Design And Fabrication Of 3-Phase Ac Voltage Controller Fed Speed Control Of 3-Phase Sqim

L. Joseph Anil Kumar[1] B. Krishna Chaitanya[2]
[1]M.Tech scholar, Nalanda Institute of Engineering & Technology, Kantepudi, Sattenapalli.
[2]M.Tech scholar, Vignan University, Vadlamudi, Guntur.

ABSTRACT

To improve the reliability and efficiency of production in industries and other applications variable speed is required. In olden days speed control was possible for DC motors only but with advent of power electronics converters such as AC regulators, Inverters and cycloconverters the speed control is also possible for induction motors. Conventionally in the past, speed of the 3-phase induction motor was controlled by using 3-phase variac etc. These methods resulted in bulky size, high power loss and also high insulation cost. However The speed control of IM by 3-phase inverters, cycloconverters we require forced commutation circuit, which is complicated, and these introduces high surge currents and surge voltages. But AC voltage controller makes use of line commutation and as such no complex commutation circuitry is required in this controller. The main application of this model is winders, fan drives, domestic pumps, industrial heating and lighting control. Therefore most of the pump and fan drives require speed control only in a narrow range.

Keywords: IM, AC voltage controllers, TRIAC

I. Introduction

For the industrial development of a nation the choice of machines is considered as utmost importance since the early industrial era in many developing machines the machine control is more weightage than other quantities like loading factors or faults etc. All most all of these machines employed are induction machines because of their added advantages of ruggedness, low cost, weight, volume and inertia, higher efficiency and ability to operate in dirty and explosive environments, easy to control when compared with DC motors even for its disadvantage of lagging power factor. But with the advent of power electronics transformed the scene completely and today we have variable drive systems which are not only smaller in size but also very efficient, higher reliable, induction motors are able to be control even for variable speeds and in the narrow range also. In other words PE components find their use in low as well as high power applications [1].AC drive systems use the AC motor as the driven element-either induction or synchronous type. Since most of the motors in industries are only of induction type, developed in this field took place rapidly [2].

We are selecting 3-phase AC voltage controller for the speed control of induction motor, AC controllers are Thyristor-based devices, which convert fixed alternating voltage without a change in the frequency. By changing the firing angle of TRIAC the output voltage of AC voltage controller changes. Since frequency remains constant in AC voltage controller, fluxes changes with the change of output voltage and hence torque changes. Since torque is proportional to speed, speed will be controlled. However the speed variation in narrow range cannot be eliminated by variac technology. This can be eliminated by power electronics converters. With the introduction of this modern technique, high efficiency & flexibility in control can be achieved. Compact size and less maintenance are the other features of this technique. Thus these features make this method more advantages than others [7].

This paper presents the hardware implementation for speed control of 3-phase induction motor by using TRIAC-based AC voltage controllers with line commutation technique.

II. Hardware implementation for Speed control of IM

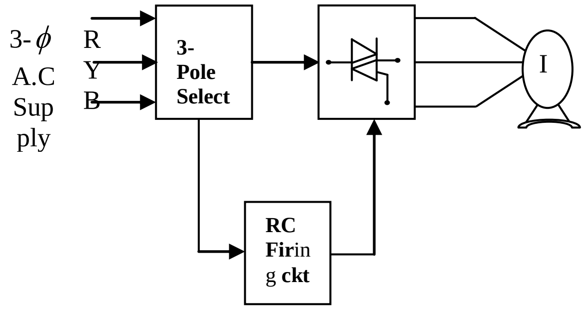

Fig.1 Block diagram and its description

As shown in the block diagram, 3-phase AC supply has been applied to the 3-pole selector switch. The output from the switch is given to the TRIAC as input and the input to the RC firing circuit is also taken from the switch. The output of the RC firing circuit is connected to the gate terminal of the TRIAC. The total output of the TRIAC is given to the 3-phase Squirrel Cage Induction Motor.

Whenever the switch is closed, the input supply has been applied across the TRIAC as well as to the RC firing circuit. By changing the firing angle of the TRIAC using RC firing circuit, the output voltage of the TRIAC is varied. This output voltage has been applied to the stator of the Induction Motor. Since the torque is directly proportional to the square of the stator voltage, as RC firing circuit controls the voltage, torque will be controlled. Thus speed of the squirrel cage induction motor is controlled. The induction motors controlled by ac voltage controllers find wide applications in fan, pump, and crane drives [7] [5].

Most of the pump and fan drives require speed control only in a narrow range. Because torque reduces as the square of the speed and the speed control is required only in a narrow range, the ac voltage controller fed class D squirrel-cage induction motor with a full-load slip of 0.1 to 0.2 is found suitable for these applications. The motor load torque is given as $T_L = C\omega^2_m = C\ (1\text{-}s)^2\ \omega^2_{ms}$,Where C is a constant. If the friction, windage, and core loss torques are neglected then $T = T_L$ [2] [3] [6].

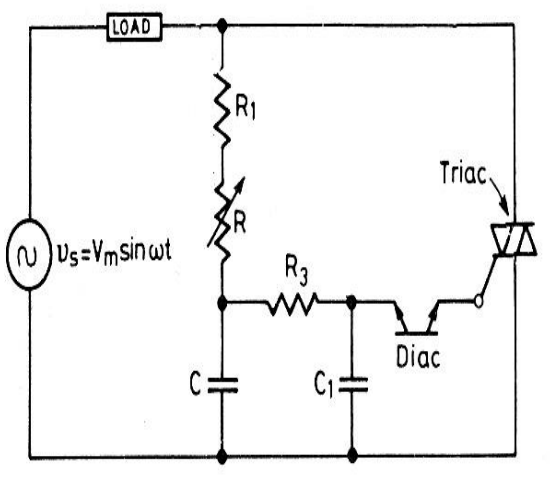

Fig.2 Commercial TRIAC firing circuit using a DIAC

When capacitor C (with upper plate positive) charges to breakdown voltage V_{DT} of DIAC, DIAC turns on.As a consequence, capacitor discharges rapidly thereby applying capacitor voltage Vc in the form of pulse across the TRIAC gate to turn it on. After TRIAC turn-on at firing angle a, source voltage Vs appears across the load during the +ve half cycle for $(\Pi-\alpha)$ radians. When Vs becomes zero at $wt=\alpha$, TRIAC turns off. After $wt=\alpha$, Vs becomes -ve, the capacitor C now charges with lower plate +ve. When V_c appears across the load during the -ve half cycle for $(\Pi-\alpha)$ radians. At $wt=2\Pi$, TRIAC turns off again and the above process repeats [4] [7].

III. Power circuit description

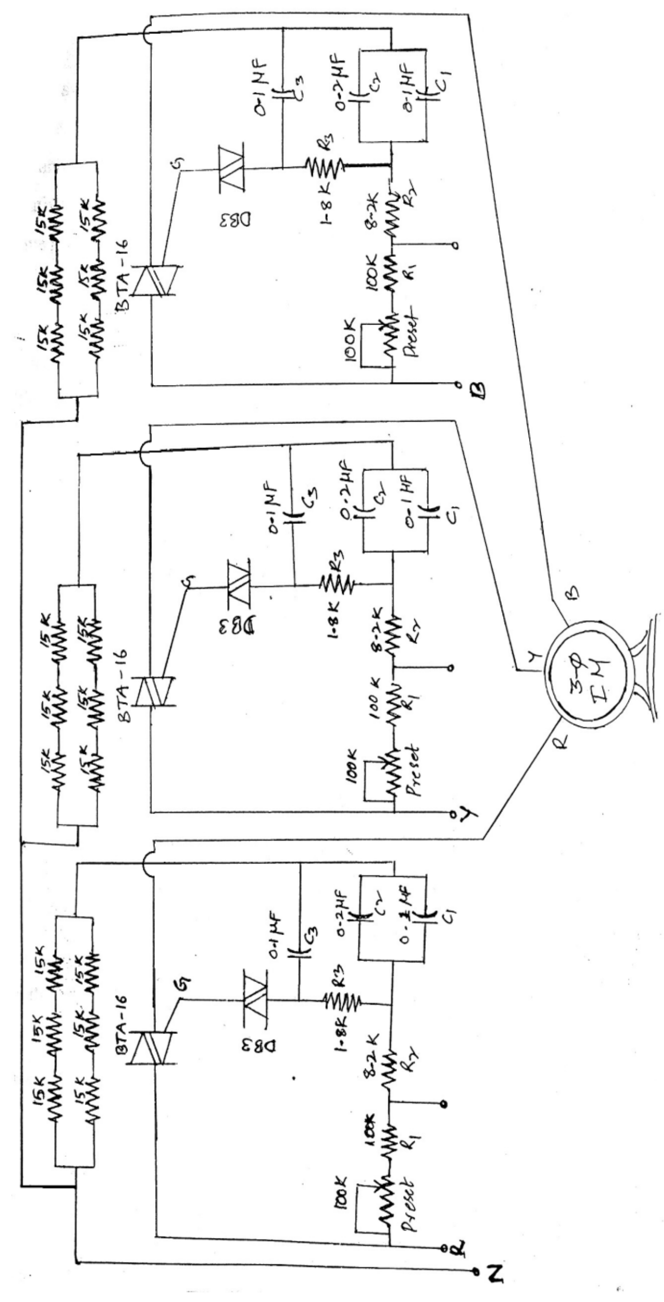

Fig.3 The Hardware design circuit for 3-phase AC Voltage Controller fed speed control of SQIM

The charging capacitor **C (C1 & C_2)** and potentiometer **(Pot)** are such that TRIACs can conduct approximately **0^0 to 180^0** and when potentiometer (Pot) is at high position, firing angle of TRIAC is large. This circuit produces unsymmetrical waveform for the positive and negative half cycles of load voltage. It is mainly due to hysteresis present in the capacitor that means when source voltage is zero, capacitor voltage across C is not zero but capacitor retains some charge. However in order to make waveform for positive and negative half cycles symmetrical, resistance R_3 and C_3 are employed.

Thus by changing the firing angle of TRIAC in each phase, the output voltage of the circuit fed to the stator of a SQIM is controlled and DIAC is mainly used as a triggering device for TRIACs which require either positive or negative gate pulses to turn on.DIAC can be turn on by applying break over voltage approximately 30to35v.Hence TRIAC can be triggered when positive or negative polarity voltages.

The capacitor C(C_1 & C_2) should be chosen to suit the gate characteristic of the TRIAC in the range of **100nf to 1µf…… (1)**

In order to vary the firing point up to **180^0 .** in each half cycle, the time constant **$(R_1+R_2+R)(C_1+C_2)$**must exceed the time period of a half-cycle For 50 Hz frequency mains, **$T(R_1+R_2+R)(C_1+C_2) \geq 10ms$…….(2)**

From the above power circuit the values of R_1 , R_2 R ,C_1 , C_2 are given as $R_1 = 100K\Omega$, $R_2 = 8.2\ K\Omega$, and R = (45 KΩ // 45 KΩ)=22.5 KΩ and from (1) $C_1 = 0.1\ \mu f$ & $C_2 = 0.22\ \mu f$ and from equation (2) T = 41.8ms which is less than 10ms and hence the above condition is satisfied.

Advantages and applications of TRIAC

1. TRIACs can be triggered with +ve or -ve polarity voltages.
2. A TRIAC needs a single heat sink of slightly larger size, whereas anti parallel Thyristor pair needs two heat sinks of slightly smaller sizes, but due to the clearance total space required is more for Thyristors.
3. A TRIAC needs a single fuse for protection, which also simplifies construction.
4. In some dc applications, SCR is required to be connected with a parallel diode to protect against reverse voltage, whereas a TRIAC used may work without a diode, as safe breakdown in either direction is possible.
5. For the speed control of small I-phase series and induction motors, in such consumer appliances as food mixers and portable drills [7].

IV. Test Results

A) For 0.5 HP AC induction motor

Supply Voltage (V)	Speed (RPM)
0	0
25	900
50	1200
75	1240
100	1370
125	1400
150	1450
175	1452
200	1460
225	1464
250	1469
275	1469
300	1469
325	1470
350	1470
375	1470
400	1470
415	1470

Table 1: Change in Speed with Voltage of 0. 5 HP Ac Induction Motor

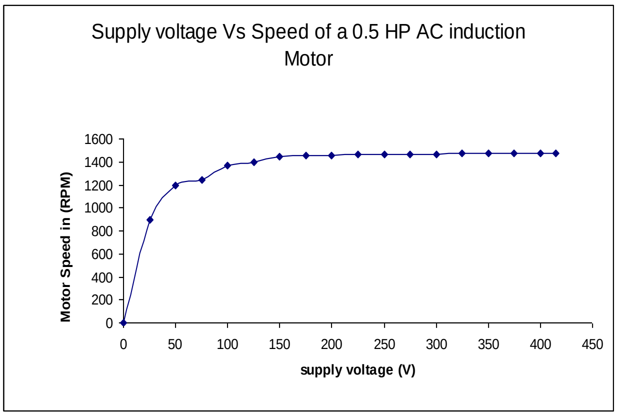

Fig.4 Output wave Forms for 0.5 HP AC Induction motor Input Voltage Vs speed of a 0.5HP Ac Induction Motor

B) For 5 HP AC induction motor

Supply Voltage (V)	Speed (RPM)
0	0
25	750
50	1120
75	1250
100	1290
125	1350
150	1400
175	1430
200	1440
225	1444
250	1454
275	1460
300	1470
325	1472
350	1475
375	1475
400	1475
415	1475

Table 2: Change in Speed with Voltage of 5 HP Ac Induction Motor

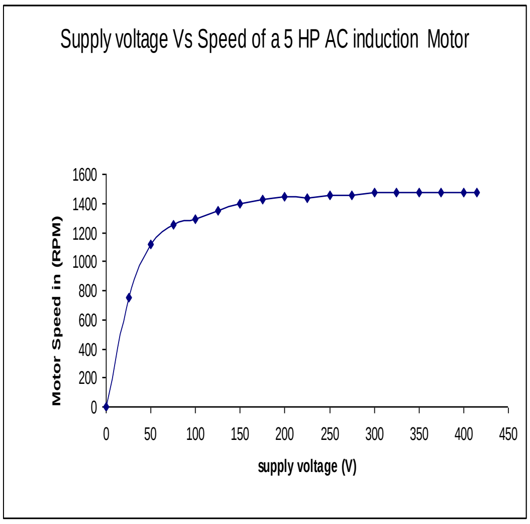

Fig.5 Output wave Forms for 5 HP AC Induction motor
Input Voltage Vs speed of a 5 HP Ac Induction Motor

From the above test results The speed of 0.5HP 3-phase SQIM can be varied in a narrow range from 1370rpm to 1470rpm,and the ranges of 5HP SQIM is from 1400rpm to 1475rpm.In general, this method of speed control is used only on loads where the torque required drops off considerably as the speed is reduced such as with small squirrel cage motors driving fans. This method, though the cheapest and the easiest is rarely used because a large change in voltage is required for a relatively small change in speed. This large change in voltage will result in a large change in the flux density thereby seriously districting the magnetic conditions of the motor.

V. Conclusion

AC motors are lighter, require less maintenance, less expensive when compare to that of DC motors. AC drives are used for several industrial applications. Induction motors, particularly SQIM, have a number of advantages when compared with DC motors. Since most of the motors in industries are only of induction type, efficient control techniques must be required for this motor. In this project stator voltage control method is used which offers limited speed drives. Based on the advantages and disadvantages of this method, they are used for low power drives, and also where flexibility in control, fast response is required.

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About the AUTHOR'S

	**L. Joseph Anil Kumar** is pursuing M.Tech(Power Electronics) in Nalanda Institute of Engineering & Technology, Kantepudi. He worked as Assistant Professor for 2 years in Loyola Institute of Technology & Management, Dhulipalla. His Areas of Interest are Power systems, Power Electronics & Neural Networks
	**B. Krishna Chaitanya** is pursuing M.Tech(Power Electronics) in Vignan University, Vadlamudi. He Completed his B.Tech from Loyola Institute of Technology & Management, Dhulipalla. His Areas of Interest are Electrical Machines, Power Electronics & Neural Networks