Real Time Speed Control of Three Phase Induction Motor By Using Firefly Algorithm

Mr. S.Raj Kumar [1], M.Saravana Rani [2], P.Pradeepa[3]
[1]Assistant Professor Dept of EEE
[2, 3]Dept of EEE
[1, 2, 3] SACS MAVMM ENGINEERING COLLEGE, Alagarkoil, Madurai, Tamilnadu, India

Abstract- *This paper is concerned with real time speed control of three phase induction motor and implementation of voltage/frequency (V/F) speed control method with the help of variable frequency drive (VFD), Firefly algorithm, and also this paper presents the V/f control of induction motor using sine wave PWM method. Because of its simplicity, the V/F control also called as the scalar control, is the most widely used speed control method in the industrial applications. The proposed technique gives better performance for three phase induction motor than the conventional technique. The main advantage of the proposed system is quick settling time, intelligent technique. The speed control is obtained by firefly control, because PI has difficulty in dealing with dynamic speed. The proposed control is done by using MATLAB/SIMULINK and also implemented in hardware.*

Keywords- Firefly algorithm, Induction motor, Microcontroller, MATLAB/SIMULINK, Variable frequency drive (VFD).

I. INTRODUCTION

Electrical Energy has the contribution more than 40 % of all energy sources usage on Earth. In the upcoming years the percentage contribution of Electrical Energy will be increase. More utilization of Electrical Energy is to convert the Electrical Energy into Mechanical Energy via different kinds of electric motors like DC Motors, Induction Motors and Synchronous Motors. From the economic point of view Induction Motor are cheap compared to DC and Synchronous Motors. Induction Motors are most popular and widely used drives in industries as well as for domestic applications. It is very important to control the speed of induction motors in industrial and domestic applications. Induction motors can be broadly classified into two types based on their speed control techniques – scalar control and vector control. By using scalar control method we can control the magnitude of voltage or frequency of the induction motor [10].In the present time, in the most of the applications, AC machines are preferable over DC machines suitable to their simple and most robust construction without any mechanical commutators. Induction motors are the most widely used motors for appliances like Industrial control, and automation; hence, they are often called the workhorse of the motion industry [1]. Control of voltage, frequency and current is required in variable speed applications for ac machines drives. Speed of induction motor can be determined with the help of frequency of supply system.

II. V\F SPEED CONTROL METHOD OF THREE PHASE INDUCTION MOTOR

The torque developed by the induction motor is directly proportional to the magnetic field, which is produced by the stator. The stator voltage is directly proportional to the product of stator flux and angular velocity. This makes the flux produced by the stator proportional to the ratio of applied frequency and voltage of supply. The voltage and frequency varied by the same ratio, the torque can be kept constant throughout the speed range. This makes constant ratio of voltage and frequency is the most common speed control of an induction motor. The torque developed by the induction motor is directly proportional to the ratio of voltage and frequency. By varying the voltage and frequency, keeping their ratio constant, then the torque produced by induction motor will remain constant for all the speed range.Fig.1 shows the torque-speed characteristics of the induction motorwith V/F control. The voltage and frequen cy reaches the maximum value at the base speed .We can drive the induction motor beyond the base speed. The torque developed by the induction motor is directly proportional to the V/F ratio will not remain constant throughout the speed [1].

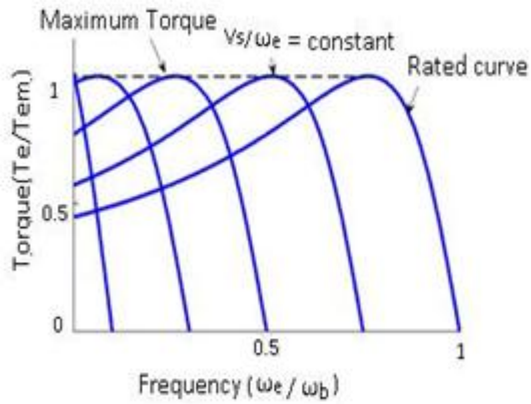

Figure 1. Torque-speed characteristi cs of the induction motor

Other than the variation in speed, th e torque-speed characteristic of the V/F control is the follo wing:
The starting current is low.

The constant operating region o f the motor is increased. Instead of simply running at its base/ rated speed (NB), the motor can be run normal ly from 5% of the synchronous speed (NS) up to the b ase speed. The torque created by the motor can be kept constant throughout this region.

Then almost constant rated torq ue is available over the entire operating range, the speed range of the motor becomes wider. User can set the s peed as per the load requirement, thereby achieving the higher efficiency.

III. FIREFLY ALGORITHM

In a mathematical optimization, the firefly algorithm is a metaheuristic proposed by Xin-She Yan g and inspired by the flashing behaviour of fireflies.

All fireflies are unisexual, so t hat any single firefly will be attracted to all other fireflies.

Attraction is proportional to their brightness, and for any two fireflies, the fewer brigh t one will be attracted by (and thus move towards) th e brighter one. Though, the intensity (apparent brightnes s) decrease as their mutual distance increases.

If there are no fireflies b righter than a given firefly, it will be travel randoml y.

The intensity should be associated with the objective function.

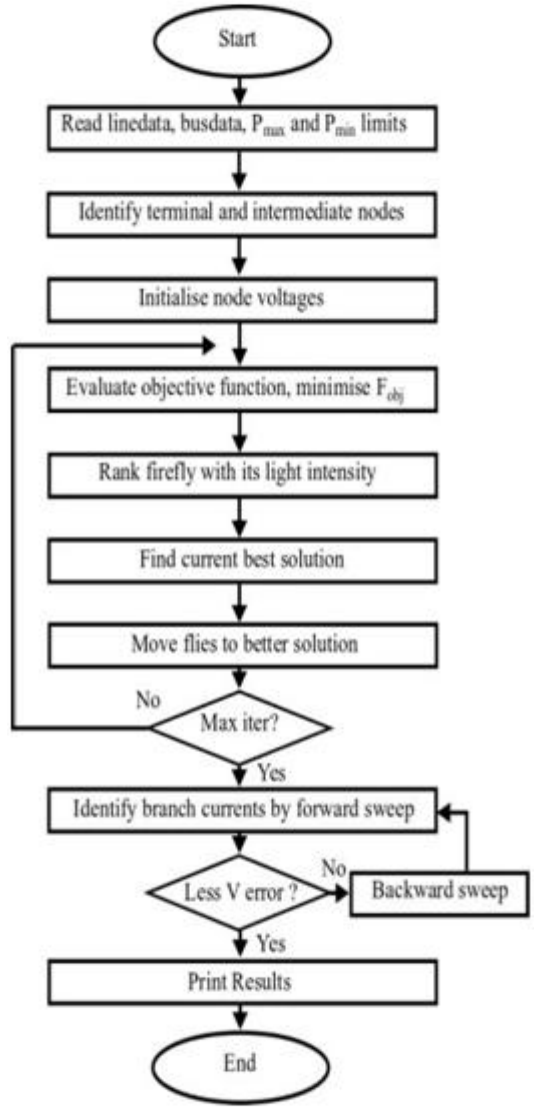

Figure 2. Flow chart for firefly algorithm

Firefly algorithm is specified based on the steps shown in below pseudo code.

1) Initialize parameters ∝, γ
2) SetNo. of initial solutions(N) and maximum iteration(MAXGEN)
3) Generate Randomly N initial solutions
4) Foriteration = 1: MaxGendo
    a. Compute the brightness I
    b. Sort the solution in such a way that Ii≥ Ii-1 , Ai
    c. For t=1…number neighbours

For i=1 : n-1

If Ij> Ii
Move firefly i towards firefly j
End if
End for

End for
Move firefly N, (xb) randomly
End for

5) Report the Best Solution

IV. PWM (PULSE WIDTH MODULA TION)

Pulse width modulation (PWM) is a modulation method used to encode a message into a pulsing signal. Even though this modulation technique can be used to encode information for transmission, its main use is to allow the control of the power supplied to elec trical devices, mainly to inertial loads such as motor s. In addition, PWM is one of the two major al gorithms used in photovoltaic solar battery chargers , the other being maximum power point tracking.

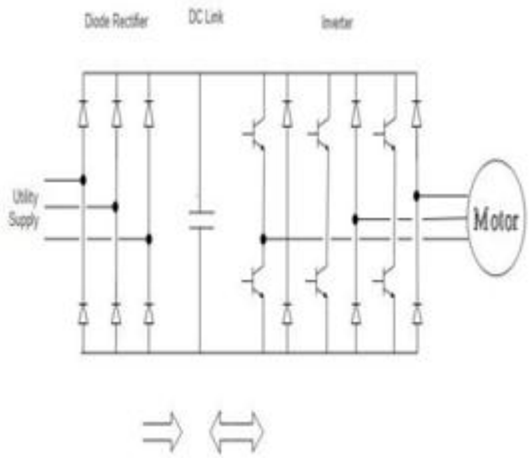

Figure 3. PWM inverter

The average value of voltage and current fed to the load is controlled by turning the switch between supply and load on and off at a quick rate. The longer the switch is on compare to the off periods, the higher the total power supplied to the load.The P WM switching frequency has to be much higher than wh at would affect the load (the device that uses the power), which is to say that the resultant waveform perceived by the load must be as even as possible. The term duty cyc le describe the proportion of on time to the usual interval or period of time; a low duty cycle correspo nds to low power, because the power is off for most of the time. Duty cycle is expressed in percent, 100% b eing fully on. The major advantage of PWM is that po wer loss in the switching devices is very low. When a switch is off there is practically no current, and when it is on and power is being transfer to the load, there is almost no voltage drop across the switch. Power loss, being the product of voltage and current, is therefore in both cases close to zero. PWM also works well with digital controls, which, since of their on/off nature, can easily set the needed duty cycle.

The Voltage source inverter's are commonly used for variable frequency drive applications and for high power applications, such as H VDC power transmission. A basic three phase inverter con sists of three single-phase inverter switch each connected to one of the three load terminals. For the most bas ic control scheme, the operation of the three switches is coordinated so that one switch operate at each 60 degre e point of the fundamental output waveform. These create a line to line output waveform that has six steps.

which will connect to your PC and you ca n program it by using software. The DIY is to build your o wn burner and use free software to program it.In these tu torial, first w will learn the programming of PIC an d will see the simulation by using Proteus. Then we will proceed to the hardware

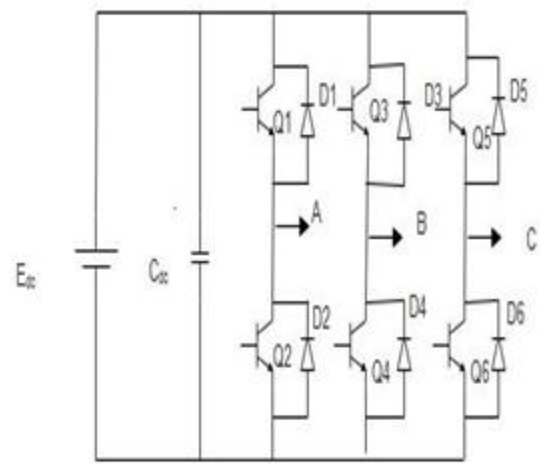

Figure 4. Voltage sour ce inverter(VSI)

The six step waveform has a zero voltage step between the positive and negative sections of the square-wave such that the harmonics that are multiples of three are eliminated as described ab ove. When carrier based PWM technique are applied to six step waveforms, the basic overall shape, or envelo pe, of the waveform is retained so that the 3rd harmo nic and its multiples are cancelled.

V. PIC18F452 MICROCONTROL LER

The 18F452 has 153GB of RAM and 1 6k of program memory. It has four port namely as port a , port b, port c and port d. Each port has eight pins. As shown in figure the pin num RA belongs to port a and sa me as for RB, RC and RD.

These are the power supply pins. VS S is ground and VDD is the positive supply pin. The ran ge of supply is 5V to 3V. The maximum supply is 5V a nd minimum is 3V. (above 5V the IC can damage so be care full).Since microcontroller has some kind of timing, so we connect an external clock with these pins. In normal mode this pin connects to the positive (5V) supply. Specially, this pin is used to erase the memory location. These are the bidirectional ports. That can be configured as an input and output. The number following RA0, RA1 is the bit number. These is an another clock, wh ich operate an internal timer. There are two ways for pro gramming, the easy and DIY way. The easy way is to bu y a PIC burner,

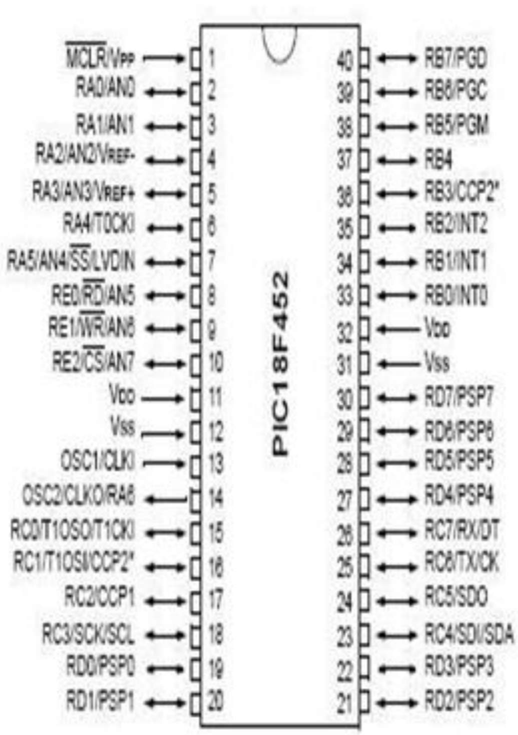

Figure 5. Pin Diagram of PIC18F452

VI. VARIABLE FREQUENCY DRIVE (VFD)

The AC60E is a mini general p urpose frequency inverter, is our independently developed electrical equipment. As a new generation of high performance v/f control drive, it is included to have modular design, small size, small temperature rise, low noise, and reliable performance.

- 220V(single-phase power) 0.4-2.2kw
- 380V(three-phase powe r) 0.75-3.7kw

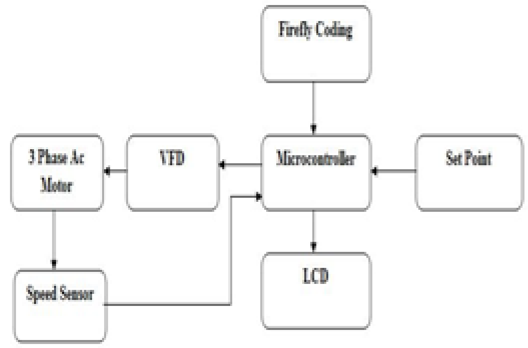

Figure 6. Block diagram of proposed system

In this proposed system, we used to control the speed of the three phase induc tion motor, by using v/f method. The speed of the induction motor is, set by the set pointer, and then the set s peed is displayed in the LCD display. The microcontroller is employed with the Firefly coding.

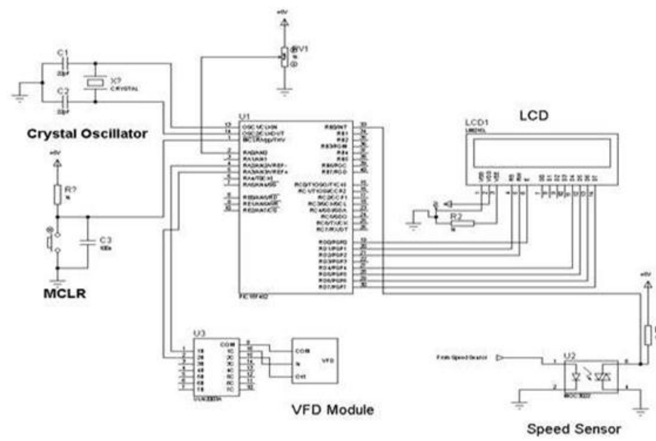

Figure 7. Circuit diagram for proposed system

The above circuit diagram is denotes the hardware implementation of speed control of three p hase induction motor using variable frequency drive.

VII. SIMULATION RESULT

7.1 OVER ALL SIMULATION MODEL

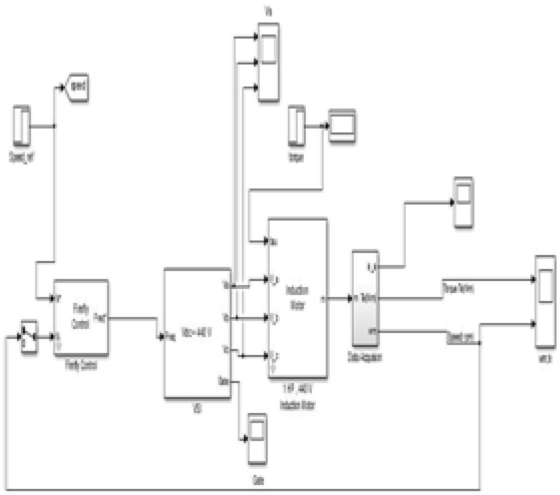

Figure 8. Simulink Diagram for proposed system

The figure 8 shows the o verall simulation model. The simulation diagram include s the Firefly control, VSI (Voltage source inverter). It's used to denote the Voltage and Current, Torque and Speed characteristics of three phase Induction motor.

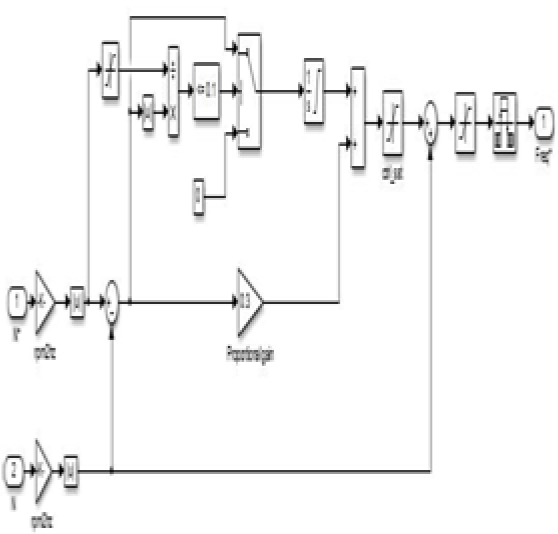

Figure 9. Simulink Diagram for Firefly Control

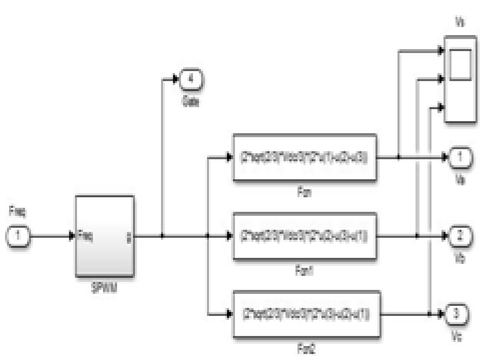

Figure 10. Simulink Diagram for VSI

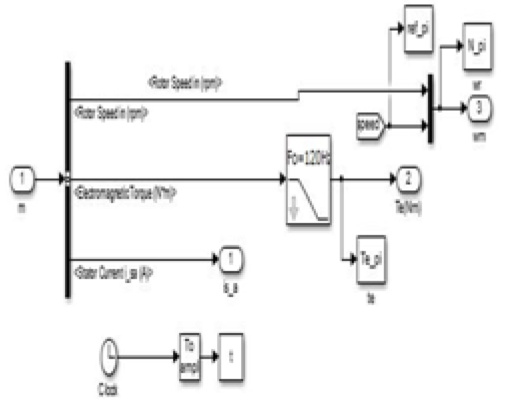

Figure 11. Simulink Diagram for Data acquisition

7.2 SIMULATION RESULT

Table 1. Ranges of Torque and S peed

S.no	Torque	Spee d
1	0.5	100 0

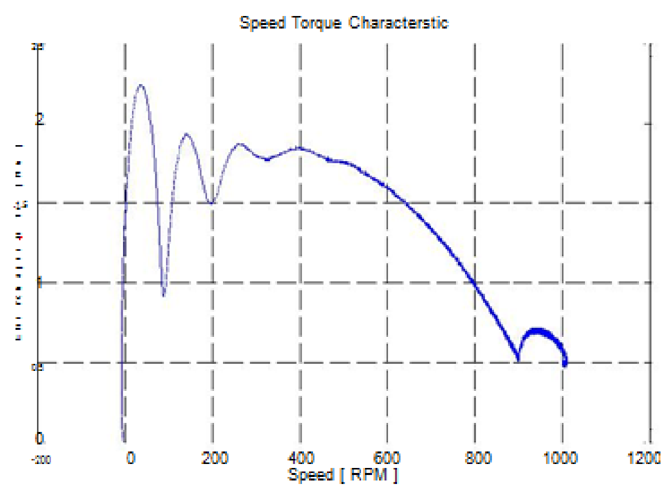

Figure 12. Speed Torque Charact eristics

The figure.12 shows speed and torque characteristics of three phase induction motor. In this waveform denotes 1000 rpm and 0.5 torque. Torque Speed Characteristic is the curve, plotted between the torque and the speed of the induction motor.

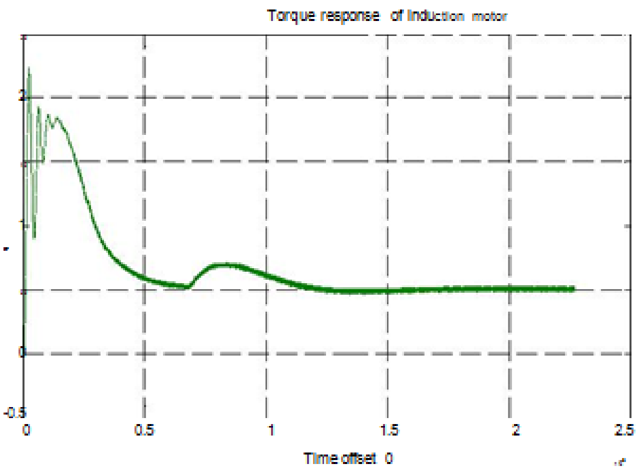

Figure 13. Torque waveform

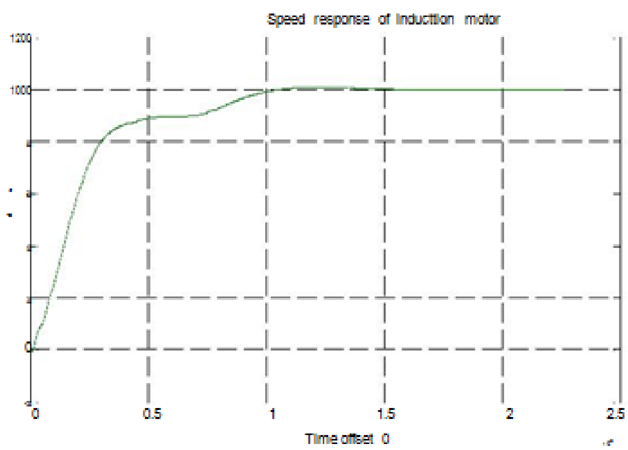

Figure 14. Speed waveform

The figure.13 and 14 show s the waveform for rotor speed and torque of three phase induction motor. This method gives better rotor speed response as in the range of 1000 rpm and 0.5 torque.

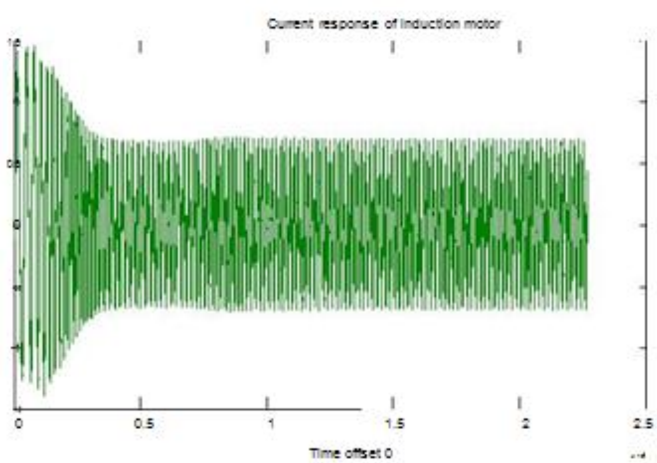

Figure 15. Current Waveform+

The figure.15 shows the waveform for current of three phase induction motor. This metho d gives better rotor speed response as in the range of 10 00rpm and 0.5 torque.

VIII. HARDWARE RESULT

8.1 HARDWARE MODEL

This is hardware module of Real time sp eed control of three phase induction motor by using variable frequency drive and Microcontroller.

Figure 16. Hardware modul e

Table 2. Motor Specificatio n

Motor parameter	Specification
Power	1HP
Type	4-pole,squirrel cage
Supply	3-phase,415V ac, 50Hz input
Rated current	1.8 amp
Rated Speed and Torque	1410 RPM and 5Nm

- N is the speed of rotor of induction motor,
- Ns is the synchronous speed, S is the slip.
- f= Frequency
- p= no.of.poles

We set the speed in the set pointer in 10 00 rpm

$$\frac{120 \quad 33.94}{4}$$

$$N_S = 1018$$

Table 3. Comparison between set rpm and motor rpm

S.NO	SET RPM	MOTOR RPM
1	1000	1018

The above table denotes t he difference between the set rpm and ratted rpm. The set rpm is 1000 and the motor is 1018.

IX. CONCLUSION

Induction motor drives are m ost widely used in the industrial applications. Various speed controlled methods have been developed. Out of w hich the V/F is the most common and easy to implement. The experimental result presented v/f controlled volt age-source inverter fed induction motor. In this project we controlled three phase Induction Motor speed in real time, by using variable frequency drive and firefly algorithm. Simulation result shows the performance of VSI control and firefly control. Hence we concluded that VFD's provide the most energy efficient means of capacity control. This drive comes in a l ead role for energy saving products for all the Industries using electrical motors. To adding a variable frequency drive (VFD), in a motor-driven system can offer poten tial energy savings in a system in which the loads vary with time. The operating speed of a motor connected with VFD, is varied by changing, the frequency of the motor supply voltage. The VFD becomes, very reliable an d economically beneficial. The hardware Implementation is verified successfully and the simulation wa s done by using MATLAB\SIMULINK.

REFERENCES

[1] M.s.Aspalli., Asha.r, P.V. Hunagund “Three phase induction motor drive U sing IGBTs and constant v/f Method”, International Jour nal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 1, Issue 5, No vember 2012.

[2] Ashutosh Mishra, Pra shant Choudhary “Speed Control Of An Induction Motor By Using Indirect Vector Control Method”, Internation al Journal of Emerging Technology and Advanced Engi neering Certified Journal, Volume 2, Issue 12, December 2012.

[3] C. Saravanan, A. Mohamed Azarudeen & S. Selvakumar “Performance of Three Phase Induction Motor Using Modified Stator Winding”, Global Journal of Researches in Engineering Electrical and Electronics Engineering Volume 12 issue 5 Version 1.0 April 2012.