# DESIGN AND IMPLEMENTATION OF MICROCONTROLLER BASED AUTOMATIC FAN SPEED REGULATOR (USING TEMPERATURE SENSOR)

**Nwankwo Nonso Prince , Alumona Theophilus , Onwuzulike Daniel .A., Nwankwo Vincent**

***Abstract*— This paper presents the design and implementation of Microcontroller based automatic Fan speed regulator using temperature sensor. Most of the available Fans today are controlled manually by voltage regulators which have different stages of speed. During summer nights especially, the room temperature is initially quit high, as time passes, the temperature starts dropping. Also, after a person falls asleep, the metabolic rate of one's body decreases, and one is expected to wake up from time to time to adjust the speed of the Fan. Many people have died as a result of this, and the disabled / physically challenged persons are affected the most because of the inconveniences associated in changing the Fan speed level manually when the room temperature changes. So, an efficient automatic Fan speed control system that automatically changes the speed level according to the change in environment / room temperature was implemented to solve the problems associated in Fan speed manual control system. To solve these problems the system made use of; AT89C51 Microcontroller, temperature sensor (LM 35), Analog to Digital Converter (ADC) and the Liquid Crystal Display (LCD) as its main components to achieve a new technology in "control system" that monitors and regulates the speed of a Ceiling Fan depending on the room temperature at any point in time. The temperature sensor (LM 35) which is directly connected to the Analogue to Digital converter (ADC) is used to sense any slight change in room temperature. The output of the temperature sensor which is in Analogue form is fed to the input of the Analogue to Digital Converter (ADC) whose main task is to convert the analogue signal (change in room temperature) from the temperature sensor to its digital equivalent. The output of the (ADC) is directly coupled to the Microcontroller for further processing and control to achieve the desired system. The sensed and the set values of the temperature, including the Fan speed are displayed on the (16 x 2) Liquid Crystal Display (LCD). The designed system has been proven to be a reasonable advancement in control system technology.**

***Index Terms*—** Analogue to Digital Converter (ADC), Temperature sensor, Liquid Crystal Display (LCD), AT89C51 Microcontroller, LM35 Temperature Sensor

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## I. INTRODUCTION

Today, Ceiling Fan is always used in the daily purposes especially in Africa. It is used to control the room temperature. All the activities of Ceiling Fan can be controlled by using centrifugal switch. The user can select the interested speed by switching the appropriate level in switch centrifugal [1]. Normally, a ceiling Fan has six speeds' switches. There are speed 0, speed 1, speed 2, speed 3, speed 4 and speed 5. The speed 0 is especially for switching off the ceiling Fan. The slowest is for speed 1 and the fastest is speed 5. During the night, the metabolic rate of one's body decreases, and one is expected to wake up from time to time to adjust / regulate the speed of the Fan (with respect to room temperature). Many people have died as a result of this, and the disabled / physically challenged persons are affected the most because of the inconveniences associated in changing the Fan speed level manually [2]. Thus electricity usage by Fan about 100watts~80watts (depending on the make) is more than what is required for the desired low speed operation of Fan (approximately 10 watts to 30watts). So, an efficient and reliable **closed loop control**

**system** that automatically changes the Fan speed level according to the change in room temperature was built to solve the problems and shortcomings associated with manually method of Fan speed control [3].

### 1.1. Objectives

The objectives of this project are to:

1) Design an electric Fan (Ceiling Fan) that will automatically change the speed level according to change in room / environment temperature.
2) Develop an automatic Fan system that can monitor the room temperature and compare it with the stored temperature in other to switch the Fan to the appropriate speed.
3) Develop an intelligent system that can automatically switch OFF a Ceiling Fan if the room temperature falls below critical value ($16^0$ c).
4) Design a closed loop system based on combination of software and hardware.
5) Design an intelligent control system that can display both the Fan speed and the temperature (at any point in time) on the Liquid Crystal Display (LCD) made available in the system.

### 1.2 Problem Statement

Most people find it difficult to be waking up during the night to adjust the Fan speed level manually when the room temperature changes. Many lives have been lost as a result of this, and the disabled / physically challenged persons are affected the most because of the inconveniences associated in changing the Fan speed level manually. Thus this problem situation has two (2) perspectives. In one perspective we end up spending more electricity than desired and in another perspective, even on spending greater electricity we are not able to get the comfortable sleep with respect to waking from time to time to manually control / regulate the Fan speed. So, an automatic Fan that automatically changes the speed level according to temperature changes is recommended to be built for solving these problems.

## II. Concepts of the Project

This project is used to control the speed of a Ceiling Fan according to the environment / room temperature. It also senses the room temperature (at any point in time) and displays it on the Liquid Crystal Display (LCD) which serves as the output of the system [4]. The system will get the temperature sense from the temperature sensor (LM 35) and controls the Fan speed depending on the corresponding temperature range stored in the AT89c51 microcontroller which serves as the brain of the system. The hardware tools employed in designing the system includes :- AT89c51 microcontroller, Temperature measuring IC (LM35), resistors, capacitors, Liquid Crystal Display (LCD), Ceiling Fan, power supply , Analog to Digital Converter (ADC0804), etc. This is a wonderful breakthrough in digital control system and technological advancement in general.

### 2.1. Concepts of Control and Control Systems

Control means directing and commanding a process. A control system can be defined as a device or a collection of physical components to regulate, direct and command the flow of energy, or a process. Figure 1 below is a generalized block diagram of a control system.

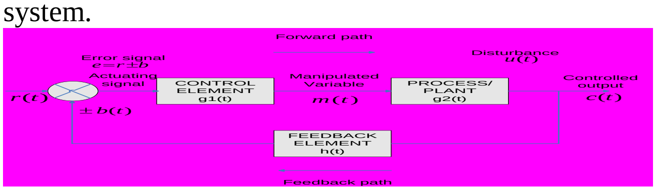
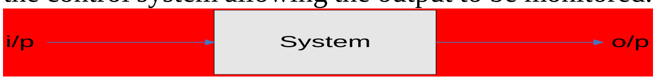


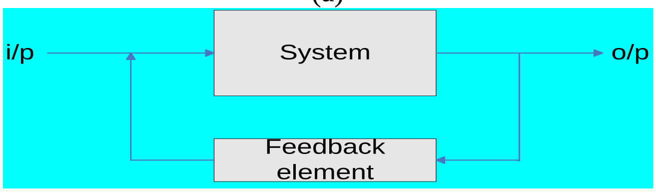

Figure 1. Generalize Block Diagram of a Control System

### 2.2. Open and Closed Loop Control Systems

Control systems can be classified as either open loop or closed loop. In an open loop system, there is no means by which the output is monitored by the system. However, a closed loop system has a feedback path from the output of the controlled process to the input of the control system allowing the output to be monitored.




(a)




(b)

Figure 2. Block Diagram of an Open and Closed Loop Control System (respectively)

In this project the system has a closed loop control mechanism which monitors the environment / room temperature and controls the Ceiling Fan by switching it to the appropriate speed. The temperature sensor (LM 35) which is coupled to the AT59c51 microcontroller via Analog to Digital Converter (ADC) works in harmony to achieve the desired system. The temperature sensor is used to sense any change in room temperature. The Analog to Digital Converter as the name implies, is used to convert the sensed change in room temperature (which is in analog form) to its digital equivalent. While the microcontroller is used to direct, control, coordinate and manage all the activities of the system. The ability of the system to monitor any change in room temperature (at any point in time) and regulate the Fan speed automatically makes it a closed loop control system. The temperature sensor (LM 35) serves as the feedback element / component.

### 2.3. Manual and Automatic Control Systems

Control systems can be classified as manual or automatic, based on the type of process or plant controlled. In manual control systems every process is executed by a manual operator .In the case of the automatic control systems the entire process is executed by machines which have been programmed appropriately. This project is an automatic control system since it is programmed and responds to changes automatically.

### 2.4.0. Classification of Controllers (Control Elements)

There are a number of different types of control systems that have already been designed and studied extensively. The mission of the controlling device is to make the measured value, usually known as the process variable, equal to the desired value, usually known as the set-point [5]. These controllers are the Proportional (P), Proportional Derivative (PD), Proportional Integral (PI) and Proportional Integral Derivative (PID) controllers.

### 2.4.1. Proportional Controllers

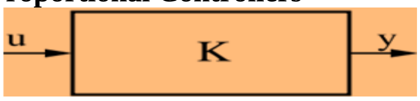



Figure 4. A Proportional controller block diagram

Proportional controllers are simply gain values. These are essentially multiplicative coefficients, usually denoted with a K. Proportional Control, determines the magnitude of the difference between the set-point and the process variable (known as error), and then applies appropriate proportional changes to the control variable to eliminate error.

### 2.4.2. Proportional – Derivative Controllers

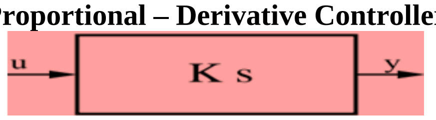



Figure 5. A Proportional-Derivative Controller Block Diagram

Derivative Control monitors the rate of change of the process variable and consequently makes changes to the output variable to accommodate unusual changes. Derivative controllers should be used with care, because even small amount of high-frequency noise can cause very large derivatives, which appear like amplified noise [6]. Also, Derivative controllers are difficult to implement perfectly in hardware or software. Frequently, solutions involving only integral controllers or proportional controllers are preferred to the use of derivative controllers.

### 2.4.3. Proportional - Integral Controllers

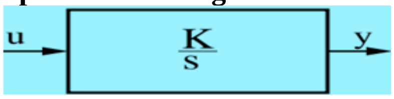



Figure 6. A Proportional-Integral Controller Block Diagram

Integral Control examines the offset of set-point and the process variable over time and corrects it when and if necessary.

## III. System Implementation

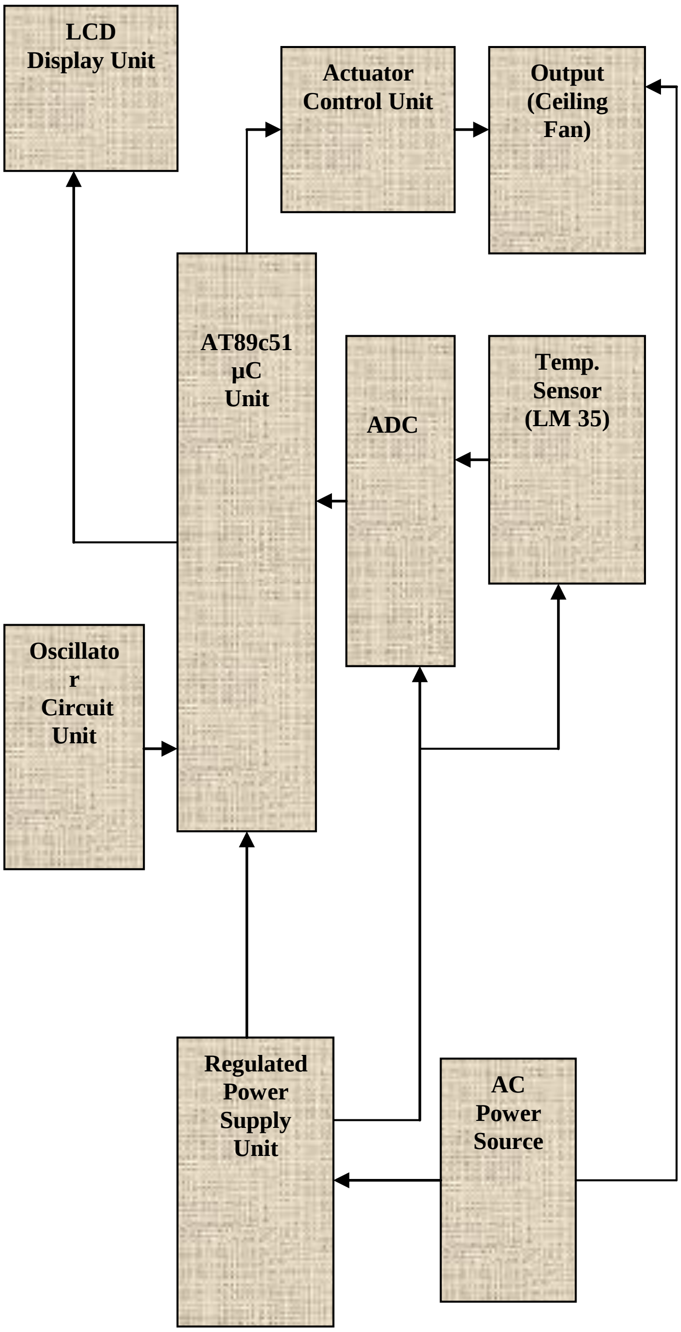



figure 7. Block Diagram of Microcontroller Based Automatic Fan speed Regulator

### 3.0.1. Microcomputer Architecture

A microcomputer is made up Hardware and Software. Hardware refers to the parts we can see and touch while the Software is made up of the various programs i.e.

sequence of instructions installed / programmed into the computer which direct the operation of the Hardware parts.

### 3.0.2. Microcomputer Hardware

The microcomputer contains a microprocessor, a memory unit and an input/output (I/O) unit as well as a system bus which allows information to be moved between the units of the computer.

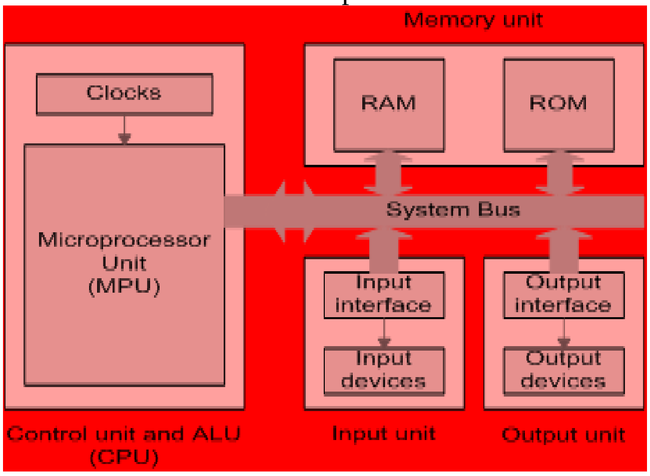



Figure 8. A Block Diagram of the Basic Elements of a Microcomputer System

### 3.1: Hardware Implementation

### 3.2. The Temperature Sensor (LM 35)

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in$^{o}$C). *Why Use LM35 to Measure Temperature?*

1) It can measure temperature more accurately than a using a thermistor.
2) The sensor circuitry is sealed and not subject to oxidation.
3) The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified.

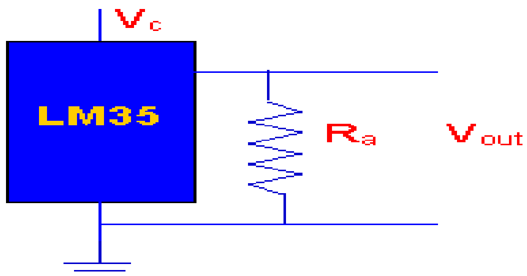



Figure 9: Connection Diagram of LM 35 Temperature Sensor

The general equation used to convert output voltage to temperature is:

Temperature ( oC) = Vout * (100 oC/V)

So if Vout is 1V , then, Temperature = 100 oC

The output voltage varies linearly with temperature.

Since the sensed change in room temperature is in analog form, the output of the LM 35 is directly coupled to the Analog to Digital Converter (ADC) for further processing.

### 3.3: The Analog to Digital Converter (ADC0804)

ADC0804 is an 8 bit successive approximation analogue to digital converter from National semiconductors. The features of ADC0804 are differential analogue voltage inputs, 0-5V input voltage range, no zero adjustment, built in clock generator, reference voltage can be externally adjusted to convert smaller analogue voltage span to 8 bit resolution etc. The voltage at Vref/2 (pin9) of ADC0804 can be externally adjusted to convert smaller input voltage spans to full 8 bit resolution. Vref/2 (pin9) left open means input voltage span is 0-5V and step size is 5/255=19.6V.The pin out diagram of ADC0804 is shown in the figure 10 below.

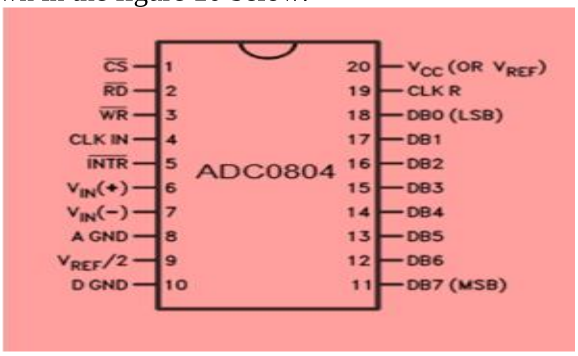



Figure 10: Pin out Diagram of ADC0804

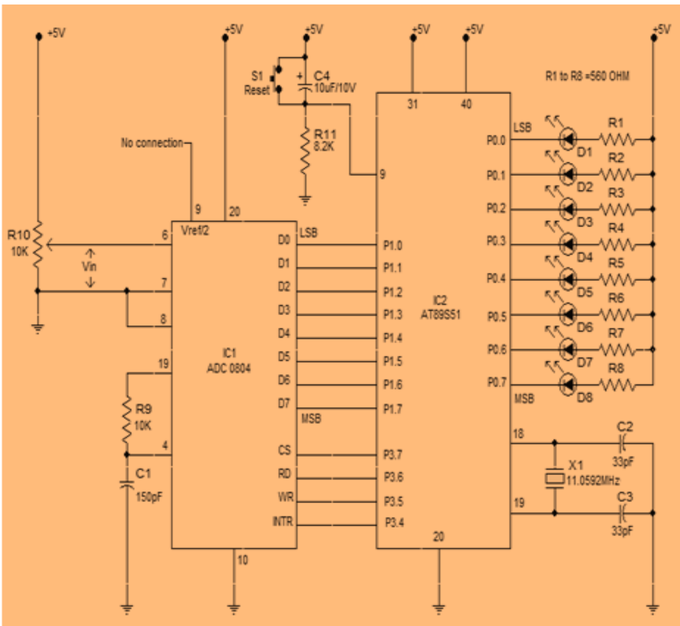


Figure 11: Interfacing ADC to Microcontroller

The sensed change in room temperature by the temperature sensor is directly coupled to the ADC for further processing and conversion. As the name imples, the ADC is used to convert the change in room temperature (which is in analog form) to its digital equivalent required by the microcontroller

### 3.4. The AT89C52 Microcontroller

The **AT89C52** is a low-power, high-performance CMOS 8-bit microcomputer with 8K bytes of Flash programmable and erasable read only memory (PEROM). The device is manufactured using Atmel's high-density non-volatile memory technology and is compatible with the industry-standard 80C51 and 80C52 instruction set and pin-out [7]. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. The 8951 microcontroller onboard the system is used to store the entire assembly language program needed for the system to function appropriately. All the units that made up the system are directly or indirectly connected to it. Refer to **figure 12** below for the pin out configuration of the microcontroller.

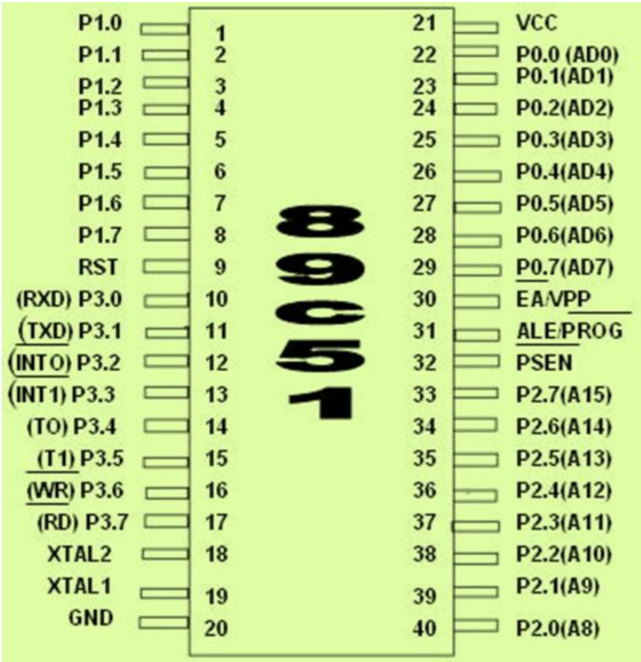



Figure 12. The pin out configuration of the AT89C51 microcontroller

The digital equivalent of the change in room temperature converted by the ADC is coupled to the microcontroller for further processing and control. On receiving any variation / change in room temperature, the microcontroller switches or changes the Fan speed according to the temperature range stored or programmed in its internal memory.

### 3.5. The Liquid Crystal Display (ADC)

Liquid Crystal Display (LCD) consists of rod-shaped tiny molecules sandwiched between a flat piece of glass and an opaque substrate. These rod-shaped molecules in between the plates align into two different physical positions based on the electric charge applied to them. When electric charge is applied they align to block the light entering through them, where as when no-charge is applied they become transparent. Light passing through makes the desired images appear. This is the basic concept behind LCD displays. LCDs are most commonly used because of their advantages over other display technologies. They are thin and flat and consume very small amount of power compared to LED displays and cathode ray tubes (CRTs). Figure 13 below shows the pin out diagram of Liquid Crystal Display (LCD).

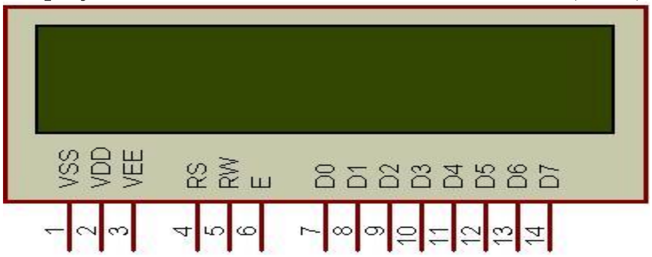



Figure 13: Pin out Diagram of Liquid Crystal Display (LCD)

The Liquid Crystal Display (LCD) is used to display all the information of the system. It is uesd to display the room temperature as well as the Fan speed (at any point in time). Any vairation in room temperature can be noticed from the LCD.

### 3.6. The Crystal Oscillator

XTAL1 and XTAL2 are the input and output, respectively, of an inverting amplifier which can be configured for use as an on-chip oscillator, as shown in Figure 14 (figure 1). Either a quartz crystal or ceramic resonator may be used. To drive the device from an external clock source, XTAL2 should be left unconnected while XTAL1 is driven as shown in Figure 14 (figure 2).

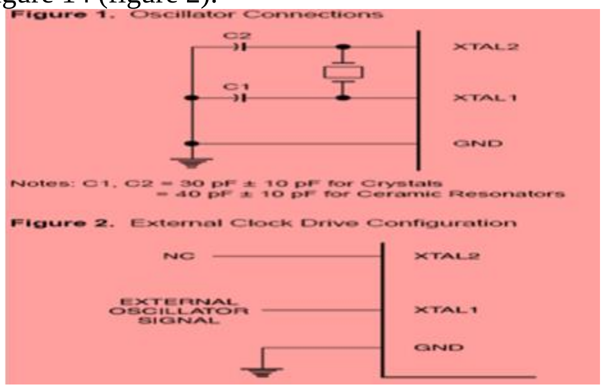



**Figure 14: Crystal Oscillator Connection and External Clock Drive Configuration**

### 3.7. The Actuator

The actuators used for this system are relays which function by connecting or disconnecting the Ceiling Fan terminals from supply. The choice of the relay used was based on the following ratings:

Voltage rating – 12V (switching voltage)

Contact rating – 10A (max. current that can be controlled by the relay)

Coil rating – 100mA (max. coil current) [8].

Below is a figure showing how the **ULN2003A IC** was connected to the relay.

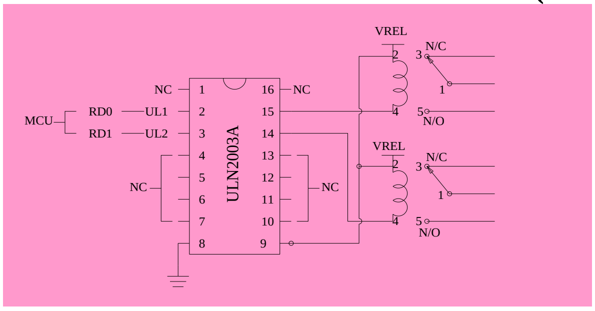



Figure 15. ULN2003A IC Connection to the Relay

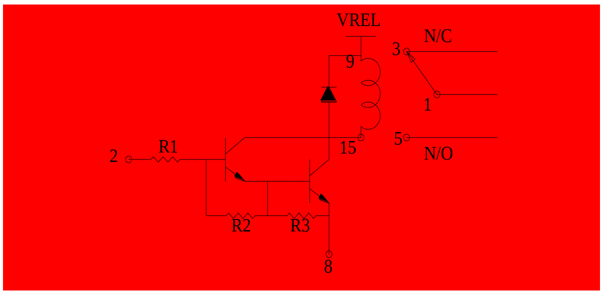



Figure 16. Darlington pair making up the ULN2003 IC

**3.8: The Regulated Power Supply Unit (RPSU)**
All electronic components require a steady dc power supply. Thus a regulated dc power supply unit was built to this effect. The **RPSU** is made up of the following sections. **Transformer (Transformation)** – This section scales down / reduces the supply voltage to an R.M.S. value close enough to the desired DC value (12V). **Rectifier (Rectification) –** This section converts the scaled down ac signal to a varying dc signal. Capacitor (**Filtration) –** This section removes ripples from the rectified signal to give a fairly constant dc value. **Regulator (Regulation) –** This section fixes a positive dc output voltage (+5V) by eliminating ripples.

The circuit diagram of the RPSU is shown in figure 17 below.

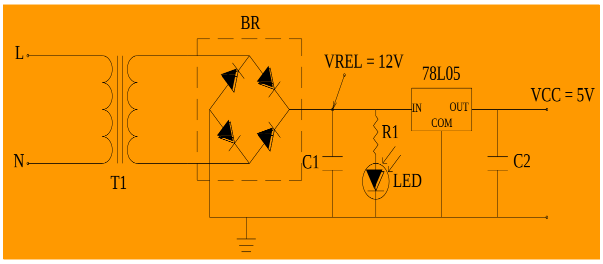



Figure 17. Circuit Diagram of the (RPSU)

**3.9: The Output Unit (Ceiling Fan)**
The output unit consists of Ceiling Fan and the regulator. Normally, a ceiling Fan has six speeds' switches. There are speed 0, speed 1, speed 2, speed3, speed 4 and speed 5. The speed 0 is especially for switching off the ceiling Fan. The slowest is speed 1 and the fastest is speed 5. The five outputs from the **ULN2003A IC** connected to the Ceiling Fan regulator. Inside the regulator, each speed has a terminal and those terminals are connected to the circuit via the relay. The relays that control the Fan speed are controlled by the microcontroller via the **ULN2003 IC.** Figure 18 below shows the normal Ceiling Fan connection.

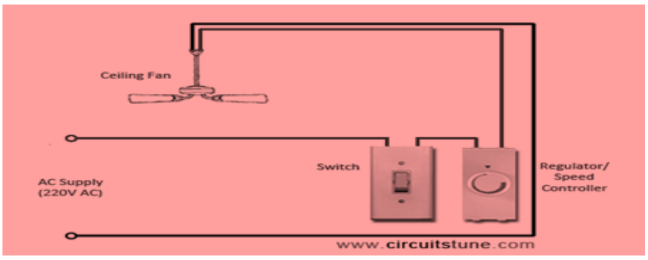



Figure 18: Normal Ceiling Fan Connection

## IV. Software Implementation

The steps taken in assembling the program is summarized as follows:

1. Type the program in notepad.
2. Save it as "Fanspeed.asm" in drive C: /

Ensure that drive C: / has the 3 applications (A51, OHS51and L51) required to assembly the program.

3. Launch the "run" command from the start menu and type the commands

* a51.Incubator.asm
* l51.Incubator.obj
* ohs51.Incubator.obj

And then click OK; In case of syntax error in program code, program will not be compiled and HEX file will not be generated.
Errors need to be corrected in the original program file (the one typed in Notepad) and then the source file may be compiled again. The best approach is to write and test small, logical parts of the program to make debugging easier.
The PM-51 Macro Assembler was used for this project. The term PM-51 belongs to an entire family of single-chip microcomputers, all of which have the same processor design. They use the same instruction set, but differ slightly in Memory mapped special function registers (SFRs) and on-chip ROM and RAM.
The assembler is a software tool- a program-designed to simplify the task of writing computer programs. It performs the clerical task of translating symbolic code into executable object code. This object code may then be programmed into one of the PM-51 processor to which the 8051 belongs.

## V. CIRCUIT WORKING DESCRIPTION

The temperature sensor LM35 is employed to sense the temperature from atmosphere. It produces voltage of 10mV for $1^0$c rise in temperature. The output of the Temperature sensor (analogue signal) is fed to the input of the ADC, which converts the analogue temperature value to digital equivalent required by the micro-controller. Thus, the output of the ADC is directly coupled to the microcontroller whose main task is to control / regulate the Fan speed via the actuators. The LCD made available in the system is used to display all the information of the system like: - the Fan speed and the room temperature (at any point in time).

***The microcontroller is programmed as follows;***

- *Critical Value:* ***Temperature below*** *$16^0$c*, ***FAN would be OFF (Temperature very Low).***
- *Speed 1:* ***Between*** *$17^0$c - $20^0$c (Low Room temp.)* ***FAN would be ON in SLOW speed.***
- *Speed 2*: ***Between*** *$21^0$c - $24^0$c (Room temp.).*
- *Speed 3:* ***Between*** *$25^0$c - $28^0$c (Room temp.).*
- *Speed 4:* ***Between*** *$29^0$c - $32^0$c (Room temp.).*
- *Speed 5:* ***Temperature*** *> $32^0$c (Room temp.).*

***At speed 5, FAN would be ON in HIGH speed, because of high room temperature.***

### 5.1: Testing and Results

The test was done by powering the system. When powered, it first displayed "microcontroller based automatic Fan speed regulator" on the system screen (LCD). After displaying the name of the system, **$27^0$c** was shown on the screen, which is the room temperature at that moment. Also displayed on the screen was **Speed 3** which is the corresponding speed level for room temperature between **$25^0$c - $28^0$c** this moment, the Fan turn at speed three (3).

To ascertain the workability of the system, heat source (soldering iron) was bring in contact with the temperature sensor (LM 35) and the temperature increased dramatically from **$27^0$c to $32^0$c** signifying a rise in room temperature and automatically the Fan changed speed and speed 5 was displayed on the screen (signifying that the Fan has changed from speed 3 to speed 5 as a result of the change in room temperature). Also cool water was brought in contact with the temperature sensor (LM 35) and the temperature decreased dramatically from **$32^0$c** to **$20^0$c** signifying a decrease in room temperature and automatically the Fan changed speed and speed 1 was displayed on the screen (signifying that the Fan has changed from speed 5 to speed 1 as a result of change in room temperature). This is a wonderful breakthrough in house / appliances control system.

## Conclusion

The paper presents 'Microcontroller based automatic Fan speed regulator (using temperate sensor). The designed system automatically controls the speed of Fan (ceiling Fan) according to changes in room temperature. A temperature sensor (LM 35) is used to sense the room temperature and it is directly coupled to the Analogue to Digital Converter (ADC) whom major task is to convert the analogue data from the temperature sensor to its digital equivalent required by the microcontroller for further processing. The microcontroller serves as the brain of the system. It is used to store all the assembly language program of the system; it also controls, coordinates and manages all the activities of the system. All the components that made up the system are directly or indirectly connected to it to achieve the designed project. The Liquid Crystal Display (LCD) is used by the microcontroller to communicate to the outside world. It displays the Fan speed as well as the room temperature at any point in time. The speed of the Fan increases with the increase in room temperature and decreases with decrease in room temperature. Normally people tend to cover themselves and let the Fan run at the same speed. This results in several types of illness in people and also causes wastage of electricity due to Fan being operated at speed more than required, thus spending **80~100 watts** whereas the desired Fan speed was the speed corresponding to **20 ~ 30 watts** electricity consumption. This causes wastage of electricity along with resulting illness. Therefore, we decided to work out a solution for controlling Fan speed (automatically). The designed system is economical and easy to operate across people of all age range. The system performs the operation in an effective and efficient way. The system is very useful for all areas where temperature variation overnight is considerably high.

Finally, the designed system is a remarkable breakthrough in monitoring and control system technology and should be adopted in order to explore all its numerous benefits. The system is secure and reliable device which can excel in this day and age.

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