ISSN 2250-3153

# Automatic Speed Control of Single Phase Induction Motor with the Variation of Ambient Temperature

**Rabisankar Roy[1], Susmita Das[2], Jayanta Kumar Ray[3], Shreyashi Barat[4], Biswarup Neogi[5]**

[1] EE Dept., DIATM , Durgapur, WB, India
[2]Asst. Prof., EIE Dept., JISCE, Kalyani, WB, India
[3]Asst. Prof., ECE Dept., KIEM, Mankar, WB, India
[4] ECE Dept., KIEM, Mankar, WB, India
[5]Faculty member, ECE Dept., JISCE, Kalyani, WB, India

***Abstract***- This paper is based on Automatic Speed Control of Single Phase Induction motor with variation of ambient temperature. The circuitry of the system comprises of temperature detector, control circuit and loading circuit. The control circuit is embedded with comparators, amplifiers and relays. Here algorithm, flowchart and computational approach is initiated. The detailed circuit diagram is given. This system has undergone a successful test approach and its behavior is observed by analyzing its temperature versus load curve. The equation of the curve using Newton's Interpolation method is incorporated. Simulation approach is incorporated.

***Index Terms***- Automatic Speed Control (ASC), Domestic Cooler Fan, Single Phase Induction motor, Newton's Interpolation Technique.

## I. Introduction

Being in comfort zone is a vital nature of human being. Something less effort able always attracts human mind. This innovation belongs in a zone far more advanced than a fan operated by a manual regulator. This device controls the speed of the induction motor used in a fan automatically by sensing the ambient temperature [Fig 1]. Like normal household fan regulators it does not need any attention for controlling the speed of the fan and thus it reduces human effort which is very much clear to us. It uses a TRIAC (Triode for AC) based circuitry which minimizes energy consumption and thus saves power [1]. It gives a wide control of working temperature range to the user while also providing manual control in case of need. These features are as interesting as well as very useful for the mediocre class because of a low buying and maintenance cost. This whole innovation will be discussed in succeeding points.

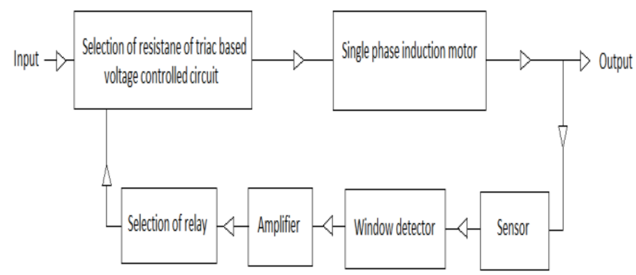


**Fig. 1: Block diagram of Automatic Speed Control of Single Phase Induction Motor**

### 1.1 Control process sequence for Temperature Control of Automatic Single Phase Induction Motor

The following steps describe the whole working principle of the device.

**Step 1:** From the point of making the speed ranges are divided by the manufacturer. For "n" number of speed ranges a total of (n-1) window detector and one single comparator is needed.

**Step 2:** Initially the working temperature range is set (by user or by default). The window detectors are provided for this issue, they compare the output of the sensor to its reference voltage. Each window detector has a maximum and minimum reference value which works as the temperature range. For example if the first speed range lies between 15-25°c then the reference values of the window detector will be 0.15 & 0.25 V for this device as a sensor gives output in mV and varies with the variation of temperature.

**Step 3:** Now only one window detector will give positive output for a particular ambient temperature which will lie in the range of that window detector. [Fig. 2]

**Step 4:** Then the output of the window detector is amplified and feed to a corresponding contact relay which completes the circuit by connecting the TRIAC based voltage control circuit to a resistance which corresponds to its relative window detector.

**Step 5:** Here the voltage to the fan is controlled and hence the speed is controlled

### 1.2 Algorithmic representation of control process of Temperature Control Single Phase Induction Motor

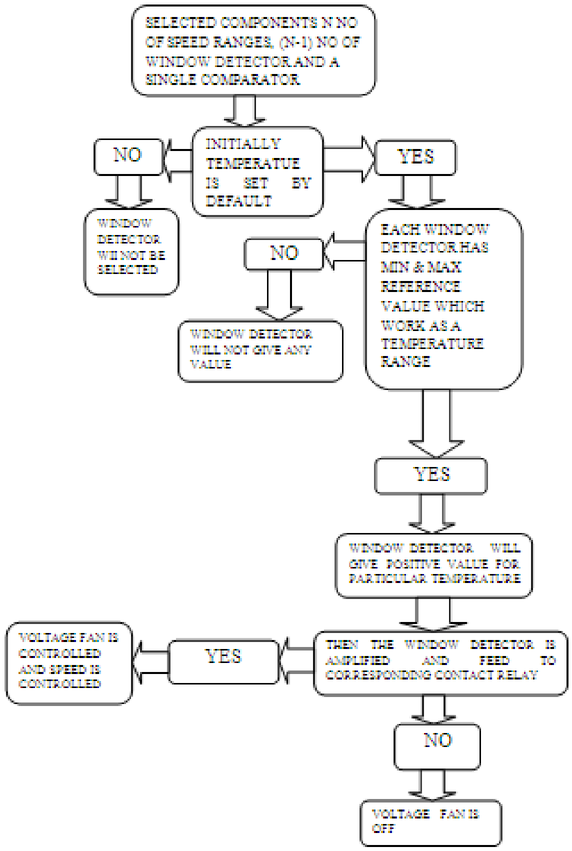


**Fig. 2: Flowchart representation of system**

### 1.3 Schematic representation of Automatic Speed Control for Single Phase Induction Motor:

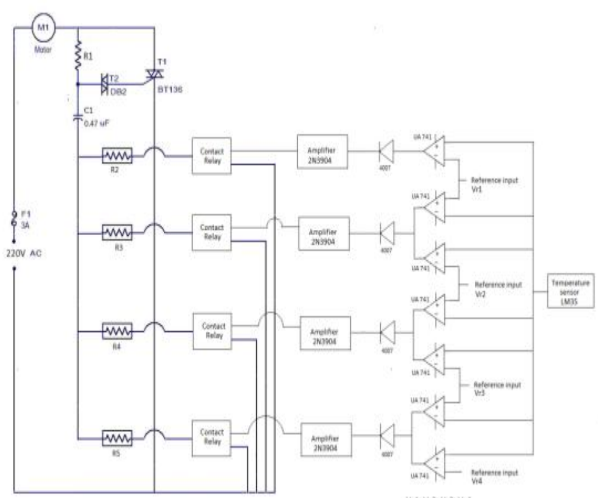


**Fig. 3: Componential representation of system prototype**

In this device a LM35 temperature [Fig 4] sensor is used which gives output in mV with respect to the ambient temperature and for the change of 1°c temperature [Table 2 & 3] the output of the sensor will vary 10mV. Now if the total speed of the fan is divided into 4 parts then 3 window detector and one single comparator is used. Each window detector has two reference values and they are used to control the speed within a limit lower than the maximum speed of the fan, these reference values of the window detectors can be set by user and the single comparator is used for the maximum speed [2]range of the fan. Giving an example for these reference values say, the reference values of the 1st window detector are 0.22V & 0.24V, for the 2nd detector these are 0.24V & 0.26V and for the 3rd these values are 0.26V & 0.28V and the last comparator has a value of 0.28V in its inverting terminal. Now when the ambient temperature is in between 22-24°c the sensor gives an output in between 0.22-0.25V. In this case only the 1st window detector gives positive voltage output. Similarly when the ambient temperature will be 24-26°c the sensor will be giving an output of 0.24-0.26V and for this case the 2nd window detector will give positive voltage output. Now with the output terminal of all the window detectors a diode is connected [3]which will block the negative voltage. Now with every window detector and one single comparator an amplifier (NPN transistor) is connected and with every amplifier a contact relay is connected. Here the output of the amplifier energizes the relay which works as a switch and completes the TRIAC based voltage controlled circuit.

Now from the diagram it is seen that for the energization of different relays, [Fig 3] different values of resistance are selected in voltage controlled circuit where a BT136 TRIAC, a DB2 DIAC and 0.47µF capacitor [4] is used. So with the change of resistance between the capacitor and AC voltage terminal the firing angle of the TRIAC is also changed as the resistance controls the charging time of the capacitor and therefor the firing angle because when capacitor C is charged to its breakdown voltage Vat of DIAC[1][8][12][13]. it 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[1][8][12][13]. After the TRIAC turns on the source voltage Vs appears across the load. In this way the voltage across the load is controlled and so the speed is also controlled by the means of voltage.

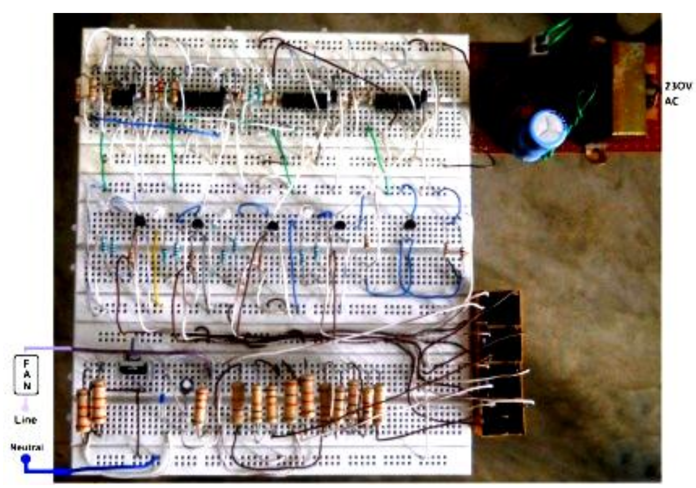


**Fig. 4: Hardware model of the system**

### 1.4 Result and performance analysis of Single Phase Induction motor:

This model was connected with a ceiling fan for testing purpose and the following results [Table 1] were got by connecting a voltmeter across the fan, an ammeter in series with the fan and a wattmeter.

| Temperature (°c) | Voltage across fan (V) | Current (A) | Wattage (W) |
|---|---|---|---|
| 34 | 224 | 0.32 | 68.8 |
| 32 | 160 | 0.27 | 59.6 |
| 30 | 134 | 0.23 | 51.2 |
| 28 | 124 | 0.22 | 47.2 |

**Table 1: Chart of Voltage, Current & Wattage against ambient Temperature**

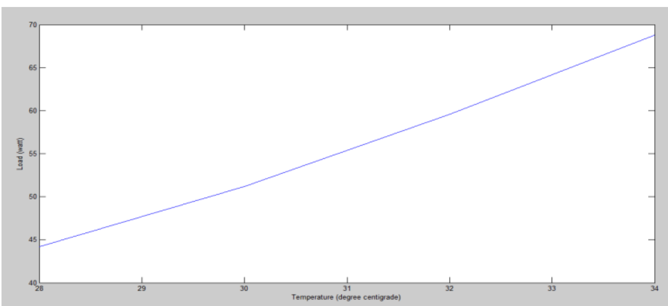


**Fig. 5: Graphical Representation of Temperature versus Load**

## II. ENTITY RELATION WITH INTERPOLATION TECHNIQUE

A relation is made between the loads and temperatures using interpolation technique.

| Temperature (°c) **x** | 28 | 30 | 32 | 34 |
|---|---|---|---|---|
| Load (w) **f(x)** | 47.2 | 51.2 | 59.6 | 68.8 |

**Table 2: Chart of Load against increasing Temperature**

| x | f(x) | Δf(x) | Δ²f(x) | Δ³f(x) |
|---|---|---|---|---|
| 28 | 47.2 | | | |
| | | 4 | | |
| 30 | 51.2 | | 4.4 | |
| | | 8.4 | | -3.6 |
| 32 | 59.6 | | 0.8 | |
| | | 9.2 | | |
| 34 | 68.8 | | | |

**Table 3: Chart of Interpolation technique**

Now S = [(x-28)/h =(x-28)/2]

$y0 = 47.2$

$\Delta y0 = 4$ , $\Delta^2 y0 = 4.4$, $\Delta^3 y0 = 3.6$

$$f(x) = y0 + s\Delta y0 + \frac{s(s-1)\Delta^2 y0}{1.2} + \frac{S(S-1)(S-2)\Delta^3 y0}{1.2.3}$$

$$\mathbf{f(x)} = 47.2 + \frac{(x-28)}{2} + \frac{(x-28)\left[\frac{(x-28)}{2}-1\right](4.4)}{2.2!} + \frac{[(x-28)[(x-28)/2-1]\left[\frac{(x-28)}{2}-2\right]}{2.3!}$$

So **f(x)** = $-0.075x^3 + 7.3x^2 - 232.1x + 2469.2$

## III. CONCLUSION

The block diagram, working principle, circuitry and device operation has described and the test results [Fig 5] are shown by which, it is very clear that the device controls the load with the variation of the temperature. It reduces human effort and as TRIAC is used for controlling [5] the voltage so saves power and more of all it is a device which is very much user friendly as the user can always change the range of operation by the needs and the buying cost is low where the reliability is high. These features surely make the device interesting and very useful. In future, the work will be done using control analogy.

## REFERENCES

[1] *SCR Manual,5th Edition,N.Y.,General Electric Company,1972.*
[2] *Hamid A. Toliyat,Gerald B. Kliman,HANDBOOK OF ELECTRIC MOTORS, Second edition revised and expanded*
[3] *Stephen L. Herman, electricMotor Control,9th edition.*
[4] *Three Phase Sold State Relays & Their Application in Three Phase Motor Circuits, Paul Bachman, Fellow Engineer, Dr. Oscar Montero, R&D Manager, and Doug Sherman, FSAE Manager, Crydom, Inc.*
[5] *Zahm A. An automatic speed control for wind tunnels,1928.*
[6] *F. Csaki et. Al., 'Power Electronics', Budapest : Akademiai Kiado, 1975.*
[7] *F.E. Gentry et. Al., 'Semiconductor Controlled Rectifier', Prentice-Hall of India New Delhi, 1964.*
[8] *B.K.Bose, 'Power Electronics and AC Drives', Printice-Hall, Englewood Cliffs, New Jersey 07632,1986.*
[9] *P.C Sen, 'Thyristorised DC Drive', New York: Wiley. Interscience, 1981.*
[10] *J.M.D Murphy and F.G. Turnbull 'Power Electronic Control of AC Motors', Pergamon Press,Oxford,1988.*
[11] *B.K. Bose ,'Evaluation of Modern Power Semiconductor Devices and Future Trends of Converters', IEEE Trans. Industry Application, vol. 28,No.2,pp. 403-413,March/April, 1992.*
[12] *NED MOHAN et.al., 'Power Electronics', John Willey and Sons, 1989.*
[13] *M.H, Rasid,' Power Elactronics', Printice-Hall of India, New Delhi, 1993.*
[14] *MChilikan,'ElectricDrive',Mir Publishers,Moscow,1970.*

ISSN 2250-3153

## AUTHORS

**First Author** – Rabisankar Roy received his B.Tech degree in Electrical Engineering from WBUT (Durgapur Institute Of Advanced Technology & Management) in 2012.He had participated in the model designing event of Scimantek (health & education fair) and designed the working model of 'Temperature Controlled Fan Regulator' in 2010 under the guidance of Dr. B. Neogi, organized by Rahul Foundation, Rajbandh ,Durgapur-12. In the final year of his B.Tech degree he has successfully completed the project 'Speed Control of DC Motor Using Chopper' with working model.

**Second Author** – Susmita Das is awarded the degree of M.Tech in Instrumentation & Control Engg. from Calcutta University (Rajabazar Science College) in 2011. Before that she received the B.Tech degree in Electronics and Instrumentation Engineering Dept. from GNIT (WBUT) in 2008. Now, she is engaged as an Assistant Professor rank of EIE Dept. in JISCE, Kalyani. She has been engaged as a successful examiner of WBUT curriculum. She has initiated her PhD (engineering) under the supervision of Dr. B .Neogi. Her research interest includes Control Theory, Process control and Biomedical Engineering etc. Email: susmitad2011@gmail.com

**Third Author** – Jayanta Kumar Ray received degree AMIETE from IETE Calcutta Centre. After that he awarded M.Tech in Electronics and Communication Engineering Dept. from MCKV College of Engineering. Recently, he is engaged as an Assistant Professor rank of ECE Dept. in KIEM, Mankar. His research interest includes Control Theory, Biomedical Engineering, and Microwave Engineering etc

**Fourth Author** – Shreyashi Barat is a fresher B.Tech in Electronics and Communication from WBUT in 2012.She is now working for publishing research paper for various journals. She is also working under Dr. Biswarup Neogi for various researches. Her field of interest is Control Theory, Power Electronics.

**Fifth Author** – Dr. Biswarup Neogi is awarded PhD (Engineering) from Jadavpur University, India. He received M.Tech degree in ECE from Kalyani Govt. Engg. College in 2007. Before that He obtained B.E in ECE from UIT, The University of Burdwan in 2005.He has a experience on various project of All India Radio attached with the Webel Mediatronics Ltd, Kolkata. He was a lecturer in ECE Dept, Haldia Institute of Technology. WB, India. He was working as a faculty in ECE Dept, Durgapur Institute of Advanced Technology & Management. Currently he is engaged with JIS College of Engineering, Kalyani as a Faculty member and flourished R&D related activity. Recent now he is also engaged as a consultant executive engineer of YECOES Ltd, Hooghly, and attached as an advising body of different Engineering College under WBUT. His research interest includes Prosthetic Control, Biomedical Engineering, Digital Simulation, Microcontroller based Embedded System. He is guiding five Ph.D theses in this area. He has published about fifty several papers in International and National Journal and Conference conducted both in India and abroad. Additionally, he attached as a reviewer of several journals and yearly conference.
Email: biswarupneogi@gmail.com