Speed Control of Induction Motor using SCR Based Cycloconverter for Variable Torque Load Drive Application

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Abstract— The cycloconverter 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. Single-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. A cycloconverter fed variable frequency motor is a typical example of such improvement. In this regard, the paper presents an analysis of the performance and speed control of the split phase induction motor when it is fed with cycloconverter. The various speed of induction motor is obtained by varying the supply frequency by using cycloconverter. The speed control by this method is simple and can be made economical by using different methods to control the operation of cycloconverter which in turn controls the performance of motor. The formula for speed for induction motor is Ns=120f/p. from this formula we can conclude that the speed of the motor can be varied in two ways, one is by changing the number of poles and the other 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 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.

Key words: Single Phase to Single Phase Cycloconverter, Split Phase Induction Motor, Voltage Regulator, Supply Frequency

I. INTRODUCTION

Speed control of induction motor is necessary in industrial applications. There are several methods for the speed control of induction motor. Cycloconverters are used in very large 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 static 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 frequency and voltage. Cycloconverter eliminates the use of flywheel because the presence of flywheel in machine increases torsional vibration and fatigue in the component of power transmission system. 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).

II. SCHEMATIC DIAGRAM

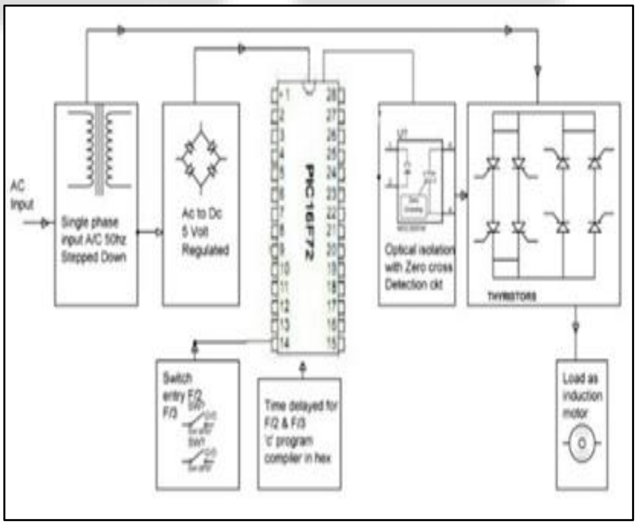

Fig. 1: Schematic Diagram

III. WORKING

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. 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.

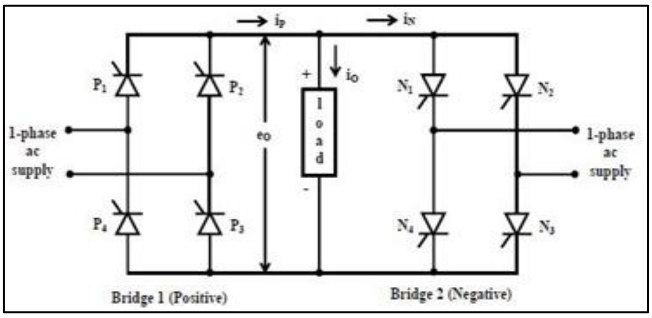

Fig. 2: Single phase cycloconverter

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.

Fig. 3: Hardware model of cycloconverter with induction motor.

V. SIMULINK MODEL

SIMULINK model of single phase to single phase cycloconverter and single phase induction motor is shown in Fig 3. 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.

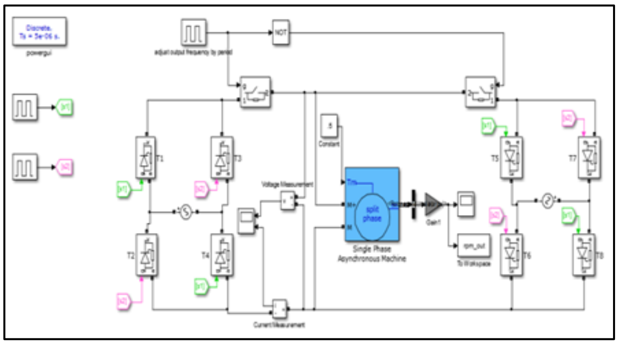

Fig. 3: Split phase induction motor with cycloconverter

VI. RESULTS

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.

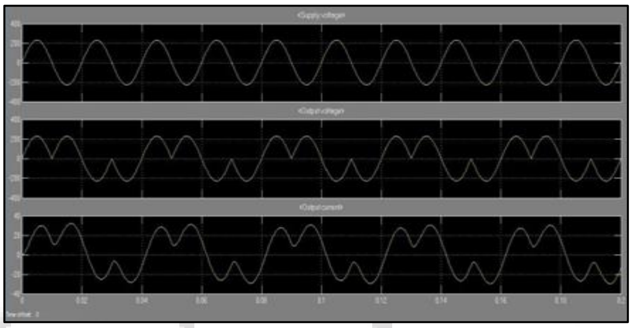

Fig. 4: Input and Output waveforms.

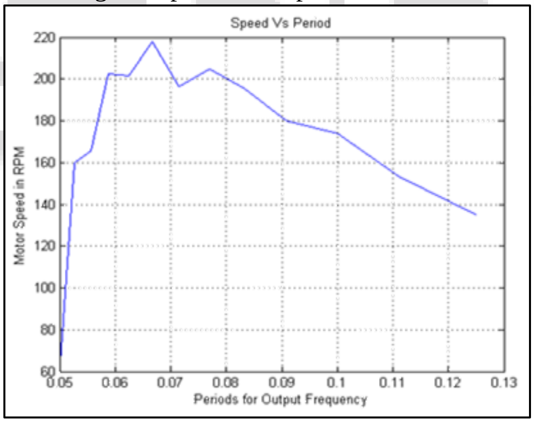

Fig. 5: Speed Vs time period output of single phase induction motor

Supply frequency (Hz)	Output Frequency (Hz)	Speed of induction motor (rpm)
50	50	1434
50	25	762
50	16.66	500
50	10	405

Table 1: Simulation Data (Change in frequency and speed)

VII. CONCLUSION

The cycloconverter circuit are designed and simulated and finally desired results are obtained. The single phase cycloconverter employed for split phase induction motor to give supply torque characteristic matching with demand torque characteristics of particular machine by the use of designing cycloconverter different desired frequency can be obtained. The different frequency of cycloconverter is useful to replace flywheel from operating machine which reduces the cause of torsional vibration and fatigue damage of machine. The paper proposed a feedback control system of cycloconverter fed split phase induction motor. Furthermore, it provides means for limiting the slip and consequently the motor current. This means a reduction in the cycloconverter rating and better efficiency. The results obtained using MATLAB for single phase cycloconverter fed induction motor.

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