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Speed Control of Induction Motor by Using Cyclo-converter

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Abstract: *This paper is used to control the speed of the induction motor. The speed control of Induction Motor is simple and can be made economical by using different methods to control the operation of Cyclo-converter which in turn controls the performance of motor. The speed of the motor can be varied in two ways, one is by changing the number of poles and the second method is by changing the frequency. The speed control through the first method is uneconomical and the number of poles can't be varied under running conditions and the size of the machine also becomes bulky. These problems can be overcome by the second method. In this method, the frequency can be varied under running conditions also and there is no change in the size of the motor. In this method, the frequency changing device is Cyclo-converter. A Cyclo-converter is a power electronic device used to convert constant voltage constant Frequency AC power to adjustable voltage adjustable frequency AC power without a DC link. In among all the methods this method is simple, reliable and economical. The various speed of induction motor is obtained by varying the supply frequency by using Cycloconverter.*

Keywords: *Cycloconverter, Microprocessor 8051, Opto-coupler, Split Phase Induction Motor.*

I. Introduction

Speed control of Induction motor plays Important role in industries, there are various ways to control speed of motor but considering its efficiency, we proposed is designed to control the speed of a single phase induction motor in three steps by using cyclo convertor technique by thyristors. A.C. motors have the great advantages of being relatively inexpensive and very reliable. Induction motors in particular are very robust and therefore used in many domestic appliances such as washing machines, vacuum cleaners, water pumps, and used in industries as well. The induction motor is known as a constant-speed machine, the difficulty of varying its speed by a cost-effective device is one of its main disadvantages [1]. Cycloconvereter have several importants features, cycloconveter frequency can be varied by conduction period for each MOSFET. However, control of induction motor is challenging task, many authors have suggested different techniques for speed control of induction of induction motor. These includes sliding mode control [2], fuzzy logic control [3] and model predictive control [4] and cycloconverter [6-8] etc.

In [2] control methodology could be viewed as an advancement of the standard field oriented control. It consists of two control loops, i.e. the rotor flux and the speed control loops, designed using the active disturbance rejection control method, with the aim to cope with both exogenous and endogenous disturbances, which are estimated by means of two linear extended state observers and then compensated. Moreover, with the aim of achieving total robustness, a sliding mode based component is designed, in order to take into account disturbance estimation errors and uncertainties in the knowledge of the control gains.

The design of Fuzzy controller is carried out by fuzzy set theory in MATLAB/Simulink 2013a, using Takagi-Sugeno (T-S) fuzzy model. The simulation results for both controllers are then compared and the results revealed that T-S Fuzzy Controller perform better in terms of control delay to load variations, as compared to Conventional PI controller. The overall pre and post disturbance analysis presented the robustness of the proposed controller to all load disturbances. The T-S fuzzy controller thus can be used as an alternative to PI controller, where dynamic superior performance of nonlinear systems is required [3].

In some cases, such as restarting after power interruption or starting a motor rotated by external load, the motor may be rotating before being powered by the inverter. For speed-sensorless operation, as both the initial rotational direction and speed is unknown, it would be difficult to achieve smooth and fast resumption of normal operation if the starting scheme is not deliberately designed. In this paper, a method based on adaptive full order observer (AFO) is proposed to address this problem. For AFO without a properly designed feedback gain matrix, the estimated speed cannot converge to the actual speed if initial estimated speed is significantly lower than the actual speed. Through analyzing the transfer function of stator current error, the convergence condition of speed estimation is deduced. A feedback gain matrix and the condition for shifting to normal operation are subsequently proposed to improve restarting performance [4].

The variable frequency has important usage in the industrial world. The electricity produced from the generating station are normally 50Hz and these frequency is not applicable for most of the application. There are some electrical devices which need variable frequency than the fixed supply frequency. The induction motors are one of the best example for variable frequency drives. The induction motors are used in traction system, mobile power supplies etc. The variable frequency drive has the great demand in industrial applications. The cyclo-converter is such a device which generates variable frequency. This project proposes the Cyclo-converter for induction motor application with neuro fuzzy controller [5].

In this paper AC supply frequency cannot be changed, so this paper uses a thyristor controlled Cyclo-converter which enables the control of speed in steps for an induction motor. The microcontroller used in this project is from 8051 family, a pair of slide switches is provided to select the desired speed range (F, F/2 and F/3) of operation of the induction motor. These switches are interfaced to the microcontroller. The status of the switches enables the microcontroller to deliver the pulses to trigger the SCR's in a dual bridge. Thus, the speed of the induction motor can be achieved in three steps i.e. (F, F/2 and F/3).

The speed control of asynchronous motor (AM) or induction motor (IM) can be varied by varying the slip 'S' or number of poles 'p' or frequency 'f' of the supply. The ability of varying any one of the above three quantities will provide methods of speed control of an induction motor. Constant V/F method is commonly used for constant and variable speed control of induction motor. The different methods of speed control of IM can be broadly classified into scalar and vector control methods. In this paper, scalar control methods are used.

In this paper, speed control of induction motor using cyclo-converter is presented. The brief outline of this paper is as follows. In section II, overview of cycloconverter is given. In section III, modeling of split phase induction motor is discussed. Section IV, presents the hardware results followed by conclusion in section V.

II. Overview Of Cyclo-Converter

The single-phase to single-phase Cyclo-converter with mid-tap transformer type converter is shown in Fig.1, this type of arrangement midpoint tap transformer is use to obtain variable voltage and variable frequency. Waveforms shown are obtained by varying the number of cycle covered by positive and the negative converters and firing angle.

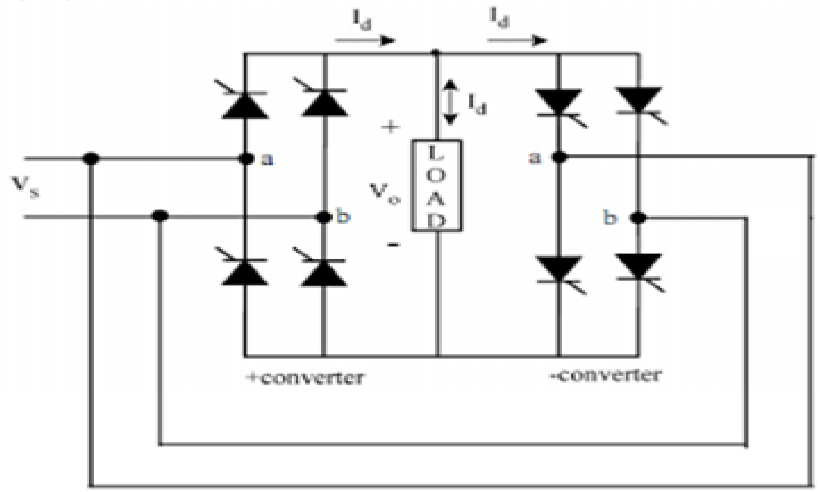

Fig. 1: single-phase to single-phase Cyclo-converter with mid-tap transformer

The frequency can be varied by varying the conduction period for each MOSFET. The gate pulse for SCR can be provided by either by using firing circuit. Here for positive half cycle of input or supply. T1, T2' are forward biased, T1 is given pulse. For negative half cycle of input or supply T1', T2 are forward biased. T1' is given pulse. For another positive half cycle T2' is given pulse. For another negative half cycle T2 is given pulse. By using Cycloconverter we can vary voltage and frequency. As AC motor characteristics require the applied voltage to be proportionally adjusted whenever the frequency is changed in order to deliver the rated torque this method is also called volts/hertz. For optimum performance, some further voltage adjustment may be necessary especially at low speeds, but constant volts per hertz are the general rule. This ratio can be changed in order to change the torque delivered by the motor.

III. Modeling Of Split Phase Induction Motor

Split phase induction motors are usually constructed with two windings on the stator side and squirrel cage winding in the rotor side. The auxiliary winding is used to produce a rotating field to start the motor. The axis of the auxiliary winding is placed 90 electrical ahead of the main winding as shown in Fig.2. The lively simulation of the motor is presented in the stationary d-q frame to facilitate the application of the inverter and, later on, the feedback regulators. Since the axis of the main and auxiliary windings are already orthogonal, the stationary d-q axes are chosen aligned with the orthogonal axes of the physical windings. The squirrel cage rotor is represented by equivalent two coils transformed to the stationary d-q axis as shown in Fig.2.

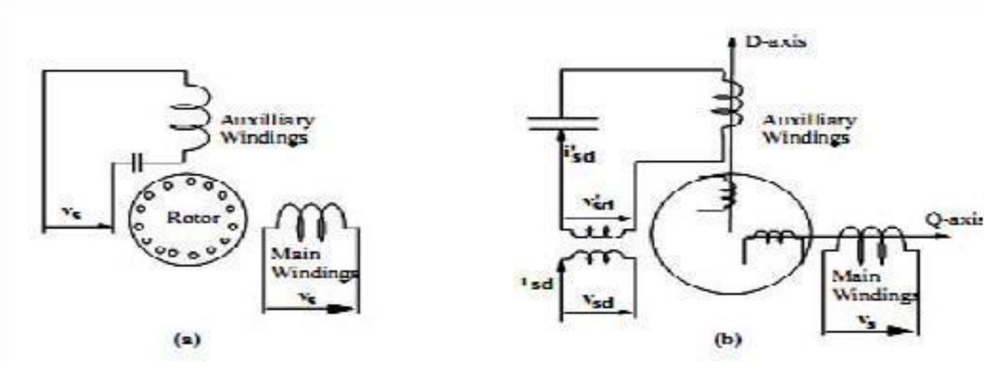

Fig.2.d-q Transformation of the Split Phase Induction Motor

Since the two stator windings; namely the main and auxiliary coils, have different number of turns, they will yield different mutual reactance. Therefore, a transformation is made to transfer the auxiliary winding to an equivalent winding with the same number of turns as that of the main coil. The new variables referred to the equivalent coil are given as follows:

$$V'_{sd} = V_{sd}.(N_{sq}/N_{sd}) \quad (1)$$

$$r'_{sd} = r_{sd}.(N_{sq}/N_{sd})^2 \quad (2)$$

$$X'_{sd} = X_{sd}.(N_{sq}/N_{sd})^2 \quad (3)$$

$$X'_c = X_c.(N_{sq}/N_{sd})^2 \quad (4)$$

The voltage equation of the motor can be written in the d-q stationary frame as

$$V'_{sd} = r'_{sd} i'_{sd} + \frac{1}{\omega_0} \dot{\Psi}_{sd} + v'_c \quad (5)$$

$$V_{sq} = r_{sq} i_{sq} + \frac{1}{\omega_0} \dot{\Psi}_{sq} \quad (6)$$

$$0 = r_r i_{rd} + \frac{1}{\omega_0} \dot{\Psi}_{rd} + \frac{\omega_r}{\omega_0} \dot{\Psi}_{rq} \quad (7)$$

$$0 = r_r i_{rq} + \frac{1}{\omega_0} \dot{\Psi}_{rq} - \frac{\omega_r}{\omega_0} \dot{\Psi}_{rd} \quad (8)$$

$$v'_c = \omega_0 X_c \mathbf{i}_{sd} \quad (9)$$

The equations of motion are given by:

$$T_e = \frac{P}{2\omega_0}(\Psi_{sd} i_{sq} - \Psi_{sq} i'_{sd}) \quad (10)$$

$$\dot{\omega}m = \frac{P}{2J}(T_e - T_l - T_{damp}) \quad (11)$$

Where:

Ψsd and Ψsq Stator leakage flux in d-q co-ordinates

ψrd and ψrq Rotor leakage flux in d-q co-ordinates

IV. Hardware Result

After applying our desired control strategy. Microcontroller 8051 triggers the cycloconverters circuit for different stages of speed with the help of switches given to change the speed of induction motor. Hence we have obtained F, F/2 and F/3 of the rated speed. during checking of speed at normal supply frequency i.e 50Hz, speed observed was 1304 rpm. Its rated speed of the motor and during F/2 frequency of normal supply frequency i.e. 25Hz. Speed observed was 600 rpm it is below the rated speed of the motor. And during F/3 frequency is 16.67Hz, speed observed was 218 rpm it is below than F/2 frequency.

Sr. No.	Frequancy in (F)	Frequancy in Hz.	Speed in rpm
1.	F	50Hz	1304
2.	F/2	25Hz	600
3.	F/3	16.67Hz	217.8

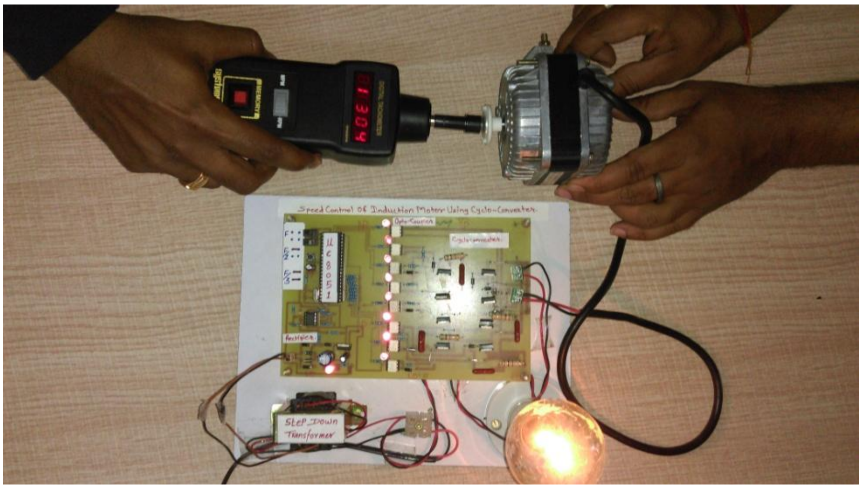

Fig. Speed of induction motor at F

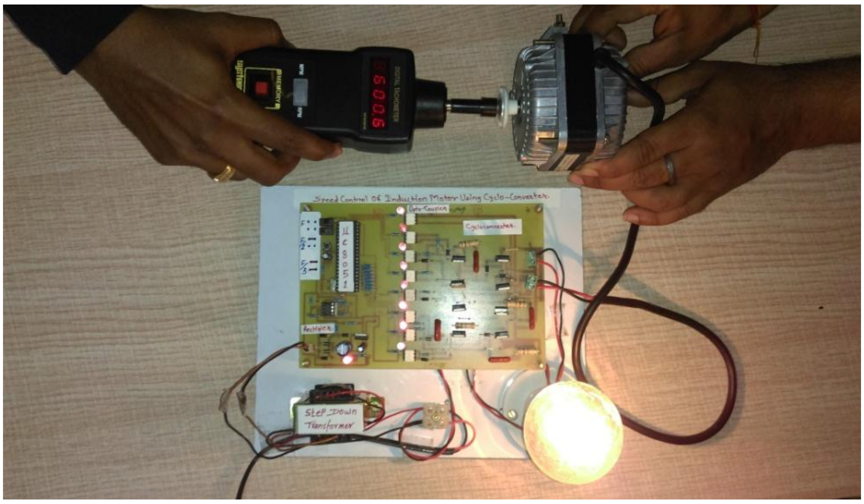

Fig. Speed of induction motor at F/2

V. Conclusion

The cyclo-converter circuit have designed for speed control of induction motor for adjustable frequency. Single phase Cyclo-converter used to change the speed of induction motor with the help of microcontroller, different desired frequency is obtained to equalize the desired speed. This different frequency of cyclo-converter is obtaind in the manner of adjustable speed to F, F/2 & F/3. Furthermore, it provides means for limiting the slip and consequently the motor current, also high voltage circuit from affecting the system receving the signal can be prevent with the help of opto-coupler. This means a reduction in the Cyclo-converter rating and better efficiency.

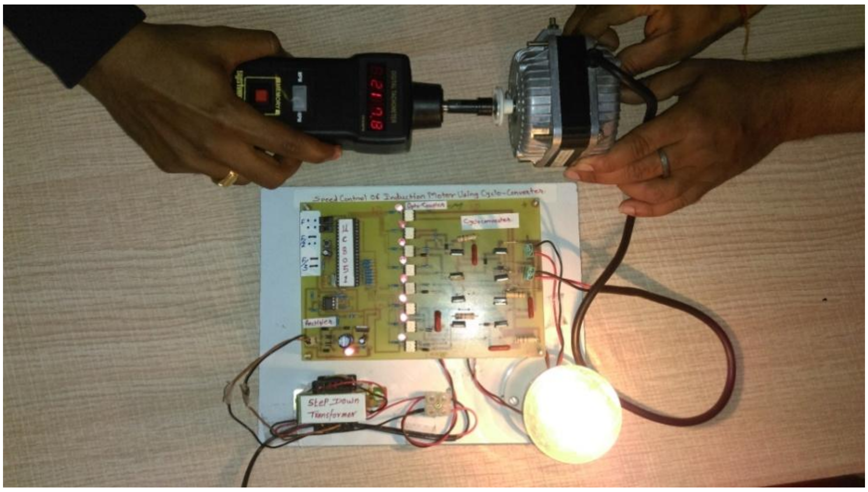

Fig. Speed of induction motor at F/3

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