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Induction Motor Drive Using Thyristor Based Cycloconverter for Variable Torque Load Application

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ABSTRACT

We have designed this project to control the speed of a single phase induction motor by using cycloconvertor technique by thyristors. 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. A.C. motors have the great advantages of being relatively inexpensive and very reliable. 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. As the AC supply frequency cannot be changed, so this project uses a thyristor controlled cycloconverter which enables the control of speed in steps for an induction motor. 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 thyristors 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). This very concept can be further enhanced and implemented to control the speed of a three phase induction motor. It can also be coupled with firing angle control for any desired speed.

Keywords: Cycloconverter, Induction Motor, Voltage Regulator, Supply Frequency

I. INTRODUCTION

In industrial applications Speed control of induction motor is necessary. There are several methods for the speed control of induction motor. Cycloconverters are used in very wide variable frequency drives with ratings from few megawatts up to many tens of megawatts. A cycloconverter is controlled through the timing of its firing pulses, so that it produces an alternating output voltage. It can also be considered as a constant frequency changer and typically contains silicon-controlled rectifiers. The development of the semiconductor devices has made it possible to control the frequency of the cycloconverter according to the requirement and deliver a large amount of controlled power with the help of semiconductor switching devices like thyristors, in order to get alternating output of variable frequency. The quality of the output waveform improves if more switching devices are used. Split-phase induction motors are widely used in many applications due to their energy efficient characteristics. Improvements in its performance mean a great saving in electrical energy consumption. Thus, a cycloconverter has the facility for continuous and independent control over both its output voltage and frequency.

This paper uses a thyristor controlled cycloconverter which enables the control of speed in steps for an induction motor. 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).

Traditionally we use the converter and inverter to vary the AC supply frequency (i.e. it converts AC to DC by using converter and then inverter for DC to AC) to change the frequency which is very costly and complicated. Due to this switching of AC to DC and DC to AC the noise produces also the harmonics creates so the sensitive electronic devices may get damaged ,if the input and output waveforms is small then sub harmonics also get produced and this limitation is overcome by using the cycloconverter i.e. Intermediate DC stage is not used in this conversion.

Cycloconverter is used to convert the AC supply frequency from one input frequency to another output frequency. Cycloconverter is used for high power applications for driving induction and synchronous motor. So, cycloconverter is used for providing a variable frequency due to its 4-quadrant operation .Intermediate DC stage is not used in this conversion. In cycloconverter power flow is bidirectional.

II. LITERATURE SURVEY

Anshu Sharma, Shilpi Sisodiya ; A Survey on Single Phase to Three Phase Cyclo-Converter Fed Induction Motor ; IJSRD - International Journal for Scientific Research & Development| Vol. 3, Issue 10, 2015 | ISSN (online): 2321-0613 ;Page no. 815

In this paper presents a survey on 1-ϕ to 3-ϕ cycloconverter technique using thyristor with 3-ϕ induction motor along load frequency analysis. The cycloconverter is inspected in its outmost straight forward form without further output filters or elaborate control technique. This paper is the survey of applications of cycloconverter fed induction motors to electrical energy system. Frequency changers are an extending field of power conversion innovation. The increasing usage of ac motors in the production of electrical power from variable speed sources are illustrations of this area application. Currently systems of frequency changers incorporated rotating machines. These systems have been to a great extent supplanted by static frequency changers utilizing power semiconductor devices.

Kamaljeet Singh Thakur ,C. S. Sharma; Modeling and Simulation of Single Phase to Three Phase Cycloconverter for Low Cost AC Motor Drives; international journal of innovative research & development; may, 2014 vol 3 issue 5;page no.160

This paper presents Matlab modeling and simulation of Single phase to three phases Cycloconverter for driving three phase induction motor and analysis of torque for various frequencies. The proposed converter employs only six naturally communicated thyristor, so the resulting Cycloconverter-motor drive system is cheap and compact, however single phase to three phase modulation strategy is proposed on the basis of variable frequency technique.

The conventional method for conversion of a single phase to three phase voltage is the utilization of rotator, capacitor or autotransformer converters. Most of these converters remain balanced only at one specified load. There are also many converter topologies that can transform a single phase AC Voltage into variable into variable voltage, variable frequency three phase voltage supply.

Atul M. Gajare, Nitin R. Bhasme; A Review on Speed Control Techniques of Single Phase Induction Motor ; International Journal of Computer Technology and Electronics Engineering (IJCTEE) Volume 2, Issue 5, October 2012; page no.33

In this paper, various types of speed control methods for the single phase induction motor are described. This research paper explains speed control of single phase induction motor by means of frequency ,its implementation and test result also the power conversion section in the given speed drive is consisting IRF840 N-channel MOSFET as a switching element.. A variable-frequency drive (VFD) is a system for controlling the speed of a rotational or linear alternating current (AC) electric motor by controlling the frequency of the electrical power supplied to the motor. A variable frequency drive is a specific type of adjustable-speed drive. Variable- frequency drives are also known as adjustable-frequency drives (AFD), variable-speed drives (VSD), AC drives, micro drives or inverter drives .The multispeed operation and multipurpose operation are provided by controlling the speed of these motors.

M. Narayanan ,R. Vidhya , P. Yuvaraj ;Phase Angle Control method of Speed Control of Single Phase Induction motor ;international journal of innovative research in electrical, electronics, instrumentation and control engineering; vol-3 ,Issue 11 Nov 2015 ;Page no.111-114, The study of power electronic converters is vital to gain knowledge on Variable Speed Drives or Energy Efficient Drives. Induction motors are the load which contributes to about 70% of total loads used in the world Variable speed drives are employed for industrial processes and in many applications. In this paper ac – ac voltage controller is used to vary the input voltage to control the speed of the induction motor. The effect of harmonics and Total Harmonic Distortion (THD) is also studied in this paper.

To obtain energy efficiency instead of running machines at a constant speed, speed control method is used. The conventional speed control methods suffer from various disadvantages like mechanical wear and tear, frequent maintenance requirement, less efficient and bulky. Therefore the use of power electronic devices and controllers play a vital role it improving the above factors and also help them in soft starting.

III. METHODOLOGY

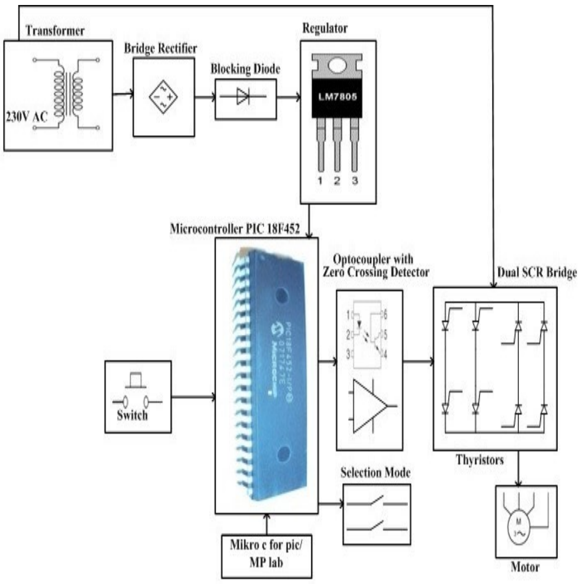

Figure 1. Schematic Diagram

Sathish Bankanagari , Jagadeep Peddapudi , A. Mahesh Kumar; A Novel Approch to Speed Control of Induction Motor by Cyclo-converter with Thyristors; Sathish Bakanagari et al Int. Journal of Engineering Research and Applications www.ijera.com ISSN : 2248-9622, Vol. 3, Issue 6, Nov-Dec 2013, pp.2159-2164 The project 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. As the AC supply frequency cannot be changed, so this project uses a thyristor controlled cycloconverter 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. Thus, the speed of the induction motor can be achieved in three steps i.e. (F, F/2 and F/3).

Cycloconverter consists of two single phase full bridge circuits bridge1 and bridge 2, load is connected in between these two bridge circuits as shown in figure. Each bridge consists of four thyristors. From these upper group thyristors are positive and lower group are negative group thyristors. These thyristors gate pulses are controlled by zero crossing detector and microcontroller. The firing angle control consists of eight MOC 3021 opto-isolators. MOC 3021 contains a LED and a light sensitive TRIAC. When the LED s switched on then the TRIACs in MOC3021 gets the input and they turn on. The opto-isolators (MOC 3021) isolate the high frequency modulated driver control circuit with low frequency cycloconverter circuit. At time t=0+ the thyristors on the 1^{st} bridge to switch on for predefined time period t, during this time period to other bridge is kept off position. To control the speed of the induction motor frequency control of the output voltage by turn-On and turn-Off time periods of the thyristors. When the switch 1 is closed SCR gets conducting for 20 ms for first bridge and next 20ms for second bridge so the total time period of AC cycle is 40 ms, so it gives the frequency 25Hz i.e. F/2. When the switch 2 closed the time period of conduction for the 1st bridge takes place for 30ms and then other bridge for 30ms,so the total time period of AC cycle is 60ms 16.66 Hz i.e. F/3. This supply is given to the motor by using F/2 and F/3supply we can control the speed of the AC motor

IV. CONCLUSION

In manufacturing and process industries, the variable frequency is required for driving various electrical machineries. The cycloconverter or variable frequency generator plays a significant role in driving those electrical machineries. The study mainly focuses on the design and construction of the single phase cycloconverter. The commercially designed single phase cycloconverter circuit may use different design pattern than this one. This single phase cycloconverter circuit can be extended further for three phase application. In case of the three phase cycloconverter, each of the positive and negative converter group operates for half the period of the output frequency.

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