ANN Based Energy Conservation in Single Phase Induction Motor Drives

S.Gowri Shankar
AP/ EEE,
Shree Venkateshwara Hi-Tech Engineering College,
Gobichettipalayam, Erode
gowrishankar.power@gmail.com

P.Chinnasamy
Department of EEE,
Shree Venkateshwara Hi-Tech Engineering College,
Gobichettipalayam, Erode
eeechinnasamyp@gmail.com

M.Logananthan
Department of EEE,
Shree Venkateshwara Hi-Tech Engineering College,
Gobichettipalayam, Erode
m.logananthan@gmail.com

K.Naveendran
Department of EEE,
Shree Venkateshwara Hi-Tech Engineering College,
Gobichettipalayam, Erode
naveendran.k@gmail.com

***Abstract*— The purpose of this project is to save the energy in a single phase induction motor drives at different load conditions. The induction motor is one of the electrical drive being used in many industrial applications. Mostly the input voltage to the single phase induction motor at any load is fixed as 230 voltage. The same input voltage is applied to the machine even on no load which results in wasting of energy. In this project, it is proposed to apply the reduced voltage to the machine with which it can drive the load at different load conditions without sacrificing the original load performance. Then the percentage saving of energy at different load conditions are obtained. It is found from the analysis that the percentage saving of energy at reduced load conditions are considerable which is not so for the full load or more than 75% load conditions.**

***Keywords*— artificial neural network, mat lab, analog to digital converter, current transformer.**

I. Introduction

There is a growing demand for power in the world. Power generating sources like coal, oil, gas are rapidly depleting in nature. The generation is not able to meet the load demand. In addition, losses occur in transmission systems. Therefore, it is better to develop energy savers to conserve the energy that can minimize the load demand. In total generation of electrical energy 40% of electricity is used by industrial sector and motor drive system consumes over half the electricity. The induction motor is one of the electrical drive being used in many industrial applications. This motor is always connected to the mains irrespective of the load conditions. Due to the rated voltage at stator terminals, rated iron loss have to be supplied constantly to the motors.

If it is possible to reduce the voltage at the stator terminals from no load to 75% of the rated load, then losses can be reduced and some electrical energy might be saved.

The neural network is trained to estimate the required voltage at different load conditions.AT89C51 Microcontroller is used to control the relay operation. LCD is used to display the applied input voltage to the motor and load current.

II. Block Diagram Description

A. Block Diagram

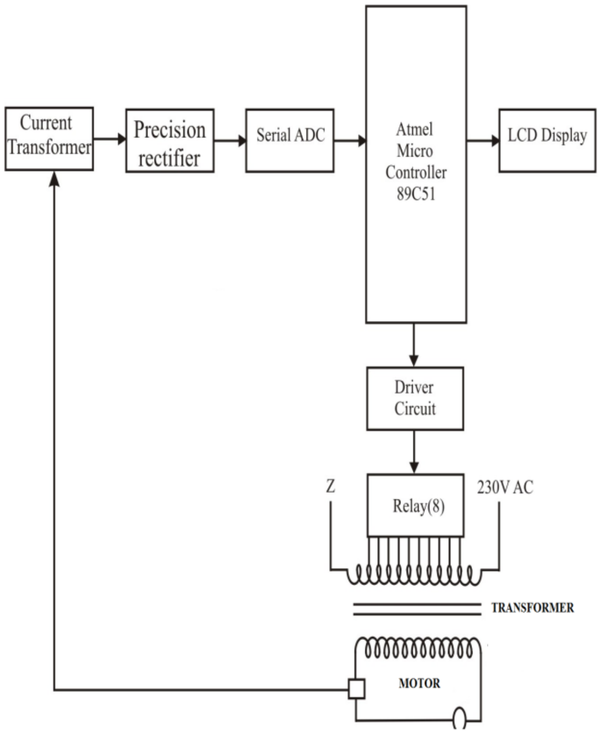


Fig.1. Functional Block Diagram

The block diagram in figure 1 shows the overall processes of this project .Here we are going to control the input voltage of the single phase induction motor corresponding to the load condition. So to determine the load condition, the load current is used as a sensing parameter.

The CT (Current Transformer) is used to sense the load current of the single phase induction motor .The current rating of current transformer is 15 amps here .The output of the current transformer is an analog quantity .So before it is given to the micro controller we have to change the analog signal into digital signal. This analog to digital conversion is done by an integrated chip IC3208.Now the output of the ADC chip is digital signal and it is equal to the load current sensed in CT. The Micro controller AT89C51is programmed to select the input voltage of the motor corresponding to the line current. So the load current as a digital signal from the ADC is given to the microcontroller to select the suitable input voltage to the motor.

The output of micro controller is given to a relay driver circuit which will trip the relay from NO (Normally Open) to NC (Normally closed) position. Totally there are eight number of relays for a eight load conditions .The load current from the current transformer decides the relay to be on. To indicate the load current and the applied voltage to the motor LCD display is connected with micro controller.

B. Current Measurement

This circuit is designed to monitor the supply current. The supply current that has to monitor is step down by the current transformer. The step down current is converted by the voltage with the help of shunt resistor. Then the converted voltage is rectified by the precision rectifier. The precision rectifier is a configuration obtained with an operational amplifier in order to have a circuit behaving like an ideal diode or rectifier.

The full wave rectifier is the combination of half wave precision rectifier and summing amplifier. When the input voltage is negative, there is a negative voltage on the diode, too, so it works like an open circuit, there is no current in the load and the output voltage is zero. When the input is positive, it is amplified by the operational amplifier and it turns the diode on. There is current in the load and, because of the feedback, the output voltage is equal to the input.

In this case, when the input is greater than zero, D2 is ON and D1 is OFF, so the output is zero. When the input is less than zero, D2 is OFF and D1 is ON, and the output is like the input with an amplification of $-R_2 / R_1$. The full-wave rectifier depends on the fact that both the half-wave rectifier and the summing amplifier are precision circuits. It operates by producing an inverted half-wave-rectified signal and then adding that signal at double amplitude to the original signal in the summing amplifier. The result is a reversal of the selected polarity of the input signal.

Then the output of the rectified voltage is adjusted to 0-5v with the help of variable resistor VR1. Then given to ripples are filtered by the C1 capacitor. After the filtration the corresponding DC voltage is given to ADC or other related circuit.

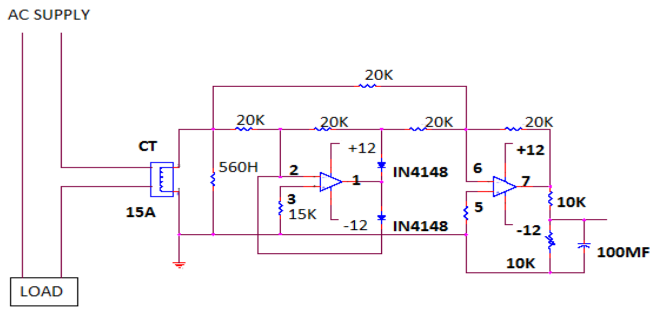


Fig 2. Current measurement circuit

C. Artificial Neural Network

Neural network is the simplified models of the biological neuron system. Neural network is also called as artificial neural network or Artificial neural system. Neural network is a parallel distributed processing system. Highly interconnected network of simple processing elements called Neurons. The general block diagram of a neural network is shown below

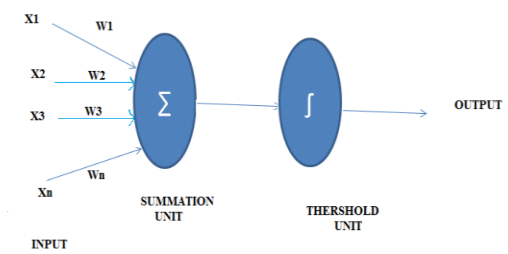


Fig.3. Basic model

Where

x1,x2,x3….xn => n inputs to the artificial neuron

w1,w2,w3….wn=> weights attached to the links

Total input I =>w1x1+w2x2+w3x3+………wnxn.

III. CIRCUIT DIAGRAM DESCRIPTION

Fig 4 shows the circuit diagram of this project. The load current is measured by using current transformer. The current rating of CT is 15A.The output of the current transformer is given to the shunt resistance for converting current into voltage. The converted voltage is applied to the precision rectifier for unity gain output. IC 1458 acts as a precision rectifier. The output of the precision rectifier is proportional to the load current that is given to the IC 3208.

IC 3208 is a 3bit serial ADC. It converts the analog current into digital value. Now the converted digital value is given to the IC AT89C51 microcontroller. AT89C51 is a 8 bit microcontroller. Based on the value of load current it produce a control signal to relay circuit through relay driver unit. Port pins (P3.0 to P3.7) is used as a output port.

The output of a controller is logic 1 means transistor Q1 is turned ON and Q2 is turned OFF. Now the relay is in OFF condition and there is no change in relay contact position. The output of a controller is 0 means the transistor Q1 is turned OFF and Q2 is turned ON. Now the relay coil will get 12V dc supply. Now the relay is in ON condition and the relay contact point NO is changed to NC and NC is changed to NO position.

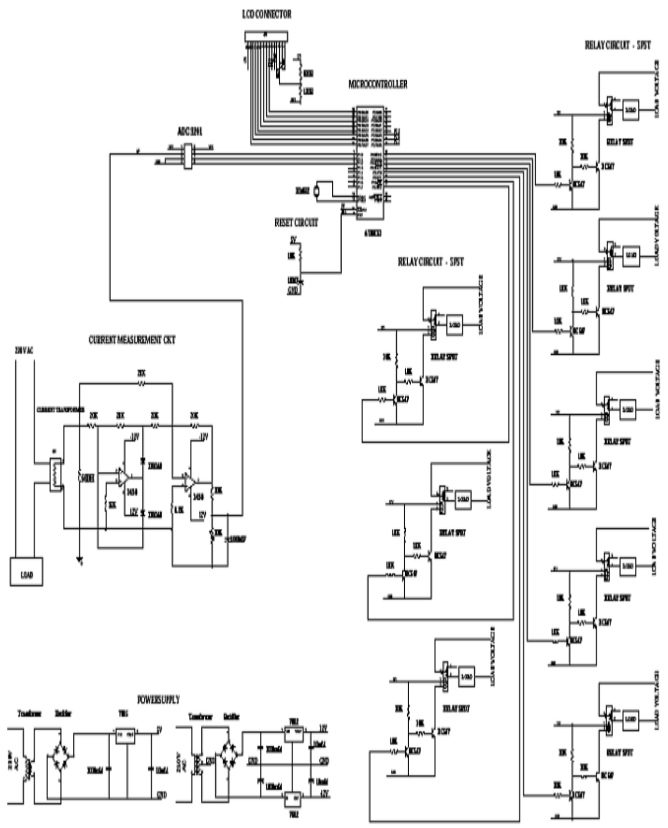


Fig 4. Circuit diagram

Now the motor gets input voltage from the tap changing transformer. Totally 8 tappings are taken in the transformer. LCD is used to display the load current and applied load voltage values based on the load condition.

IV. SIMULATION RESULTS

The simulation is carried out by mat lab and the results are tested with hardware setup.

INPUT-P	TARGET-T	OUTPUT-Y
0.0	80	83.4791
0.25	130	130.7708
0.5	150	147.7642
0.7	160	160.1512
1.0	230	225.4960

Table 1. Ann simulation results

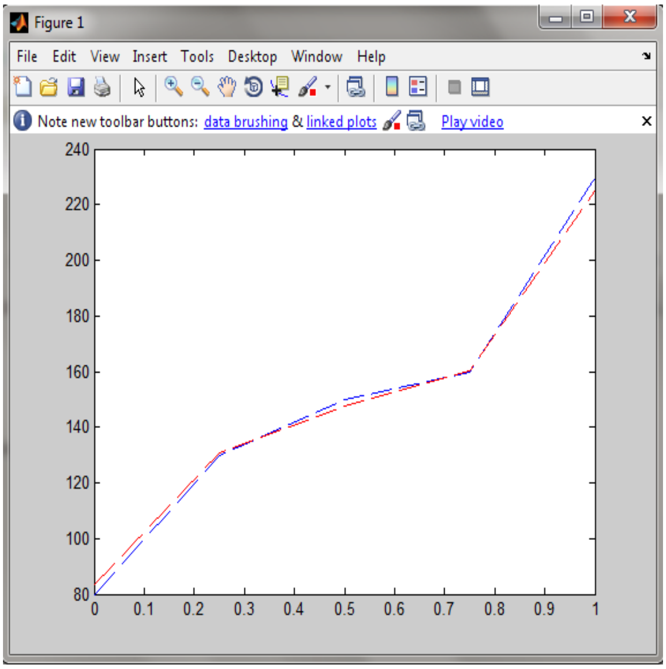


Fig 5. Simulation Output

V. EXPERIMENTAL RESULTS

Single phase Induction motor is a rotating machine. The input to the motor is electrical energy and the output of the motor is mechanical energy. Single phase Induction motor works under the principle of double field revolving theory. The motor has two windings namely starting winding and running winding. Starting winding is used only at the time of starting and it is disconnected from the supply when the motor starts to run. The motor has many advantages such as simple construction, good efficiency.

NAME PLATE DETAILS

- Capacity: 0.75KW/HP
- voltage:230V AC, 1PH
- Ct rating:4.5amps
- Frequency:50Hz
- Type: capacitor run
- Insulation type: B

A. Energy conservation in Induction motor drives at different Load conditions

Energy saving at 0% load for different voltage

Voltage in Volts	Current in amps	Input power in watts	losses in watts	% of energy saving
80	0.5	20	20	87.01
100	0.6	30	30	80.52
120	0.65	44	44	71.43
140	0.7	60	60	61.04
160	0.7	80	80	48.05
180	0.7	100	100	35.06
200	0.75	120	120	22.08
230	0.8	154	144	-

Table 2. Energy saving at no load

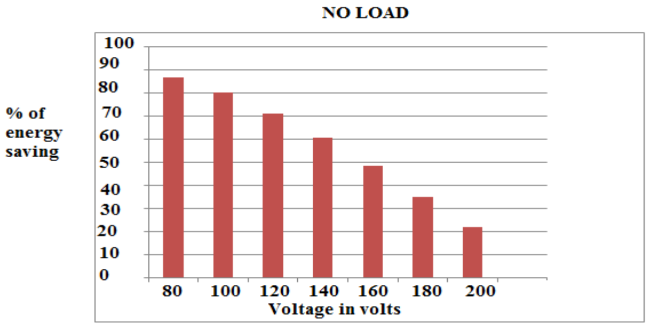
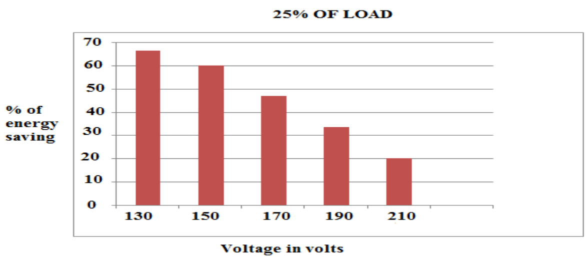


Fig 6. Energy saving at no load

Energy saving at 25% load for different voltage

Voltage in Volts	Current in amps	Input power in watts	losses in watts	% of energy saving
130	1.7	190	48.92	66.58
150	1.55	200	57.95	60.41
170	1.5	220	77.18	47.28
190	1.45	240	96.79	33.88
210	1.4	260	116.6	20.35
230	1.4	290	146.4	-

Table 3.Energy saving at 25% load



Energy saving at 50% load for different voltage

Voltage in Volts	Current in amps	Input power in watts	losses in watts	% of energy saving
150	3.5	480	103.22	59.76
170	3.4	530	144.59	43.63
190	3.3	582	193.36	24.61
210	3.2	630	238.66	6.95
230	3.0	650	256.11	-

Table 4. Energy saving at 50% load

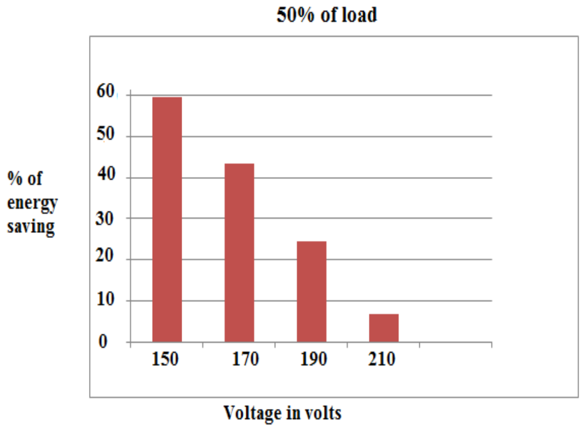


Fig 7. Energy saving at 50% load

Energy saving at 75% load for different voltage

Voltage in Volts	Current in amps	Input power in watts	losses in watts	% of energy saving
160	4.6	680	190.13	28.46
180	4.2	710	218.057	15.65
200	3.8	720	244.952	12.99
220	3.4	730	233.947	9.51
230	3.3	756	258.54	-

Table 5. Energy saving at 75% load

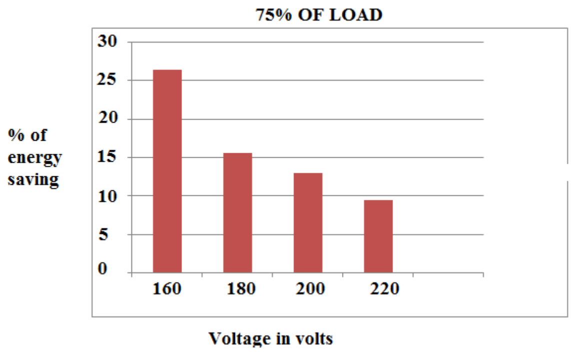


Fig 8. Energy saving at 75% load

Calculation of energy saving

% of Energy Saving =>

$$\frac{\text{Losses at full voltage} - \text{Losses at reduced voltage}}{\text{Losses at full voltage}} * 100$$

Optimal energy saving through experimental results

SL. NO	% OF LOAD	INPUT VOLTAGE IN VOLTS	LOAD CURRENT IN AMPS	INPUT POWER IN WATTS	LOSSES IN WATTS	% OF ENERGY SAVING
1	0	230	0.8	154	154	87.01
		80	0.5	20	20	
2	25	230	1.4	290	146.4	66.58
		130	1.7	190	48.92	
3	50	230	3	650	256.51	59.76
		150	3.5	480	103.22	
4	75	230	3.3	680	258.54	26.46
		160	4.6	756	190.13	

TABLE 6. OPTIMAL ENERGY SAVING

VI. CONCLUSION

We wish to conclude that we have successfully completed our project energy saving in single phase induction motor. A neural network is trained successfully using the feed forward network and it is used to give the input voltage of the motor depending upon the load condition. ANN soft computing method also trained successfully.

The control signal production for relay operation is done by AT89C51 Micro controller. We can able to get the energy conservation from 50% to 75% of load conditions. Industrial automation of this project is very easy and possible for future expansion. By doing this project we gain some technical and practical knowledge and also it is helpful to know the outside world to us.

REFERENCES

[1]. Jamuna, V., & Reddy, S.R. (2008). Neural Network controlled Energy Saver for Induction Motor Drives - International conference on Power Electronic Drives and Power systems POWER COIN, pp 36 – 3

[2].Asaii, B., Gosden, D.F., & Sathiakumar, S. (1996), “Neural Network Applications in Control of Electric Vehicle Induction Machine Drives”, IEE Transactions on Power Electronics and Variable Speed Drives, Conference publication No.429, pp273-278.

[3].Freeman, J.A., & Skapura, D.M. (2002), “Neural Networks Algorithms, Applications, and Programming Techniques”, Pearson’s Education, Asia, Ed. 6

[4].Kioskeredis, I., & Margaris, N. (1996). Loss minimization in scalar controlled induction motor drives with search controllers –IEEE Trans. On Power Elec., Vol. 11, No.2, pp. 213-230.

[5[.Gowri Shankar S,Jamuna P,Bharathi V, Loganayaki A, Praful Nandankar, Neelam Sanjeev Kumar, “IoT based Energy Efficient Smart Metering System” Proceedings of the Second International Conference on Electronics and Renewable Systems (ICEARS-2023)