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 cycloconverter 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 thyristor 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. Cycloconverter 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. SCHEMATIC DIAGRAM

Fig. 1: Schematic Diagram

III. WORKING

Cycloconverter consists of two single phase full bridge circuits bridge 1 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 1st 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.

Fig. 2: Single phase cycloconverter
IV. CYCLOCONVERTER

The single phase to single phase cycloconverter connects with split phase induction motor as shown in Fig.4. Which is operating without circulating current; the non-conducting thyristors should always be kept off otherwise the input power supply could be shorted. When the load current is positive, the output voltage is only controlled by phase control of thyristors T1 and T3 at the same time, the other two negative thyristors T2 and T4 are kept Off and vice-versa when the load current is negative. When the load current changes its direction at the same time ensuring that the two thyristor half bridges do not conduct at the same time.

V. MATLAB SIMULINK MODEL

SIMULINK model of single phase to single phase cycloconverter and single phase induction motor is shown in Fig 2 and 3, respectively. The objective of this work is to analyses the speed of single phase induction motor performance for various output frequency of the 1-phase cycloconverter.

![Single phase cycloconverter SIMULINK model](image1)

![Split phase induction motor with cycloconverter](image2)
VI. RESULTS AND DISCUSSION

After applying the control strategy, the proposed cycloconverter simulation results are shown in Fig.5 and Fig.6. The simulation starts with the generation of 50 Hz reference sine wave.

![Input and Output waveforms.](image1)

**Fig. 5: Input and Output waveforms.**

![Speed Vs time period output of single phase induction motor.](image2)

**Fig. 6: Speed Vs time period output of single phase induction motor.**

VII. 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.

REFERENCES


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