. 2. Direct Torque Control

The estimation of torque and flux are based on machine voltage equations. The discrete equations of time-voltage using the methods of back or enter discretization are,

Were,

$$\Psi_a = (V_a - I_a R_{as}) \frac{Ts\,Z}{Z-1}$$

$$\Psi_b = (V_b - I_b R_{bs}) \frac{Ts\,Z}{Z-1}$$

R_{as} and R_{bs} are the main winding resistance and auxiliary winding resistance respectively.

The main winding current and the auxiliary winding current are Ia and Ib, while the main winding and auxiliary winding voltages are Va and Vb, respectively and also the ψ_a and ψ_b are the main and auxiliary winding flux. The torque and flux obtained from,

$$T = P\,(a\Psi_a I_b - \frac{1}{a}\Psi_b I_a)$$

$$\Psi_s = \sqrt{\Psi a^{\,2} + \Psi b^{\,2}}$$

Where,

P is the number of pole pairs,

a is axillary to main winding ratio.

Employing simple hysteresis comparators detects the status of flux and torque errors,

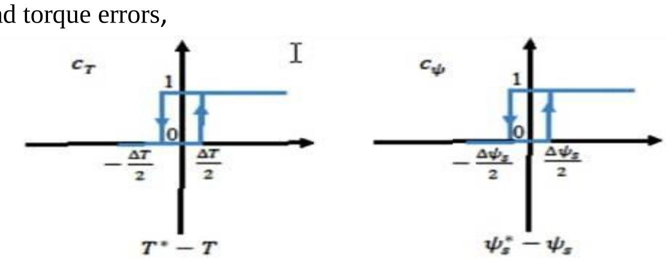

Fig.3 Hysteresis Comparators

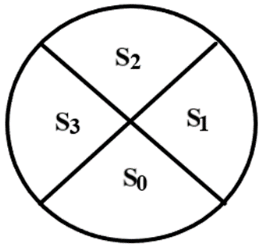

Fig.4 Switching Sectors

Table. 1. Optimum Switching

C_Ψ C_T, $S_{(0)}$		S_0	S_1	S_2	S_3
$C_{\Psi=1}$	$C_{T=1}$	1, 1	0, 1	0, 0	1, 0
	$C_{T=0}$	1, 0	1, 1	0, 1	0, 0
$C_{\Psi=0}$	$C_{T=1}$	0, 1	0, 0	1, 0	1, 1
	$C_{T=0}$	0, 0	1, 0	1, 1	0, 1

The torque reference can be given as an input, and can be generated internally using a PI speed controller in the case of speed control. The internal generation of the flux relation is used. Where W_r is the rotor angular mechanical speed in rad/sec.

F_n is rated frequency and Ψ_n is rated flux.

II. SIMULATION AND RESULTS

To study comparatively a MATLAB/Simulink based model for both (Single phase Matrix converter & Bridge converter) converters developed separately. For both cases IM simulation parameters are kept same to compare performance analysis.

A. *Simulation of Single-phase Matrix Converter*

The simulation model of single phase Matrix Converter fed induction motor drive is designed as shown in figure 3.1.

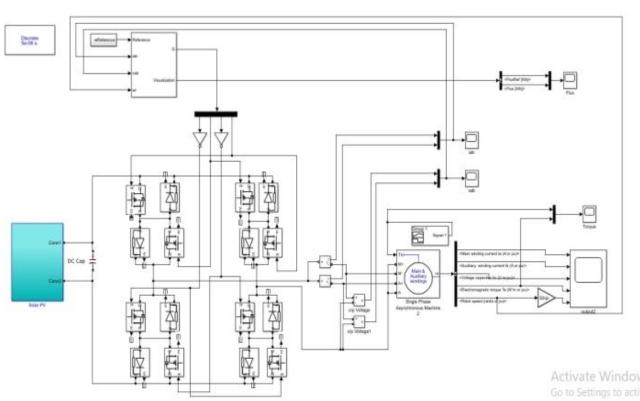

Fig.5 SPMC fed IM

The supply input to the matrix converter is generated by photovoltaic system by Maximum power tracking system. The MC takes this DC voltage and convert it into 230 volt AC at 50 Hz. The parameters used for simulation listed above.

Here the torque characteristics are observed using MATLAB/Simulink scope. Figure shows torque vs time characteristics of induction motor. It is observed that Starting torque is high and then torque is constant with value 2 N-m at given load. Torque waveform is smoother and no oscillations.

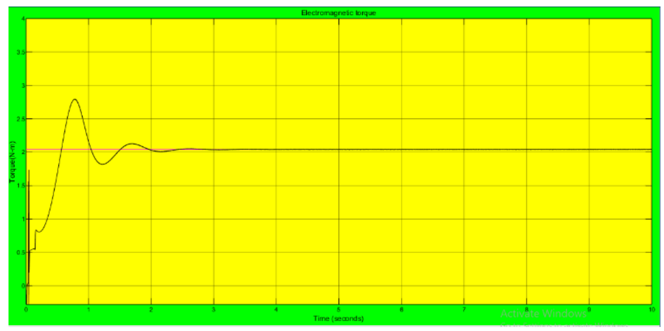

Fig6.load Torque

Figure 4 shows overall characteristics of induction motor such as auxiliary and main winding current torque and flux characteristics. All the characteristics are verified using Simulink scope.

In this figure Constant torque of 2 N-m is at time 2.3 second, no oscillations characteristics are smoothers.

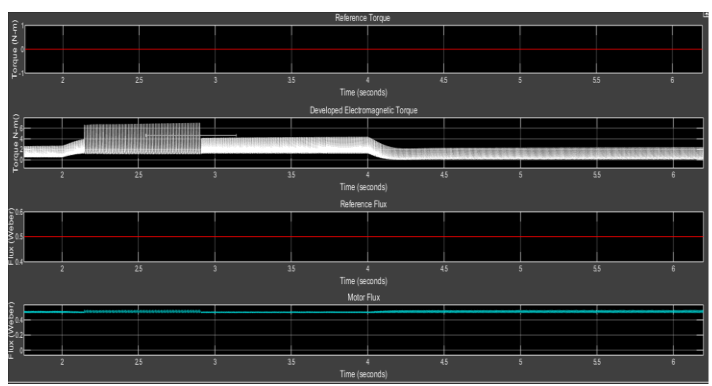

Fig.7.IM motor waveforms for MC

B. *Simulation of Single-phase Matrix Converter*

The simulated model of DC to AC bridge converter fed single phase induction motor drive is developed and shown in figure 3.4. The input supply voltage to the bridge converter is DC taken from photovoltaic input and its output is 230-volt, 50 Hz AC applied to induction motor load.

Figure 5 shows the torque and flux characteristics of Bridge converter fed IM where torque is 1.8 N-m having more oscillations.

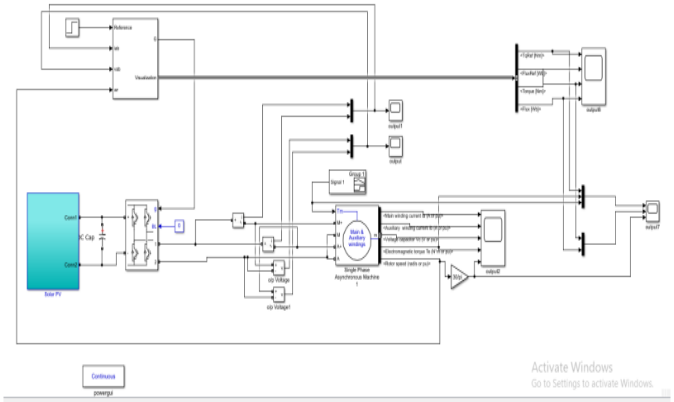

Fig.8. Bridge converter fed IM

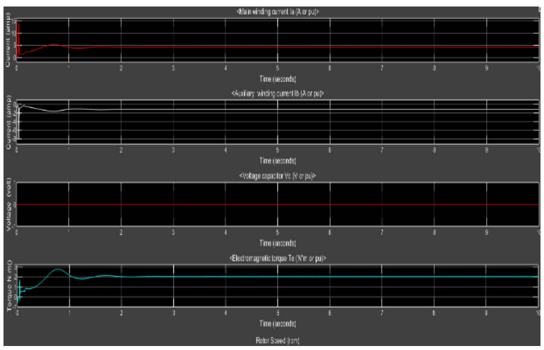

Fig.9. IM waveforms for Bridge converter

Figure 5 shows the torque and flux characteristics of Bridge converter fed IM where torque is 1.8 N-m having more oscillations.

In this figure:

Constant torque of 1.8 N-m is at time 0.7 second, oscillations are more than SPMC fed IM characteristics are not smoothers.

CONCLUSION

From the above MATLAB/Simulink results analysis it is observed that DTC technique can be apply for both single phase Matrix Converter and Bridge converter fed Induction motor and also observed that Matrix converter fed IM has better torque characteristics with less harmonics as compare to Bridge converter fed IM at constant frequency 50 Hz and the torque controls as per requirement of load.

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