Application of Phase Angle Control of Triac for Speed Control of Induction Motor

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Abstract – The paper presents the control of AC voltage fed 3 phase Induction motor by using firing angle control of triac. Efficiency of such voltage control is very high compared to any other method. The project uses zero crossing point of the waveform which is detected by comparator whose output is then fed to the microcontroller. The microcontroller provides required delayed triggering control to a pair SCRs through opto-isolator interface. Finally the voltage is applied to the load through the SCRs in series. This project uses a microcontroller 8051 which is interface through a push button switch for increasing or decreasing the AC power to the load.

Index Terms – Microcontroller 8051, Triac, Opto-isolator, Zero crossing detector.

1. INTRODUCTION

Thyristors are now widely used in many power electronics and motor drive applications. This is due to their several advantages such as relatively small size, low losses, market availability, and low cost. In this paper stator voltage control of three phase induction motor using thyristors is analysed. The stator voltage has been controlled by phase angle control of three phase supply. The delay angle and there corresponding resistor values before the thyristor fires has been analyzed. Phase angle control is a method of PWM applied to AC input voltages usually the mains supply. The supply is taken from a transformer. The purpose of phase angle control is to control or limit power to the load.

2. METHOD OF OPERATION

Stator voltage control is basically a method to control the speed of an induction motor. Initially, when the motor is started, heavy current flows through the field winding of the stator because back emf has not yet been induced. This heavy current can damage the coils of the motor. To avoid this, voltage of the stator is reduced.

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

$$T \propto \frac{sE_2^2 R_2}{R_2^2 + (sX_2)^2}$$

In low slip region (sX)2 is very very small as compared to R2 . So, it can be neglected. So torque becomes

$$T \propto \frac{sE_2^2}{R_2}$$

Since rotor resistance, R2 is constant so the equation of torque further reduces to

$$T \propto sE_2^2$$

We know that rotor induced emf E2 ∝ V. So, T ∝ sV2. From the equation above it is clear that if we decrease supply voltage torque will also decrease and hence speed will decrease.

The block diagram for phasor control is shown below:

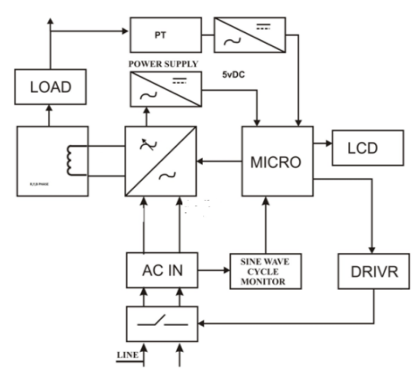

Fig. block diagram

The operation of phase angle control method is illustrated in following circuit diagram:

Fig. Circuitry for phase angle control method

In phase angle control, a gate pulse is send to triac. This is send at a time between one zero crossing and the next. Without the gate pulse send to the triac, right after zero crossing, the triac is OFF and no current flows through it. After a certain time the gating signal is given to the triac and it turns ON. The triac then stays ON until the current through it becomes zero. This is at the next zero crossing.

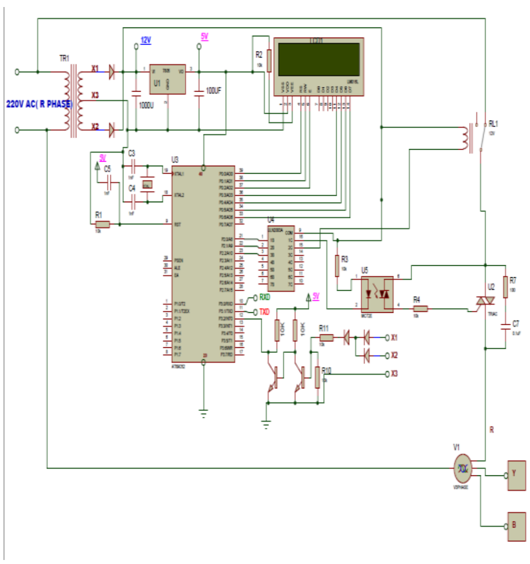

Fig. Circuit Diagram of Phase angle control

The power device used in phase angle controller is a thyristor mostly triac or SCRs. The power flow to the load is control by delaying the firing angle to the power device. We know that thyristor is a latching device when the thyristor is turned ON by a gating signal and the current is higher than the holding current and the latching current, the thyristor stays ON, until the current through it becomes sufficiently low (very close to zero). The thyristor turns OFF when current through becomes zero, as happens at the AC mains zero crossing.

This means that the voltage is supplied to the load for a fraction of the cycle, determined by how long the triac is ON. How long the triac is ON, is, in turn, determined by the delay time between the zero crossing and the applying of the triac gating signal. Hence we adjust the voltage or power delivered to the load by delaying the trigger signal to the load.

The waveforms of zero crossing detector are as follows:

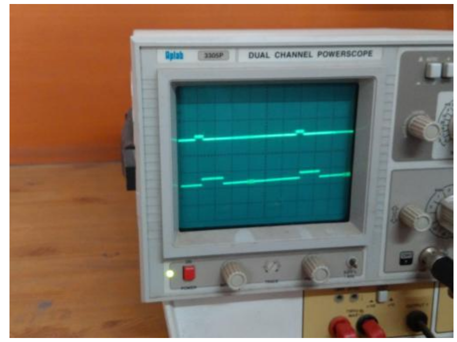

Fig. Output waveforms of zero crossing detector

3. CONCLUSION

The speed of I.M can be controlled by controlling the firing angle. The relation between speed and the firing angle depends on mode of operation and phase voltage supplied. Hence the speed can be controlled by varying stator voltage. Electrical energy is been consumed at both ends domestic and industrial premises, hence application of this power electronic control provides a larger percentage of energy consumption.

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