Automatic Speed Control of Single Phase Induction Motor Using Temperature Sensor

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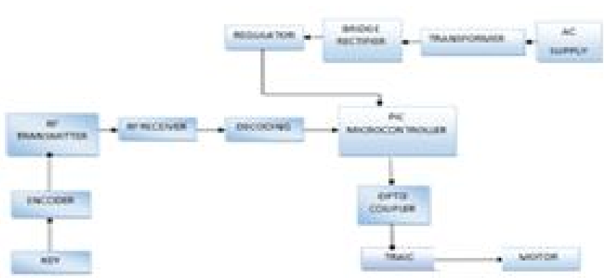
Abstract- *This paper is based on automatic speed control of single phase induction motor with a variation of ambient temperature. The circuitry of the system comprises of power circuit, control circuit, drive circuit. The control circuit is embedded with the Microcontroller, temperature sensor, LCD display. The proposed speed control method enables the user to operate induction motor using remote control. When power is supplied to the induction motor at the recommended specification then it starts to run at rated speed. However many application need variable speed operation one of the best is fan. This paper present a design of a Microcontroller based motor controller with temperature sensor which is used to vary the speed of the motor. The power delivered to the motor is controlled by the firing angle of a TRIAC where it controls the ac supply.*

Keywords- Single phase induction motor, Triac, Microcontroller, Temperature sensor, Remote.

I. INTRODUCTION

Even though the entry of Air-conditioning systems, Fan plays a major role presently due to their speed control flexibility, simple rugged design, low cost and low maintenance. Normally the speed control of the fan is done by manually, but our thesis is to control the speed of the fan automatically by sensing ambient temperature. This innovation belongs more advanced than a fan operated by a manual regulator. Like normal household fan regulator does not need any attention for controlling the speed of the fan and thus is reduces human effort also. It uses a TRIAC based circuitry which minimizes energy consumption and thus saves power. Figure 1.1 shows the automatic speed control 1Ø induction motor with the variation of ambient temperature and speed variation using remote control.



II. POWER CIRCUIT

In the control circuit and driver circuit PIC controller and opto coupler needs regulated 5V DC respectively. For this purpose the power circuit is needed. Normally available voltage source is 230V or 220V AC, but controller and optocoupler needs 5V DC source. So transformer is used to step down the 230V AC to 12V AC and it is converted into DC source using bridge rectifier. Once rectified from an AC signal, the DC needs to be smoothed to remove the varying voltage level. The large reservoir capacitors are used for this purpose. After getting smoothed output source linear regulators are used to get required voltage level (5V) for control and driver circuit.

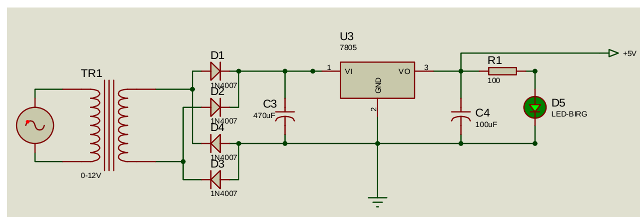


Fig. 1.2 Power circuit

III. CONTROL CIRCUIT

This circuitry consists of PIC 16F877A Microcontroller, LM35 temperature sensor, LCD. Here the PIC Microcontroller plays a major role. It is the heart of this circuitry. The voltage regulator is used to supply required voltage for controller. In this crystal oscillator is used to provide clock signal for the PIC Microcontroller. The temperature sensor senses the room temperature and it converts it into small voltage. This small level output voltage is fed to the PIC controller. For display of the room temperature and corresponding speed level of the motor LCD display is used. In general PIC controller has 33 input and output ports so we can achieve speed control of multiple motors. The output of the PIC controller is positive going square wave. Depending on the temperature of the room the duty cycle of the square pulse is varied. From the use of this we can control the speed of the motor.

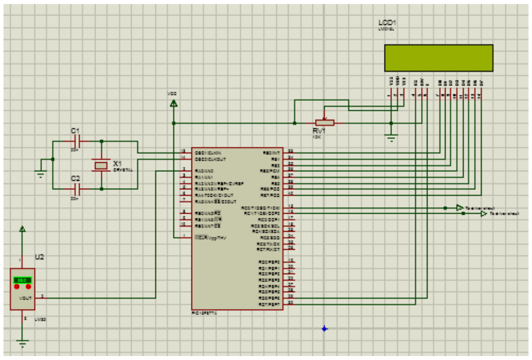


Fig. 1.3 Control circuit

I. Temperature sensor (LM35):

LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature. Temperature sensors are devices used to measures the temperature of a medium. It series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius temperature. The LM35 thus has an advantages over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracy. It low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy.

II. PIC 16F877A:

It is a 40 pin 8-bit CMOS FLASH Microcontroller. The Microcontrollers are similar to microprocessors, but they are designed to work as a true single-chip system by integrating all the devices needed for a system on a single-chip. The timing and control unit will generate the necessary control signals for internal and external operation of the Microcontroller. Microcontrollers with internal ADC can directly accept analog signals for processing.

The switching pulses required for inverter operation are generated using PIC 16F877A Microcontroller, thus reducing the overall system cost and complexity. The Microcontroller generates a PWM pulse at particular frequency and switching pulses for the MOSFET switches.

The crystal oscillator is used to generate the required clock for the Microcontroller Here we used Quartz Cristal oscillator. The maximum clock frequency of quartz crystal that can be connected to PIC 16f877A Microcontroller is 20Mhs. The Internal clock frequency of Microcontroller is same as crystal frequency or externally supplied clock frequency. The reset switch is used to reset the Microcontroller in order to bring the controller to a known state, for proper reset the reset pin should be held low for atleast 2 machine cycles.

When the temperature sensor, LM35 sensed the surrounding ambient temperature, it will produce a very small output voltage. This output voltage will then be fed to the PIC Microcontroller. PIC will perform as a digital signal process medium where it takes the output voltage and converts it into digital form for further processing. Before the system works, it requires the highest and the lowest reference temperatures to be set.

The highest reference temperature will be set to a limit boundary temperature where there should be no temperature higher than it. If the output voltage from temperature sensor is found to be higher than the highest preset reference temperature value, it indicates that there might be fire breakout occurring or there are some faulty errors occurred in the circuit. The lowest reference temperature is used to set the maximum requirement temperature in order to stop the motor. When the ambient temperature of the smart home environment is found to be lower than the lowest reference temperature, the motor will be stopped. Besides that, some of the preset values for difference temperatures are also being set in the Microcontroller. The temperature sensor is connected to RA0 hence the output voltage from the sensor will be sent to RA0.

After that, the PIC Microcontroller will digitalize the analogue signal. Then, it will compare the ambient temperature to each of the reference temperatures. The comparison results will then be used to generate different signals at the port D to trigger the BJT transistor where the BJT transistors are link to the relays in the phase control circuit. With the firing angle controlled, the motor speed can also be controlled. In addition, the temperature will also be indicated in port C.

Architectural overview:

PIC 16f877A architecture has the program and data accessed from separate memories. So the device has a program memory bus and a data memory bus separating program and data memory further allows instruction to e sized different than the 8 bit wide data word.

Analog-to-Digital Converter:

The Analog-to-Digital converter has eight inputs. The analog input charges a sample and hold capacitor. The output of the sample and hold capacitor is the input into the converter. Then, it will compare the ambient temperature to each of the reference temperatures then generates a digital result of this analog level via successive approximation. The A/D module has high and low voltage reference input that is software selectable to some combination of VKK, VSS, RA2 or RA3.

The A/D converter has a unique feature of being able to operate while the device is in SLEEP mode. To operate SLEEP mode, the A/D clock must be derived from the A/D internal RC oscillator.

Crystal Oscillator:

The 8051 has on chip oscillator pin XTAL1 and XTAL2 are provided for connecting a resonant network to from an oscillator crystal frequency ranges from 1 MHz to 24MHz.

Ceramic resonators may be used as a low-cost alternative to crystal resonators but due to decrease in frequency stability and accuracy, ceramic resonators are not preferred for high-speed serial data communication with other system.

The oscillator formed by the crystal, capacitors and on chip inverter generates pulse train at the frequency of the crystal. The clock frequency and establishes the smallest interval of time within the Microcontroller, called the pulse time. The smallest interval of time to accomplish any simple instruction, or part of a complex instruction however, is the machine cycle. The machine cycle is made up of six states. A state is the basic time interval for discrete operations of the Microcontroller such as fetching on encode byte decoding encode, executing an encode, or writing a data byte. The oscillator pulses define each state.

III. LCD (LM01L):

A Liquid crystal display is a thin, flat electronic visual display uses the light modulating properties of liquid crystals. LCDs need a light source and are classified as “passive” displays. In this paper LCD has been used to display static text files.

IV. DRIVER CIRCUIT

Driver circuit consists of Opto coupler and Triac to drive the motor.

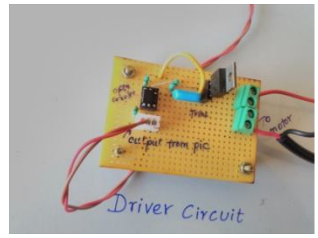


Fig.1.4A Driver circuit

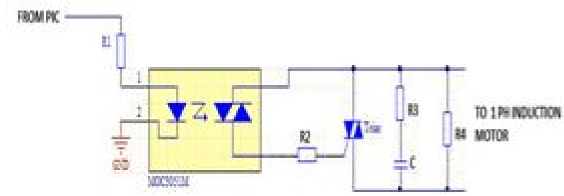


Fig.1.4B Driver circuit

I. OPTOCOUPLER:

An OPTOCOUPLER also known as an opto-isolator or photo-coupler. It is an electronic component that interconnects two separate electrical circuits by means of a light sensitive optical interface. In our paper optocoupler is used in driver circuit. When the varying duty cycle form PIC is given to driver circuit then there will be a closed current path from R3, LED and ground. Then LED starts to emit the infra-red light and photo sensitive device detects the light source which interconnects two separate electrical circuits as shown in Fig. 1.4A and 1.4B

II. TRIAC:

TRIAC is a subset of thyristors and is related to silicon controlled rectifiers. However, unlike SCRs, which are unidirectional devices and only conduct current in one direction, TRIAC are bidirectional and conduct current in both directions. Another difference is that SCR can only be triggered by a positive current at their gate but in general, TRIAC can be triggered by either a positive or negative current at their gate, although some special types cannot be triggered by one of the combinations. To create a triggering current for an SCR a positive voltage has to be applied to the gate but for a TRIAC either a positive or negative voltage can be applied to the gate. Once triggered, SCRs and thyristors continue to conduct, even if the gate current drops below a certain level called the holding current.

III. SINGLE PHASE INDUCTION MOTOR :

Single phase induction motors require just one power phase for their operation. As its name indicates stator is a stationary part of induction motor. A single phase ac supply is given to the stator of single phase induction motor. The rotor is a rotating part of induction motor. The rotor is connected to the mechanical load through the shaft. The rotor in single phase induction motor is of squirrel cage rotor type. They are commonly used in low power rating applications, in domestic as well as industrial use. When the single phase induction motor is fed with single phase supply, it produces alternating current flowing through stator winding causes induced current in the rotor bars. According to FARADAY'S LAW OF ELECTROMAGNETIC INDUCTION. This induced current in the rotor will also produce alternating flux. Even after both alternating fluxes are set up, the motor fails to start. However, if the rotor is given a initial start by external force in either direction, then motor accelerates to its final speed and keeps running with its rated speed. Our paper we use capacitor start/capacitor run induction motor is used. Here capacitor is used for starting of induction motor, because single phase induction motor does not have self starting. The capacitor mounted either at the top or side of the motor. A normally closed centrifugal switch is located between the capacitor and the start winding. This switch opens when the motor has reached about 75 percent of its operating speed. Here motor speed is controlled by variation of ambient temperature. When the optocoupler interconnects the two electrical circuits in driver circuit as shown in Fig.1.4 gate of the triac is turned on and motor is given by power supply. Similarly with the variation of duty cycle the motor speed is controlled.

V. REMOTE CONTROL

Controlling speed of ac motor is required in industries as well as in domestic use. In some other application like fan, blowers, heaters etc another method for speed control is used that is phase and control. By varying the phase angle, the current supplied to motor can be varied. And by varying supplied current the speed of motor can be varied. In domestic application the phase angle control method is used. The best example is fan regulator. In domestic fan regulator DIAC and TRIAC are used to varying the phase angle of fan motor. Instead of this regulator remote control is implemented in this paper. RF remote control is used as Remote. It consists of key part, encoder, RF transmitter, RF receiver and decoder.

I. RF TRANSMITTER:

This simple RF transmitter, consisting of a 434MHz license-exempt transmitter module and an encoder IC, was design to remotely switched appliances ON and OFF or speed control. The transmitter module has 4 pins. Apart from data and the VCC pin, there is a common ground for data and supply. Last is the RF output (ANT) pin. The block diagram of transmitter circuit is shown in Fig. 1.6

II. RF RECEIVER:

The circuit completes the RF transmitter built around the small 434MHz transmitter module. The receiver pickups the transmitter signals using the 434MHz receiver module. This integrated RF receiver module has been tuned to the frequency of 433.92MHz, exactly same as for the RF transmitter. The receiver module has 8 pins. Apart from 3 ground and 2 VCC pins, there are 2 pins(1 for digital data and other for linear data) for data output. The last is the RF input pin. The block diagram of receiver circuit is shown in Fig. 1.5

III. ENCODER:

For the transmission of a unique signal, an encoder is crucial. For this the renowned encoder IC HT12E from holtelk. HT12E is capable of encoding information which consists of N address bits and 12N data bits. Each address/data input can be set to one of the two logic states. The programmed addresses/data are transmitted together with the header bits via an RF transmission medium upon receipt of a trigger signal.

IV. DECODER:

The "Coded signal receives serial transmitted by the transmitter is processed at the receiver side by the decoder IC HT12F from holtek. It is capable of decoding informations that consist of N bits of address and 12N bits of data It decoder IC receives serial addresses and data from the HT12E encoder that are transmitted by the RF transmitter module HT12D compare the serial input data three times continuously with the local addresses.

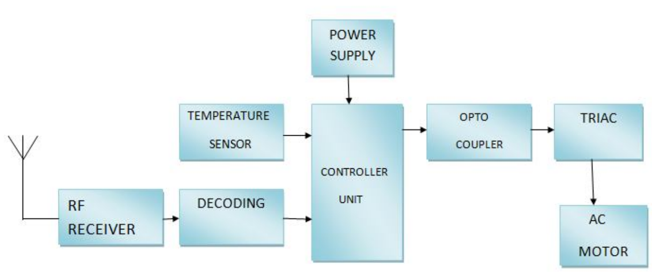


Fig. 1.5 Receiver block

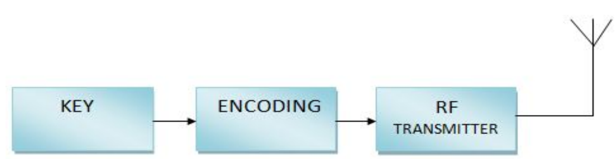


Fig. 1.6 Transmitter block

VI. OVERVIEW OF THIS PAPER

Our main objective is to control the speed of the motor by sensing the room temperature. Initially the temperature sensor senses the room temperature and converts it into voltage with respect to the temperature that is sensed by the sensor. This output from the sensor is given to the PIC Microcontroller. The analog output voltage from the sensor is converted into digital by Analog to Digital converter, which is inbuilt in the PIC controller. The operating voltage of the PIC (5V) is obtained from the power circuit. Crystal oscillator is provided to give clock pulse to the PIC. With the change in temperature the positive going output wave from PIC is also varied. The overall circuit operation and level obtained from the PIC controller is given in Flow chart and Table 1. The controlled voltage is obtained from the PIC controller is given to driver circuit for the operation of opto coupler through switching on or off the transistor. From controlling the operation of the opto coupler by triggering the triac we can control the speed of the single phase induction motor.

Table 1 speed level table

TEMPERATURE IN °C	SPEED LEVEL
20 to 25	Level 1
25 to 35	Level 2
35 to 40	Level 3
40 to 45	Level 4
>45	Level 5

FLOW CHART:

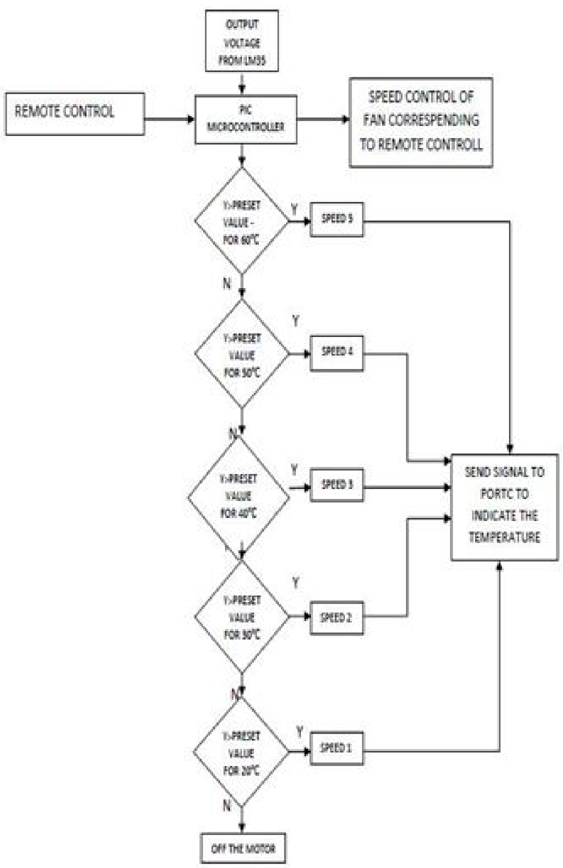


Fig. 1.7

This fig 1.7 shows flow chart for the speed change of the induction motor with respect to the room temperature by using PIC Microcontroller. The analog output obtained from LM35 is converted into digital form using ADC converter and it is given to the PIC Microcontroller. The PIC Microcontroller used is this paper is programmed to vary the speed for the change in temperature of induction motor.

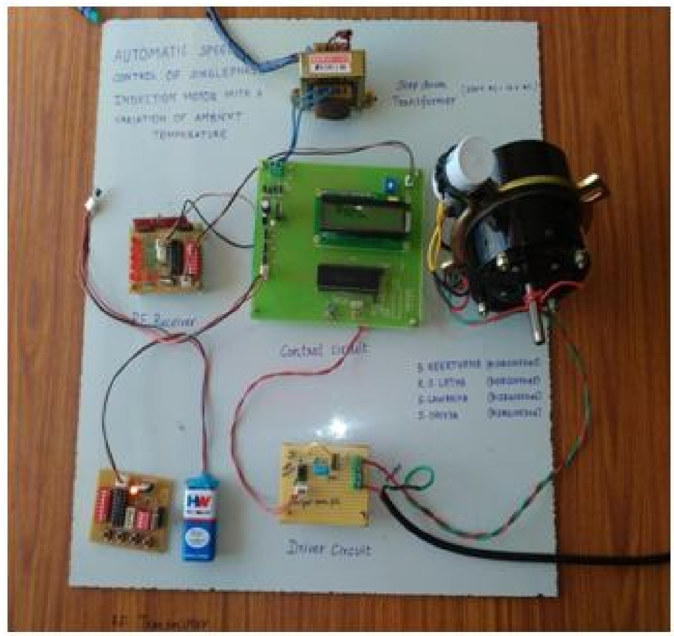


Fig 1.8 overall circuit diagram

If the temperature is maximum (45°C) the motor runs in level 5 which is the maximum speed of the motor and if it is low (20°C) runs in level 1 which is minimum speed. The temperature ranges between level 1 and level 5 are given in the table 1. Fig 1.8 and Fig 1.9 shows the overall circuit diagram and duty cycle variation of the paper.

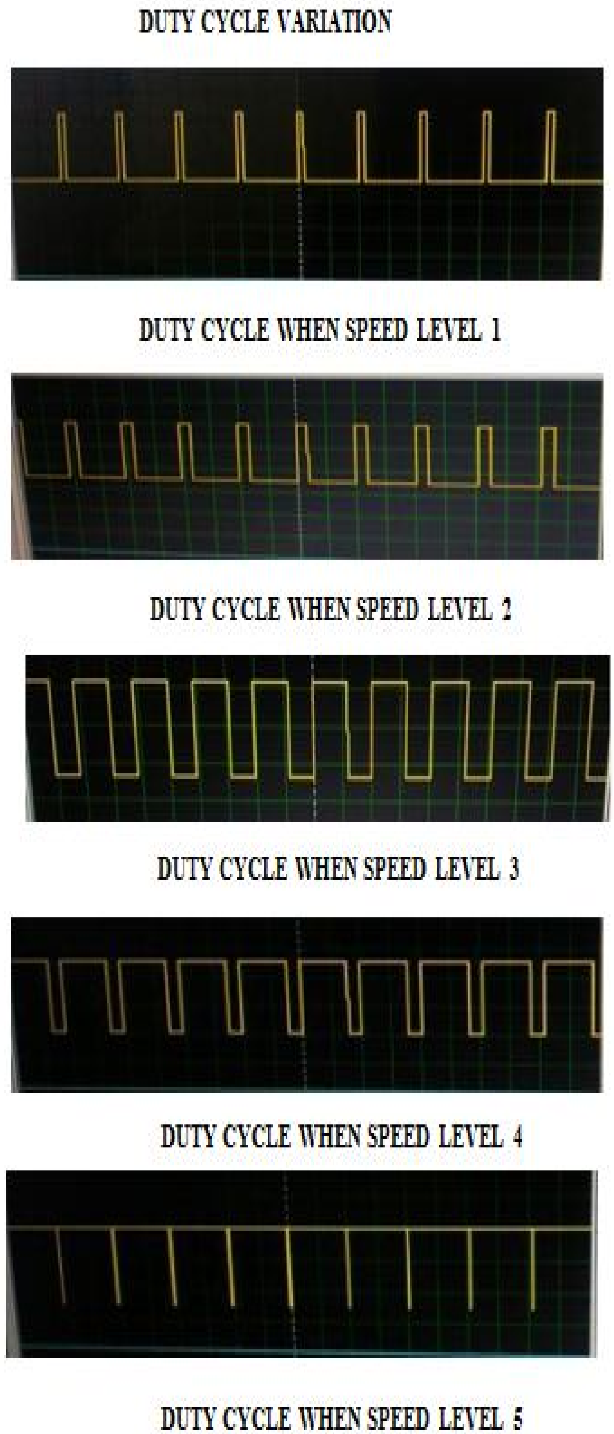


Fig 1.9 duty cycle variation

VII. CONCLUSION

The result indicates this control method can provide energy saving for home appliances. It works effectively in term of energy saving compared to the existing fan speed controlling method. In the future, the system will be integrated with zero cross detections that more precise input power to the fan’s motor can be controlled. As a result, more precise speeds of the fan can be controlled. In a nutshell, this paper is highly potential for application purposes in other fan motor speed control, hence improvement will be carried out continuously so that in one day, it will become widely used for the motor speed control and the energy can be saved effectively in a smart home.

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