Speed Control Of Single Phase Induction Motor Using Cyclo-Converter

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Abstract- *The monumental aim of this paper is to provide speed control of single phase Induction Motor. This is done with the help of cycloconverter. Cycloconverter tecnique is designed with thyristors. In industry and domestic applications, use of induction motor is incresing because of their robust construction and low cost. Generally induction motor are considered as constant speed motors.But for some applications variable speed of induction motor is required. Hence it is necessary to develop a speed control method for induction method. The speed of induction motor is given by the equation NS=120f/p. From this equation conclusion comes as the speed is directly proportional to the frequency and inversely proportional to number of poles. Hence to change the speed, either frequency or number of poles should be changed. In running condition, number of poles cannot be changed. Also this will make motor bulky. Hence variable frequency is good option for speed control. Here to change the frequency of AC supply, thyristorized cycloconverter has been used which enables the control of speed in steps. Cycloconverter is a power electronic device which converts Constant Voltage Constant Frequency AC power to Variable Voltage Variable frequency AC power without dc link. The frequency is varied under running condition.*

Keywords- Split Phase Induction Motor, Cycloconverter, Thyristors, Opto-isolator, AT89C51 Microcontroller.

I. INTRODUCTION

Induction motors are the most widely used motor in the industry due to their reliability and rugged construction. If speed control of motor becomes more easy and versatile then it is easy to replace other costly and controllable motors. Single Phase power system is widely used for domestic, commercial and industrial application. As a result of advantages of induction motor like simple construction, less cost, reliability and easy maintenance, induction motor have applications such as centrifugal pump, blowers, vacuum cleaner, washing machines, small toys etc[3,4]. The induction motor is also called as constant speed motor. The difficulty of variation in its speed by a cost effective method is a difficult task. Hence this is a disadvantage of induction motor. Speed control of induction motor is therefore a captivative issue for researchers. The main objective of the work is to make cheap and reliable speed control system for single phase induction motor. Many authors have proposed different methods for speed control of induction motor. These include sliding mode control [2], fuzzy logic control [3], model predictive-control [4] and cyclo-converter [6-8]. The speed control methodology depends on factors that affect rotor speed [6]. The synchronous speed of induction motor is given by equation,

$$N_s = \frac{120f}{p} \qquad (1)$$

Rotor speed is given by equation,

$$N_r = N_s (1\text{-}S) \qquad (2)$$

$$N_r = \frac{120f}{p} (1\text{-}S) \qquad (3)$$

Where, N_r = Rotor speed

N_s = Synchronous Speed
F = Supply Frequency
P = Number of poles
S = Slip

From equation no. (3), conclusion comes out as speed of motor depends on supply frequency, number of poles and slip. Hence the speed can be changed by varying any of above three parameters. This will lead to different methods of speed control of induction motor.

II. CYCLO-CONVERTER

Commonly the electrical energy is available in the form of constant AC and constant DC. For different applications various forms of these two energies are used. Hence these signals are converted into one form to another form for different applications.. For this conversion process different converters are used such as rectifier, inverter, chopper and cyclo-converter. Rectifier converts single phase or three phase AC signal to variable DC signal. Inverter converts from DC signal to variable magnitude variable frequency single phase or three phase AC. Chopper converts DC signal to variable DC signal. Cyclo-converter converts from single phase or three phase AC to variable magnitude

variable frequency AC. Therefore cyclo-converter is chosen for obtaining variable frequency to control the speed of induction motor.

Cyclo-converter converts AC power at one frequency to an AC power of an adjustable frequency without any DC link. There are mainly two types of cyclo-converter Blocking Mode and circulating current mode. The working of cyclo-converter can be understood with the help of its three types as single phase to single phase cyclo-converter, three phase to single phase cyclo-converter and three phase to three phase.

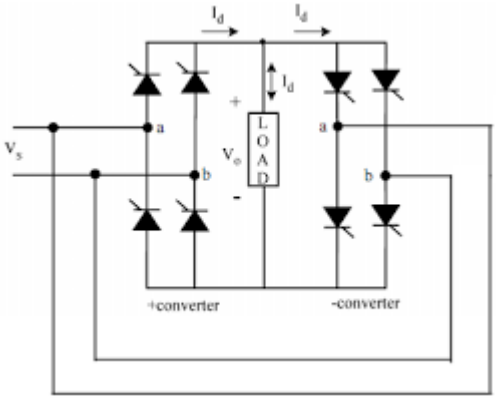

Fig.a. Single Phase to Single phase cyclo-converter[5]

In this converter two full wave rectifiers are connected back to back. Suppose output required should be one fourth of input voltage. Then for the first two cycles, positive converter will operate. This will provide output current to the load and input voltage gets rectified. For the next two cycles, negative converter will operate. This will provide output current to the load but in opposite direction. Simultaneously both converters cannot operate. This can cause short circuit in the circuit. By controlling switching periods of thyristors, time period of both positive and negative half cycles are changed and hence the frequency. This frequency of fundamental output can be easily reduced in steps like 1/2,1/3,1/4 and so on. Duration of conduction of each positive and negative converter determines desired output frequency.
The following figure shows waveforms for single phase to single phase cyclo-converter.

(a) Input Voltage
(b) Output Voltage with zero firing angle
(c) Output Voltage with p/3 firing angle
(d) Output Voltage with varying firing angle

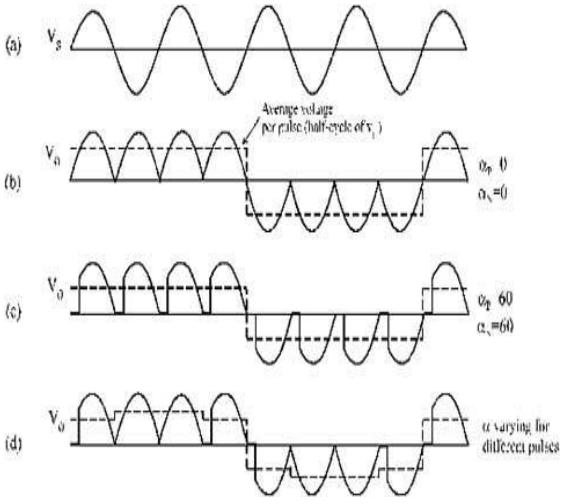

Fig.b.Waveform for Cyclo-converter [7].

III. AT89C51 MICROCONTROLLER

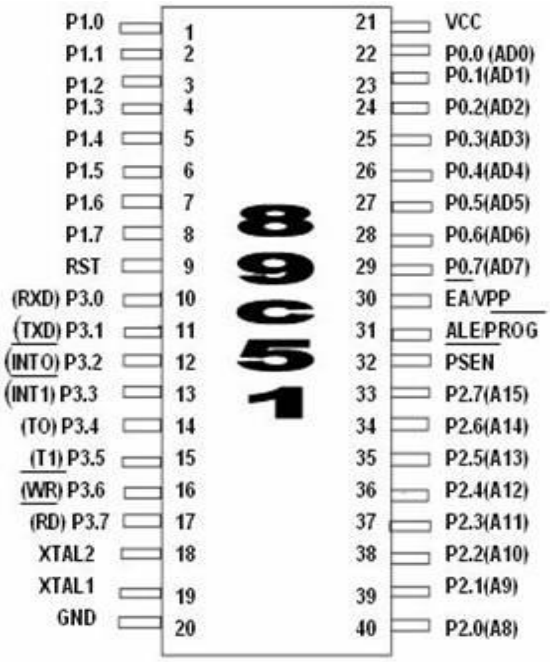

Fig.c. Pin Description of 89C51 Microcontroller

The microcontroller 89C51 is compatible with MCS51 family. It has 4K bytes of onchip reprogrammable flash memory. It has 8bit data bus and 8bit arithmetical logical unit (ALU). It has 16 bit address bus and 64Kb of random access memory (RAM) and read only memory (ROM). It consists of one UART programmable serial port, six interrupts source, two multi mode 16bit timers. It also consists of power saving mode. In 40 pin AT89C51, there are four 8 bit bidirectional ports as port0, port1, port 2 and port 3. All these ports are having internal pull-ups except port 0 which requires external pull-ups. These ports can be used as not only input port but also output port. The purpose of use of micro-

controller is to provide control action over firing angle of thyristors in the cyclo-converter.

IV. BLOCK DIAGRAM

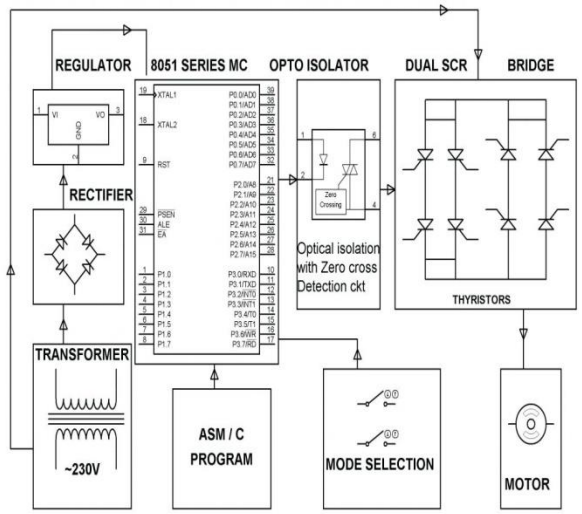

Fig.d. Block Diagram for Speed Control of Single Phase Induction Motor[1]

Power supply consists of transformer, rectifier and voltage regulator**.** Micro-controller requires 5V DC supply for its operation. This supply is feed by power supply. Transformer will step down the voltage then rectifier will convert it into DC voltage. Regulator is used to get constant voltage of 5V. Micro controller will send the signal to the opto isolator which will control the gate pulse of thyristor. Microcontroller provides time delay according to program feed into it. Programming language used is c language. Opto isolator is a device which uses short optical transmission path to transfer the signal from its input to output while keeping them electrically isolated from each other. Opto-isolators protects high voltages from affecting the system receiving the signal. Opto isolator provides electrical isolation between micro-controller and cyclo-converter. The cyclo-converter is connected to induction motor. In mode selection, frequency is selected i.e. F, F/2,F/3. This frequency selection switch is connected to micro-processor. According to selected switch, frequency is controlled by using cyclo-converter.

V. CONCLUSION

The circuit is designed for speed control of induction motor which adjusts the frequency. Cyclo-converter performs role of converter which changes the supply frequency. By using this circuit, desired frequency is obtained to get the desired speed. The various frequencies obtained to get variable speed are F,F/2,F/3. In addition to this, the circuit provides instrumentality for limiting the slip. This makes impact on motor current. The opto-coupler is used to govern the operation of the switch or another type of digital input signal. All these thing reduces the rating of cyclo-converter and gives better efficiency.

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