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Speed Control of AC Motor Using Frequency Control Method

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***Abstract*—As Induction Motors are widely used for many purposes, their speed control may be required in many applications. There are many methods of speed control of induction motor like pole changing method, stator voltage control and rotor resistance control but here we are using speed control of induction motor using cycloconverter. The disadvantage of pole changing method is that, this method is not economical. Also number of poles can't be varied in running condition and machine size become bulky. This drawback can be overcome by using changing frequency and this is done by the Cycloconverter. In this method frequency can be varied under running condition and also there is no change in machine size which is beneficial for industrial application.**

***Index Terms*—Single Phase Induction Motor, Speed Control, Cyclo-converter**

I. Introduction

Nowadays Induction motors are the widely used electrical motors. Because, motors do not intrinsically have the capability of variable speed operation. As a result of this reason, earlier dc motors were applied in most of the electrical drives. Recently noticeable exertions have been made in adjustable speed single phase induction motor drives. But the recent evolution in speed control methods of the induction motor has given rise to their broad use in almost all electrical drives.

In this work, a cycloconverter will be used to control the speed of a single phase induction motor. Cycloconverter is a frequency converter that converts AC (alternating current) power at a certain frequency into AC power of another frequency without the help of any intermediate DC (direct current). It converts fixed voltage, fixed frequency AC input to variable voltage, variable frequency AC output.

The single-phase induction motor can successfully be driven from a variable frequency power supply. Hence, the motor speed can be easily adjusted. Other methods for speed control, such as voltage amplitude control do not allow for the range of speed, which is achievable with the use of a variable frequency supply.

II. Single Phase Induction Motor

Improvements in induction motor performance mean a great saving in electrical energy consumption. Single phase motors are very extensively used in home, offices, workshops etc. The power distributed to most of the residences and offices is single phase. The single phase motors are reliable, economical, simple in construction and easy to repair. Single phase induction motors usually have a construction similar to that of a three phase motor: an AC windings is placed on the stator, short-circuited conductors are placed in a cylindrical rotor. The important difference is that there is only a single phase supply to the stator. Its characteristic features are:

1. Simple and rugged construction
2. Low cost and minimum maintenance
3. High dependability and sufficiently high proficiency

The motor construction, the way electric power is supplied and improvement in performance this all factors give the induction motor several advantages

Less cost: As compared to synchronous and DC motors Induction motors are very cheap. This is because the quiet simple design of induction motor. Therefore, these motors are intensely preferred for fixed speed applications in industrial applications and for commercial and domestic applications.

1. *Speed Variation:* The Induction motor is constant speed motor. The speed generally varies only by a few percent going from no load to rated load.
2. *Less maintenance cost:* Induction motors are maintenance free motors unlike dc motors and synchronous motors. The construction of induction motor is quite simple and therefore maintenance is also easy which resulting in low maintenance cost.
3. *High starting torque:* The Induction motor have very high staring torque which makes motor suitable for operations where load is applied before the starting of the motor. Three phase induction motors will have self-starting torque unlike synchronous motors. Yet single-phase induction motors does not have self-starting torque and are made to rotate using auxiliary winding.

4. *Durability:* The major advantage of an induction motor is that it's durability. This makes it quiet essential machine for many uses. This results the motor to run for long duration with no cost and maintenance.

III. AC Motor Speed Control

Generally for changing the speed of motor V/F control method is used in which single phase cycloconverter is used to control the speed. The speed of induction motor is directly proportional to the supply frequency and the no. of poles of the motor. Since the number of poles are fixed according to design, the best approach to vary the speed of induction motor is by changing the supply frequency. By changing the voltage and frequency but keeping the V/F ratio constant, throughout speed range. This type of exact result v/f control method tries to accomplish. In the industrial world, the variable frequency technique has always been of great importance.

In India the generating station generates electricity of the fixed frequency of 50 Hz. which is not always suitable for some electrical appliances. There are some electrical devices which need variable frequency ranging from one tenth up to one third of the supply frequency. The rotor speed of an induction motor is shown below,

Nr = Ns (1-S)

But,

Ns = 120f/p

Where, Nr = rotor speed

Ns = Synchronous speed

F= Supply frequency

P= Number of poles

Above equations shows that the speed of an induction motor depends on the supply frequency, the number of poles and the slip.

IV. Cycloconverter

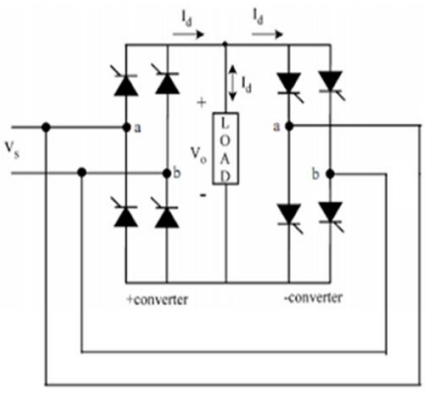

Fig. 1. Single-phase to single-phase cycloconverter

In industrial applications, we use two forms of electrical energy: direct current (dc) and alternating current (ac). Usually constant voltage constant frequency single-phase or three-phase ac is easily available. But, for various applications, different forms, amplitudes and frequencies are required. Between ac and dc power sources. There are four different conversions. These classifications of conversions are done by circuits called power converters. The converters are classified as:

1. Rectifiers: Convert single or three-phase ac to variable dc.
2. Choppers: Convert fixed dc to variable dc voltage.
3. Inverters: Convert dc to variable phase ac or magnitude or frequency.
4. Cycloconverters: Convert single or three-phase fixed ac to single-phase or three-phase ac with variable magnitude or variable frequency

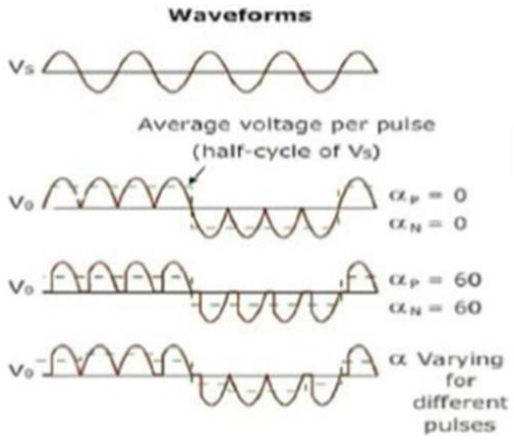

Fig. 2. Waveform of single-phase to single-phase cycloconverter

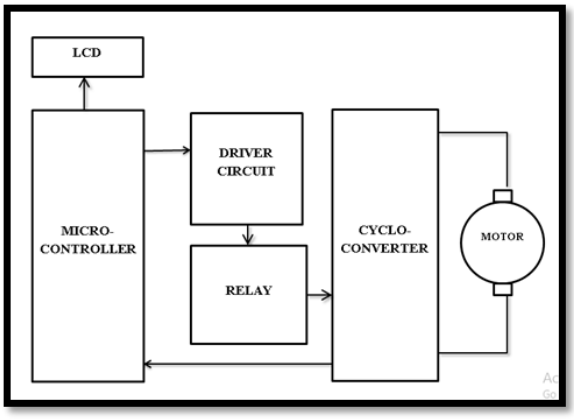

Fig. 3. Block diagram

A cycloconverter is a device which has capability to convert AC power at one frequency into AC power of an adjustable but at lower frequency without any DC link. From the power converters family used for driving electric motors, cycloconverter have the main advantages of its natural commutation and less consumption of energy. With these two desirable advantages its use in variable speed motor drives up to 1400rev/min and in broad frequency range applications with high frequency is most assuring. Cycloconverters are used in very large variable frequency drives with ratings from very few megawatts up to many 10s of megawatts. For a precise

production of alternating output voltage a cycloconverter is controlled through the timing of its firing pulses. The advancement of the semiconductor devices has made it achievable to control the frequency of the cycloconverter according to the demand and convey an immense amount of controlled power with the help of semiconductor switching devices like SCR, IGBT, MOSFET's in order to get alternating output of variable frequency. The quality of the output waveform can improves if more switching devices are used.

The above block diagram shows a scheme for speed control of single phase AC motor .The speed variation is based on frequency control mechanism. This mechanism consists of a Gate firing circuit for the switches used in the cycloconverter which is based on a microcontroller and a motor driver. Simultaneously the LCD is to be interfaced with controller so as to display the operating speed of the motor through programming.

V. Application

A few applications of this type of converter are Rolling mill drives, Ore grinding mills, Scherbius drives and Mine winders. All the applications of this type of drive are found more dynamic where the high power and low speed is required. Because of the use of the SCRs, MOSFETs and other power devices these drives are economically stand better than any other drives. High power handling capability with larger torque and lesser speed is the unique specialty of such converters.

The converters are used in low power applications and widely used in domestic applications as well as industrial applications. Some of the applications are mentioned below

1. Cement mill machine
2. Ship propulsion drives
3. Pumps
4. Washing Machine
5. Compressors
6. Mixers
7. High speed vacuum cleaners
8. Electric shavers
9. Drilling machines

VI. Conclusion

In process and manufacturing industries, the variable frequency is required for driving various electrical machineries. The cycloconverter plays a significant role in driving those electrical machineries. The study mainly focuses on the design and construction of the single phase cycloconverter.This single phase cycloconverter circuit can be extended further for three phase application.

From this work and result analysis, it is conclude that speed of an induction motor can be efficiently controlled by using Cycloconverter. The role of Cycloconverter in speed control of induction motor is to vary the supply frequency which in turn, deviate the speed of motor. In this paper presented a speed control of single phase induction motor by using frequency control method. There is various techniques use for conversion but in order to get maximum converter output, appropriate cycloconverter techniques have to be used.

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