American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-6, Issue-9, pp-324-328
www.ajer.org
Research Paper Open Access

Construction Of A Temperature Controlled Fan Using A Microprocessor.

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ABSTRACT: *Automation is a feild that continues to expand and generate interest. This is so as a result of the constant need to reduce human effort, especially in the control of electrical appliances. This work involves the construction of a circuit using a temperature sensor and a microcontroller that will automatically control the speed of the fan whenever there is a change in ambient temperature. An Arduino program is used to program the microcontroller based on the desired function. The Arduino language is an open source project that creates microcontroller based kit for building digital device and interactive objects that can sense physical quantities and control devices. The original control unit of the fan is disabled and replaced with the constructed circuit.The fan is given 3 different speed levels, with each speed level being activated by a certain degree of temperature change. This will eventualy reduce human stress as well as reduce energy wastage.*

Date of Submission: 11 -08-2017 Date of acceptance: 28-09-2017

I. INTRODUCTION

An electric fan is a device used to produce airflow for the purpose of creating comfort and ventilation. Electric fans are designed to create breeze and circulate air in a region. (Bai & Ku; 2008).The fan creates its cooling effect based on the speed at which its blades rotate; hence, the speed controller is a very important part of a fan.

The idea behind this work is to construct a circuit that will control the speed of a fan based on the temperature of its environment with the help of a microcontroller. Usually, the speed of the fan blades is controlled manually by turning the knob on the regulator. This non-innovative feature makes it unable to turn on automatically in response to temperature changes, hence an automatic temperature control system technology was applied for the switching purpose in this circuit. The temperature controlled fan is an alternative way to control the speed of the motor in that modulates the speed of the fan in response to changes in ambient temperature. The needed level of air circulation is maintained in various types of buildings and enclosed spaces, thereby ensuring efficient use of energy. A thermistor monitors the air temperature and as the temperature varies within a pre-set temperature band above setpoint, the fan speed is increased or reduced accordingly between the minimum and maximum speed values (Mustafa et al;2014).

Due to its advantages many research efforts had been focused on automatic temperature control system.

A temperature controller is a closed loop control system which senses the temperature of the environment and compares it with a user-fed threshold temperature value and changes the speed of the fan accordingly (Mustafa et al,2014 ; Levărdă and Budaciu, 2010).

In an automatic temperature controlled system, the independent variable (temperature) is measured by a suitable sensor such as a thermocouple or thermistor. and converted to a signal accepted by the controller. The controller compares the temperature signal to the desired temperature (setpoint) and activates the final control device. The final control device alters the dependent variable (fan speed) to change the quantity of heat being taken or added to the process (Bai & Ku, 2008; Saad et al,2013).

An automatic temperature control system has the ability to monitor and control the temperature of a specified space without human intervention. The primary purpose is to manage the temperature based on pre-defined setting by the user of the system. The automatic control fan uses a microcontroller to sense the temperature of its environment with the help of the temperature sensor that measures the temperature of the environment. The desired temperature setpoint had been programmed on the microcontroller with the arduino program, the temperature sensor reads the temperature every 10secs and compares it with the desired values. If the desired value is higher than the measured value, the fan will not come up. Once the measured value becomes higher than the desired value, the fan comes up with the required speed to cool the room as desired by the user.

The automatic temperature controlled fan finds application in places like hospitals and homes of handicapped and elderly people, since it requires no human effort to function.

II. THEORETICAL BACKGROUND

2.1 PROPORTIONAL INTEGRAL DERIVATIVES CONTROLLER (P.I.D)

The proportional integral derivates (P.I.D) controller is a control loop feedback mechanism (controller). A P.I.D controller continuously calculates an error value $e(t)$ (which is the function of time t) as the difference between a desired setpoint and a measured process variable and applies a correction proportional, integral and derivatives terms respectively. The controller attempts to minimize error over time by adjusting a control variable $u(t)$, such as the position of a control valve, a damper or power supply to a heating element, to a new value determined by weighted sum:

$$u(t) = K_p\, e(t) + K_i \int_0^t e(t)dt + K_d \frac{de(t)}{dt}$$

Where; K_p, K_i and K_d,(all non-negative) denote the coefficient for the proportional, integral and derivatives respectively (William,1986).

In this model, P accounts for present error. If the error is large and positive, the control output will also be large and positive. I accounts for past values of the error. If the current output is not sufficiently strong, the integral of the error will accumulate overtime and controller will respond by applying a stronger action. D accounts for possible future trends of the error, based on its current rate of change.

The P.I.D controller compares the current value of an error E, of the integral over a time interval and the rate of change of error to determine how much of a correction to apply. The controller continues to apply the correction until a change is seen in the feedback. The job of PID is to force to match a setpoint. Sometimes error between feedback and setpoint is not caused by a set point change, but in most applications the setpoint is not adjusted much (Fu et al,2010; Nwankwo et al,2014). More often, error in loop of today's controller have enabled us to achieve much greater accuracy in our commercial control system.

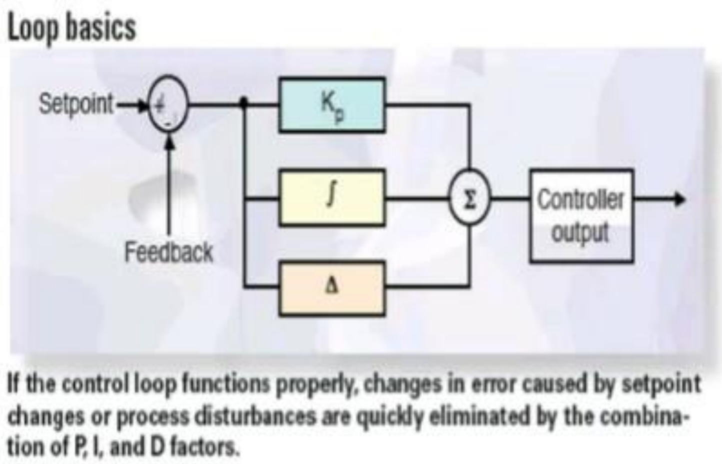


Fig.1 A P.I.D schematic diagram

2.2 ARDUINO PROGRAM

An Arduino program is used to program the microcontroller based on the desired function. The arduino is an open source project that creates microcontroller based kit for building digital device and interactive objects that can sense physical quantities and control devices.

The project is based on micro controlled board design, produced by several vendors using various microcontrollers. These systems provide sets of digital and analog input/output (I/O)pins that can interface with various expansion boards and other circuits. The board features a serial communication interface or a universal serial bus (USB) on some models, for loading program from personal computers to program the microcontrollers. The Arduino project provides an integrated development environment (IDE) based on both the C and C# languages. The first Arduino program was introduced in 2005 aiming to provide a low cost, easy way for novice and professionals to create devices that interact with their environment using sensor and activators. In this work, it was used to program the microcontroller on what to do at a certain temperature.

2.3 THERMISTOR

A thermistor or thermal resistor is a type of resistor whose resistance is dependent on temperature, more so than a standard resistor. As a result of this property, it is usually used in measurement and control circuits.

The relationship between a thermistor's temperature and its resistance is highly dependent on the material from which it is made.Thermistors are broadly divided into 2 categories: Negative Temperature Coefficient (N.T.C) and Positive Temperature Coefficient (P.T.C)

Negative Temperature Coefficient (N.T.C) thermistors are non-linear resistors which alter their resistance characteristics with temperature. The resistance of NTC will decrease as the temperature increases.

Many N.T.C thermistors are made from pressed disc, rod, plate, bead, or cast chip of semiconducting material. They work because raising the temperature of a semiconductor increases the number of active charge carriers. It promotes them into conduction band. The more the charge carrier that are available the more the current a material can conduct.

Positive Temperature Coefficient (P.T.C) thermistor exhibit increasing electrical resistance with increase in environmental temperature and decreasing electrical resistance with decrease in temperature. Most P.T.C thermistor are made from doped polycrystalline ceramic (containing bariumtitanate and other compound) .One unique property of this material isthe sharp increase in resistance at certain critical temperatures.

At the Curie point temperature, the dielectric constant drops sufficiently to allow the formation of potential barriers at the grain boundaries.

2.4 STEINHART-HART EQUATION

The Steinhart-Hart equation is a model of the resistance of a semi-conductor at different temperatures. The equation is named after John Steinhart and Stanley Harts who first published the relationship in 1968 (William,1986). The equation is given as:

$\frac{1}{T} = A + B\ \ln(R) + C\,[\ln(R)]^3$ ....(i)

Where:

T is the temperature (in Kelvin)

R is the resistance at T (in ohms)

A, B and C are the Steinhart-Hart coefficients

These vary depending on the type or model of thermistor and the temperature range of interest.

The most general form of the applied equation contain a $[\ln(R)]^2$ terms, but this is frequently neglected because it is typically much small than the other coefficients.

The equation is often used to derive the precise temperature of a thermistor since it provides a closer approximation of actual temperature than simpler equation and is useful over the entire working temperature range of the sensor. Steinhart-Hart coefficients are usually published by thermistor manufacturer.

Where the coefficients are not available, they can be derived. Three accurate measurements of resistance are made at precise temperatures, and the coefficients are derived by solving three simultaneous equations.

III. MATERIALS AND METHOD

The various materials used for this work are discussed.

3.1.1 MICROCONTROLLER

Microcontrollers are designed for embedded applications, and are used in automatically controlled devices. The features of a microcontroller include: embedded design, higher integration, programming environment. For this work, the ATMEGA 328P-PU microcontroller was used.

3.1.2 CRYSTAL OSCILLATOR

Crystal oscillator is an electronic oscillator circuit that uses the mechanical resonance of a vibrating piezoelectric material to create an electrical signal with precise frequency. The most common type of piezoelectric resonator used is "quartz crystal". A 16MHz oscillator has been used in the circuit.

3.1.3 RESISTOR

A resistor is a passive two terminal electrical component that is used to reduce current flow, adjust signal level to divide voltage bias elements and terminate transmission lines, among other uses. In this work, a 10k resistor has been used.

3.1.4 RELAY

A relay is an electrically operated switch. It is an electromagnetic switch operated by a relatively small current that can turn on or off a larger circuit. Many relays use an electromagnet to mechanically operate a switch relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuit must be controlled by one signal.

3.1.5 TEMPERATURE SENSOR

Temperature sensor is a component which uses an external diode connected to a transistor as the sensing element to measure ambient temperature. The LM35 series are precisely integrated circuit temperature device with an output voltage which is proportional to the temperature. It is interfaced with a microcontroller to measure temperature. The LM35 has an advantage over linear temperature sensor calibrated in Kelvin because the user is not required to subtract a large constant voltage from the output to obtain a convenient centigrade scaling. The LM35 device does not require any external calibration to provide typical accuracy, and as it draws only 60µA from the power supply, it has low self-heating of less than 0.1˚C in still air.

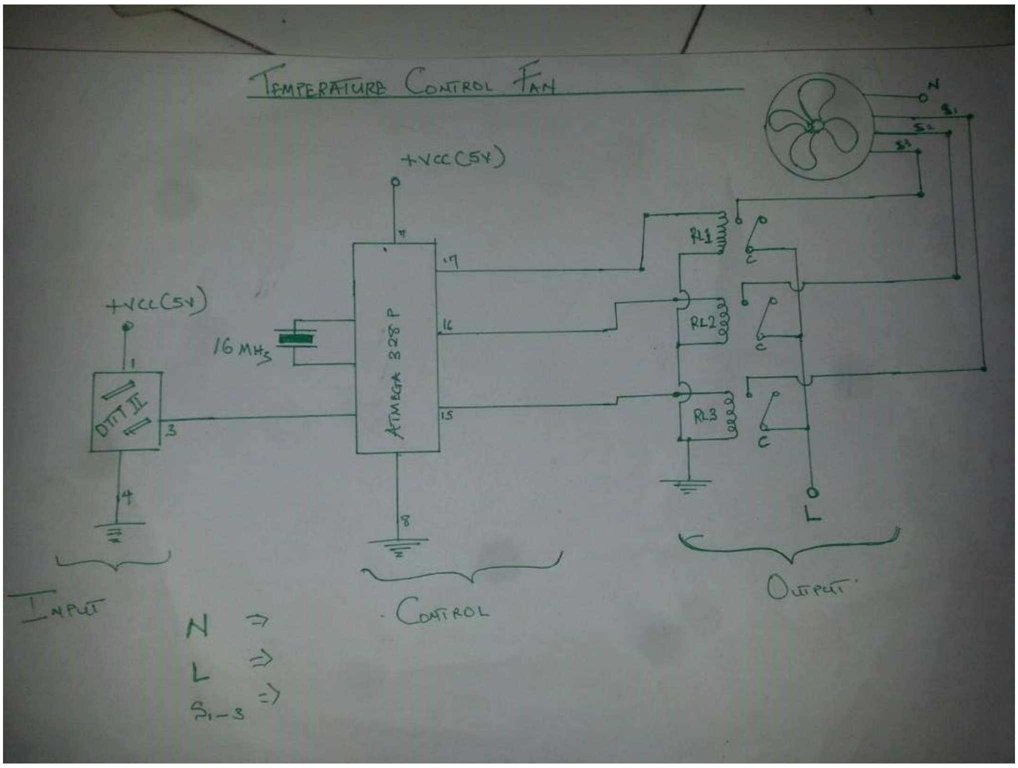


Fig.2 Circuit diagram

All these components were soldered onto the circuit board as shown in plates 3.1 and 3.2 below.

Plate 3.1 The components.

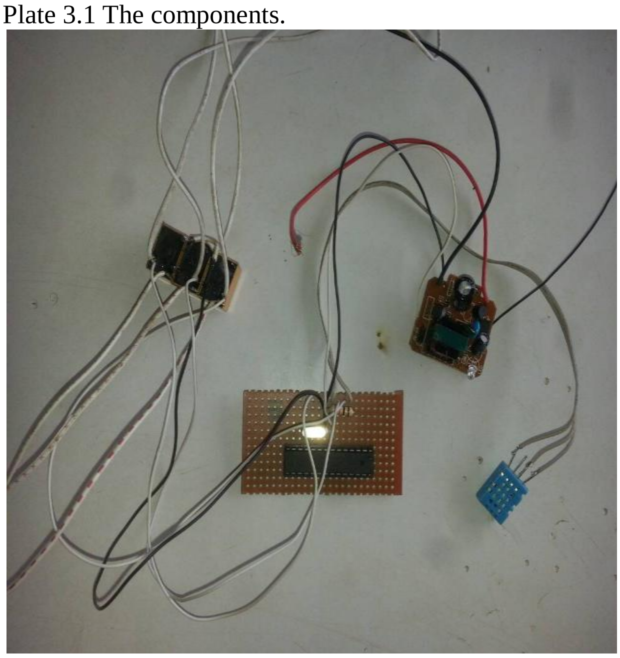
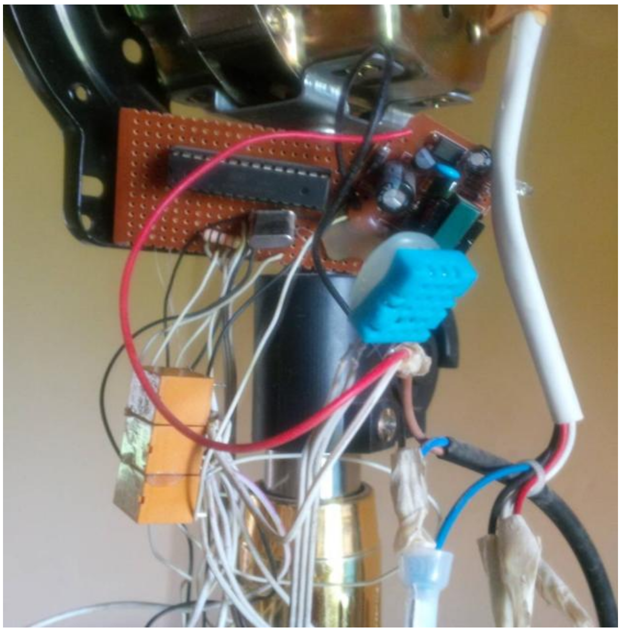


Plate 3.2 The circuit mounted on the fan.



IV. TESTING AND RESULT

After construction, the circuit was attached to the control of a standing fan using a gum with the part containing the temperature sensor exposed so as to be able to detect changes in the temperature of the environment. The control of the fan was disabled since it has become irrelevant. The fan was then connected to a power source. A slight delay was experienced as the temperature sensor took a short time to read the temperature of the surrounding. After the short delay the fan started working. To alter the temperature of the environment, a hot material was brought close to the temperature sensor and it was observed that the fan speed was fluctuating as seen by changes in the colour of light emitting diode (LED). It was observed that the closer the hot material was to the temperature sensor, the higher the speed of the fan and vice-versa.

V. RECOMMENDATION

A temperature controlled fan can be used in environments like hospitals, industries, offices and elderly peoples' homes. It is particularly useful in health care facilities since there are patients whose need for airflow is temperature dependent and may also find it stressful to manually adjust fan speed.

VI. CONCLUSION

The goal of this work was to construct a circuit that will automatically control the speed of a fan according to changes in the temperature of the surrounding. The circuit was constructed with the use of a matrix board on which all other components used were attached. The circuit was then attached to the control of a standing fan and was tested. The outcome of the test showed that our fan worked perfectly well as the speed of the blades was notice to change with changes in temperature. Based on this, we conclude that the effort has been a success.

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Adeloye, M.Y. "Construction Of A Temperature Controlled Fan Using A Microprocessor." American Journal of Engineering Research (AJER), vol. 6, no. 9, 2017, pp. 324–328.