Speed Control of Three Phase Induction by Phase Angle Control of TRIAC

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Abstract — It is very important to study the power electronic converters in order to get the knowledge on Variable Speed Drives or Energy Efficient Drives. Most of the induction motors contributes to 70% of the total load used in the world. Most of the variable speed drives find their application in for industrial processes and also in many applications. In this paper ac - ac conversion is used to obtain the desired output voltage by varying the input voltage so as to control the speed of the induction motor.

Index Terms – Drives, Energy Efficient, speed control

1. INTRODUCTION

DC motors have been replaced by induction motors in most of the applications. The reason behind this is its rugged construction, effectiveness in its cost. It has found many applications in residential as well as in industrial aspects. As far as domestic aspect is concerned, induction motor is used in washing machines, refrigerators, pumps, etc. whereas it is used in industrial robots, electric vehicles, elevators in industrial applications.

The most convenient method to achieve energy efficiency is to use the speed control method instead of running a machine at constant speed. The main objective behind a motor speed controller is to receive a signal representing the demanded speed, and to drive the motor at that desired speed. Generally speed of the motor can be achieved by varying the input parameters of motor such as voltage, current, etc.

A three phase induction motor is basically a constant speed motor and hence it becomes quite difficult to control its speed. The speed of induction motor can be controlled but can be achieved at the cost of decrease in efficiency and low power factor. Before studying the methods of speed control of three phase induction motor, let us look at the basic formulae of speed and torque of three phase induction motor as the methods depends upon the them.

$$Ns = 120f/P$$

where, Ns = synchronous speed

f = frequency and P = number of poles.

The speed of induction motor is given by,

$$N = N\, s(1- s)$$

Where N is the speed of rotor of induction motor and S is the slip.

The torque produced by three phase induction motor is given by-

$$T = (3/2\pi Ns)\times sE_2^2R_2/R_2^2+X_2^2$$

When the rotor is at standstill, slip s is one. So the equation of torque becomes,

$$T = (3/2\pi Ns)\times E_2^2R_2/R_2^2+X_2^2$$

Where E2 = rotor emf

Ns = synchronous speed

R2 = rotor resistance

X2 = rotor inductive reactance.

2. SPEED CONTROL

The speed of induction motor can be changed from both stator and rotor side. The speed control of three phase induction motor from stator side are-

1. V/f control or frequency control.
2. Changing the number of poles.
3. Controlling supply voltage.
4. Adding rheostat in the stator side.

The speed control of three phase induction motor from rotor side are-

1. Adding external resistance on rotor side.
2. Cascade control method.
3. Injecting slip frequency emf into rotor side.

In this paper, the speed of an induction motor is controlled by changing the supply voltage and keeping the frequency constant.

3. BLOCK DIAGRAM

The block diagram consist of the following components -

1.AC to AC converter
2.Micro-controller
3. Zero- crossing detector
4. Driver IC
5. Relay

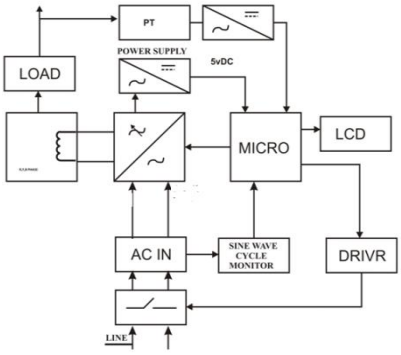

Fig. (a) Block Diagram

4. CIRCUIT DIAGRAM

The circuit diagram shows the operation for a single phase (R). Similar circuits are used for Y and B phase. The transformer is given an input of 220V ac which is stepped down to 12V ac by a step down transformer. Further 12V ac is converted to 12V dc using a full wave rectifier. The Dc ripples are then eliminated using a filter capacitor which is then given to regulator IC7805 at its input and gives 5V dc at its output which is then given to micro-controller 8051. Crystal oscillator is used to generate the clock pulses. The zero crossing detector circuit detects the sine wave passing through zero and gives command to the micro- controller to carry out its function.

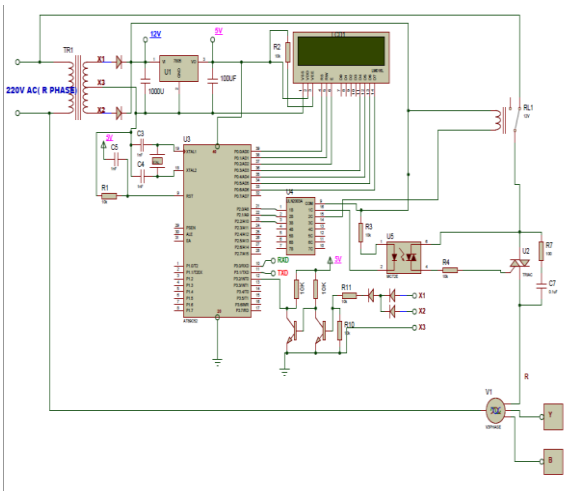

Fig. (b) Circuit Diagram

Opto-coupler is used for electrical isolation so as to protect the micro- controller from damage. Snubber circuit is used to limit the rate of rise of di/dt of current whereas relay operates when the voltage and current exceeds the desired values and protects the entire circuit from damage.

5. PHASE ANGLE CONTROL

In this method, the input voltage is controlled to control the voltage at output. It is a method of pulse width modulation applied to the AC main supply. The main objective is to limit the power supplied to the load. The device used for this control is a TRIAC. By varying the firing angle 'α', the power flow to the load can be controlled. In this method, a gate pulse is given to the TRIAC to trigger it without which there would be no current in the circuit. The mathematical equations

1. $f= 1/2(T/2+ \alpha)$
2. $V_{out} = D \times V_{in}$

where, $D= T_{on}/T_{on} + T_{off}$

The trigger delay angle α is defined as the phase angle at which the thyristors turns on and the load current begins to flow. In brief brief, an ac voltage controller is a type of thyristor power converter which is used to convert a fixed voltage , fixed frequency ac input supply to obtain a variabe voltage ac output. In this method, two thyristors connected in anti-parallel are used as switch to connect the load circuit to the input ac supply. TRIAC is used as a switching device because it can be triggered by both the positive and negative polarity voltages applied to the gate terminal and it requires only one heat sink.

6. CONCLUSION

This paper discusses the speed control of three phase induction motor using phase angle control method. Phase angle control method is used to change the output voltage by varying the voltage at the input and keeping the supply frequency constant. As the conventional method consumed more power, by delaying the angle α, energy can be saved.

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