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DESIGN APPROACH AND IMPLEMENTATION OF A MICROCONTROLLER BASED FAN SPEED REGULATOR WITH REMOTE CONTROL USING TEMPERATURE SENSOR

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Abstract

This work presents an innovative prototype design approach and implementation of a microcontroller based temperature control system with remote. The work aim at developing a prototype for microcontroller based temperature control for fan speed regulator and developing an algorithm that automatically switches on or off the fan depending on the temperature of the room or any area of interest; and to integrate radio frequency (RF) module for wireless communication between the transmitter unit and receiver unit. In this work, technologies adopted are microcontroller technologies, sensor technologies, radio frequency module technologies and liquid crystal display technologies. In other words, the adopted technologies when cascaded will help in actualizing the design and implementation of a microcontroller based fan system with remote using temperature sensor. The system simulation and prototype worked effectively and efficiently to change the fan speed at different temperature. Pulse width modulation technique is appropriate and it is incorporated in this work. The various applications and research efforts are also examined in this work, showing remarkable improvement in temperature control system.

Keywords: Temperature Control, Pulse Width, Radio Frequency.

1.0 Background of the project

In recent years, the home environment has seen a rapid introduction of network enabled digital technology. This technology offers new and exciting opportunities to increase the connectivity of devices within the home for the purpose of home automation. However, the adoption of home automation systems in Nigeria has been slow. So, this work is a remote microcontroller based temperature control using fan system that smartly and automatically controls the speed of an electric fan according to requirement. Use of embedded technology makes this closed loop feedback control system efficient and reliable. Microcontrollers allows for dynamic and faster control. Liquid crystal display (LCD) makes the system user-friendly. The sensed temperature and fan speed level values are displayed on the LCD panel. Microcontroller is the heart of the circuit as it controls all the functions. The comfort and efficiency of human bodies and equipments depend on the environmental temperature. The average temperature in Nigeria ranges from 23 º C to 34 º C (degree Celsius) and proper cooling is needed to make the body feel comfortable at all times [1]. Temperature control is defined as a process in which the temperature value of an object is taken and the passage of heat energy into or out of the object as adjusted to achieve a desired temperature [2].

In this work, the electric DC fan system is used to control temperature. The electric fan system for cooling has become a field to be worked on, to improve the user convenience by applying intelligent systems such as microcontroller. Since a fan creates its cooling effect by speeding, thus the most important part of a fan is its speed controller. The control of a fan has evolved from manual control to hand-held wireless remote control. This microcontroller based fan system operates by automatically switching the speed of fan rotation according to the environment temperature changes. This work introduced a RF module for wireless communication. The LM35 senses the room temperature; the ADC converts the analogue signal to digital signal which the microcontroller through the RF transmitter module wirelessly sends information from the controlled room to the monitoring room. The RF receiver module receives, sends to the microcontroller which displays the information on the LCD and also controls the speed of the fan using pulse width modulation. This project is a further step for developing an intelligent or smart system.

1.1 Aim and objectives of the work

The aim of this work is to design and implement a remote microcontroller based temperature control fan system. The specific objectives to actualize this aim include:

- To develop a prototype for a microcontroller based fan speed regulator with remote system using embedded systems
- To develop an algorithm that automatically switches on or off the fan to control the temperature
- To incorporate RF module for wireless communication between the controlled room and monitoring room at 433MHz.
- To simulate the model using proteus software

2.1 Temperature Sensor and Measuring Devices

Temperature is one of the most important parameters in process control. Accurate measurement of temperature is not easy and to obtain accuracies better than 0.5 º C, greater care is needed.

2.1.1 Types of Temperature Sensors

- There are many types of sensors to measure the temperature, some sensors such as the thermocouple, resistance temperature detectors (RTD), and thermistors are the older classical sensors and they are used extensively due to their big advantages. The new generation of sensors such as the integrated circuit sensors and radiation thermometry devices are popular only for limited applications [3,4,5,6]. The choice of sensors depends on the accuracy, the temperature range, speed of response, thermal coupling, the environment (chemical, electrical or physical), and the cost [7,8,9,10].

Table2.1: Types of temperature sensors and their characteristics

Sensor	Temperature range (º C)	Accuracy ± º C	Cost	Robustness
Thermocouple	-270 TO +2600	1	Low	Very high
RTD	-200 to +600	0.2	Medium	High
Thermistor	-50 to +200	0.2	Low	Medium
Integrated Circuit Sensor	-40 to +125	1	Low	Low

- Source:[3]

According to [11,12 13], a Simple Wireless transmission System using common approach Sensor Platform called the wireless based Patient Sensor platform (WSP, Sensor Node) which has remote access capability was proposed. The goals of the WSP are to establish: Standard sensor node (System on module), a common software .The proposed platform architecture (Sensor Node) offers flexibility, easy customization for different vital parameter collecting and sending. A prototype was established based on wireless communication channel. Wireless LAN (IEEE .802.15.4) was used as communication channel on this prototype (Sensor node). Desired sensor information (vital parameter) was viewed remotely, and also vital parameter was adjusted to meet demands. According to [14], it is well established fact that the process automation offers the advantages like high accuracy, power saving, manpower saving, reduction in wastage, high & efficient production volumes. In the modern industries, precise monitoring, controlling of temperatures & fluid level of various chemicals in storage tanks at various places are essential requirement.

The paper described the development of Wireless Embedded System by using Atmel's 89C51 microcontroller for monitoring & control of process parameters from remote site. The system utilized ASK transmitter & receiver for transmission and reception of reference values i.e., temperature and fluid levels from transmitter to receiver. Interaction with transmitter was done through matrix keypad. A TRIAC AC power controller circuit was used in the receiver which controls the flow of power to the heater. The fluid level was maintained by a water feed pump. User friendly Software is developed using 8051's Assembly language to control the transmitter and receiver units. According to [15], a stand-alone temperature monitoring and control unit was proposed. It used the remote control to adjust temperature in order to regulate the temperature. The system was also highly configurable in the setting up of the features and parameters. The system consists of two units, the main control unit and the Radio Frequency (RF) remote control, with inputs to thermal sensors, and output to the Liquid Crystal Display (LCD). The RF remote control controls specific settings of the unit. The remote control was powered by a 9V battery. As the result, the developed system has been observed both from simulation and real circuit, and the test was considered successful. After the integration between hardware and software had been made, the circuit worked perfectly according to the value of temperature.

2.2 System Design specifications

The system designed senses temperature of a room, communicates wirelessly to a receiver, use fan speed to control temperature of the room, and display temperature value and fan's speed. A sensor senses temperature, microcontroller by help of analog to digital converter (ADC) gets digital signals which it sends to the receiver wirelessly through RF module. As the receiver receives the signal, it displays the temperature and fan speed on a display and finally it should be capable of controlling the fan at specific speed to regulate temperature.

2.3 Hardware Design

The main components used in the hardware development:

- AT89C2051, AT89C52,LM35, ADC0804, RF Module

and 16X2 LCD(HD44780)

The system is implemented by putting all the selected units together in a single circuit as shown in fig 1.1. The circuit diagram of the design shows all terminal connections of the sensor, RF module, ADC, LCD, Fan to the digital I/O interfaces of the microcontrollers.

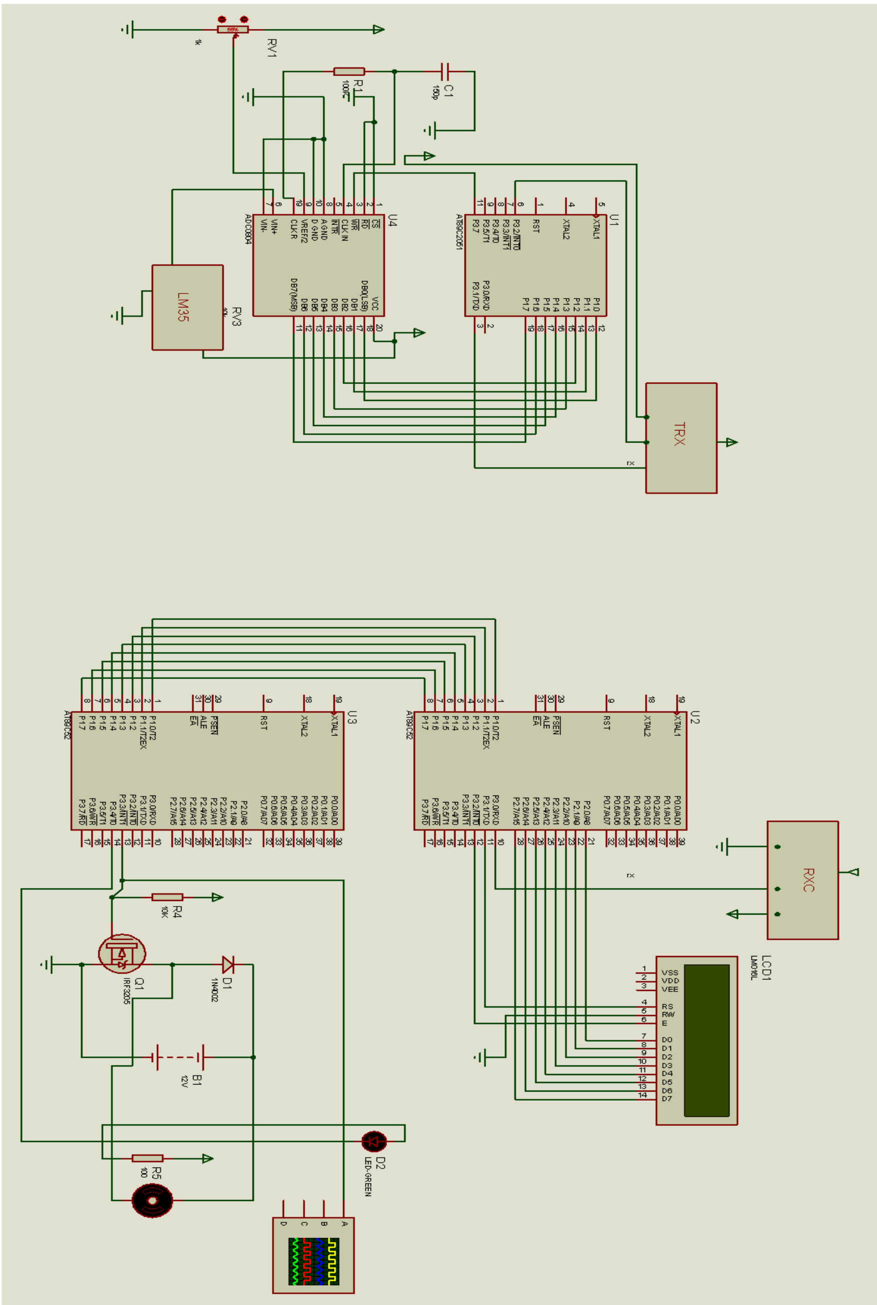

Figure 1.1: Circuit diagram with of a microcontroller based fan speed regulator using temperature sensor in proteus environment.

Figure 1.1 shows the circuit diagram of the system. The LM35 (temperature sensor) which senses the temperature gives output in volts. The output of LM35 is fed to pin 6(vin+) of the ADC0804 which converts the analogue signal to digital signal which is fed to the AT89C2051. C1 and R1 are used as RC oscillator for ADC internal clocking. RV1 is a variable resistor used to set the reference voltage for the ADC. The sends the signal serially to AT89c52 through pin3 (p3.1/TXD) and pin 10(p3.0/RXD). The LCD (lcd1) is used to display the temperature value and the speed of the motor. U2 is connected to U3 port 1 to port 1. The MOSFET (IRF3205) is a power MOSFET used for switching and driving the motor. R4 is a pull up resistor. It increases the current to a value sufficient enough to drive the MOSFET. D1 acts as a fly back diode to eliminate reverse biasing or back E.M.F. D2 is an LED to light when the temperature has gone beyond critical value. R5 is used limit current to the LED.

3.0 Hardware Implementation

After designing the circuit and determining components to be used and their values, The implementation started with mounting of the components on a bread board. The bread board circuit arrangement was done stage by stage. The components for the temperature sensing stage, ADC stage, mini microcontroller (AT89c2051), RF transmitter module, for the transmitter unit and RF receiver, two AT89C52 microcontrollers, LCD, fan motor and its driver for the receiver unit were all connected with jumper wire. The power supply was connected finally to power the circuit. The complete circuit was tested on bread board. After the test proper adjustment of the components value, the components were transferred to veroboard for permanent soldering. The soldering was done stage by stage to ensure proper connections of parts, components and wiring. During the soldering the power supply stage was first soldered as it is needed to power subsequent stages. Each stage was tested at the end of the soldering in order to detect any problem on time before the complete circuit soldering is done. The complete circuit was soldered eventually according to the circuit diagram. After the complete construction work, the unit was tested and packaged.

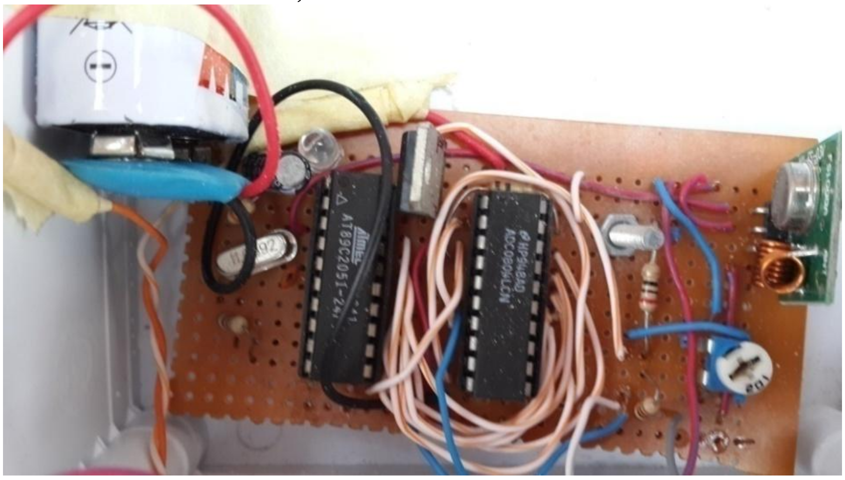

Figure 1.2: Implemented circuit of the transmitter unit

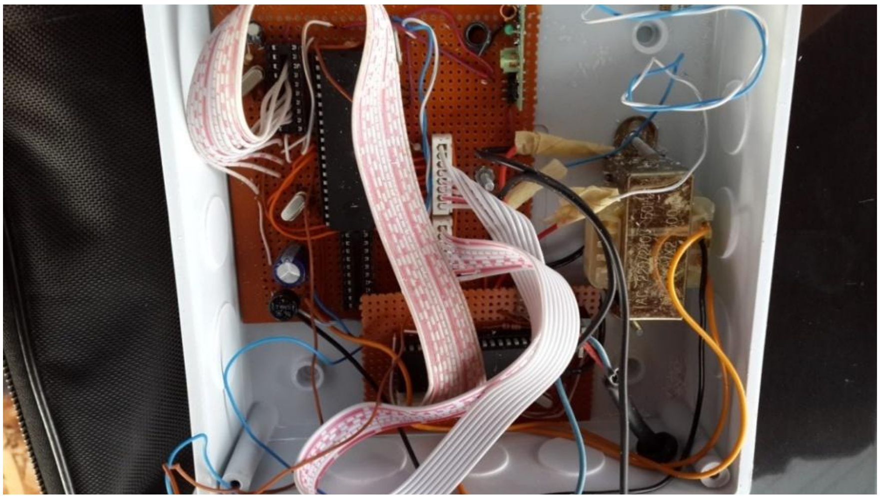

Figure 1.3: Implemented circuit of the receiver unit

Table 1.2 shows the values of temperature with corresponding duty cycle and fan speed. The oscilloscope was used to measure the duty cycle and tachometer was used to measure the speed of fan. The test result shows that the controller has a direct control relationship. It is increasing the fan speed as the sensed temperature was increasing until it got to the final speed level and vice versa as shown in Table 4.2.

Table 1.2: Test results showing temperature, duty cycle and fan speed

S/no	Temperature(^{o}C)	Duty cycle(%)	Speed(RPM)
1	< 22	0	0
2	22-28	20	260
3	29-31	40	520
4	32-34	60	780
5	35-37	100	1300
6	38-40	100	1300
7	>40	0	0

3.2 Packaging

This work is packaged with a plastic casing to reduce EMI. Similarly, the choice of plastic was also influenced by the fact that it is a domestic device and requires appropriate shielding from potential electric shock. Holes to accommodate the LCD, switches etc were made with electric jig-saw and flat file. Holes were also drilled at the bottom of both the receiver and transmitter to fasten the circuit unto the casing. And finally the boxes (casing) were sealed with bolts.

Figure 1.3: packaged transmitter unit

Figure 1.4: packaged receiver unit

3.4Conclusion

This work, the design and implementation of microcontroller based temperature control using temperature sensor was achieved in this work and is working according to system specification. The designed system automatically controls the speed of the fan according to changes in room temperature. The sensor used is LM35, and the result of sensed value shows that the response is linear and accuracy is good. PWM technique is found to be appropriate for controlling fan speed. The simulation of the system is working properly and the design is appropriate according to modern needs and technology. The prototype worked perfectly to show that the objectives of the work were accomplished. The work can be applied in our hospitals, in our homes, old people's homes, and in our industries for the smart control of temperature. These applications and others emphasize the need for more research and development to examine new ways of improving on temperature control.

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