IoT Based Relay Operation

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Abstract: As in this era enormous development of electronic technology specifically the application area of micro-controllers have resulted in a lot of innovative and inexpensive control applications. All the activities in household or industry are directly or indirectly associated with information technology and now controllers are found in almost all the automation based application. The aim of this hardware based project work is to technically understand relay control mechanism which is pertinent to the analysis and design of automated control systems. Electromagnetic relays provide a well-established solution to switching loads in a different applications. This paper presents the designs and the simulation of a relay control system based on three different techniques. Firstly we have designed relay control using adjustable LM317 voltage regulators. Secondly we have introduced the method of closed loop control with a temperature sensor (LM35) and an actuator (relay) and applied this method to building a controller with fixed voltage regulated supply that will maintain a desired temperature. Finally to develop an Arduino based room temperature sensor application. The temperature sensor IC LM35 senses the temperature and its corresponding electrical signal is forwarded to the microcontroller. The 16x2-line LCD is used to display the temperature sensed by LM35 and set values of the temperature, and accordingly the relay gets turned OFF.Also the PCB layout is designed for each setup using Express PCB software. It is being concluded that all the three designed model has accurate working capabilities in comparison to Programmable Logic Control (PLC's) circuits and is better and cost effective substitute for them. The designed project can be used for industrial applications or as a training module in teaching courses of industrial automation or mechatronics. This project uses regulated 12V, 2A power supply.

Keywords: Microcontroller, Arduino, LCD, PLC

I. INTRODUCTION

The basic principle of relays is to use an electromagnet to operate a mechanical switching mechanism and are used for the control of circuits through small power signal as well as provide electrical isolation between the actuator and the controlled circuit [1]. Nowadays a lot of research activity is going on and development of products in the field of automation and industrial applications has increased. When we talk about today's scenario in industrial manufacturing, the number of PLC applications is enormous [2].

The fast growth of the access to internet and convenience of resources led to the concept of Open Source Software and hardware as a major factor to provide unlicensed access to computer code so that anyone could review, modify, and distribute computer software. One of these Open Source Hardware developed the design of a microcontroller-based platform called Arduino [3].

In various applications we need output that is corresponding to the temperature or the system that is controlled by variations in temperature, the following project makes it automatically. We have used temperature sensor LM35 to sense the temperature and as a result of it the relay switch turns ON and OFF the appliances.

We have applied three different levels of controlling the relay. Firstly by using variable voltage regulation and secondly by OP-Amp. In Op-Amp, the differential amplifier is the input stage which has one standard input and another one is the sensed input and the output is the difference of two. It provides amplification of the difference voltage between the two inputs [4]. Finally designed relay controlling using Arduino. This hardware project used Arduino which is the microcontroller-based development platform [5]. As the project is based on open-source hardware, this development board and electronic component which we have to use in project development, their specifications, the IDE software, are available freely to use or manipulate. Also the private manufacturers produce and offer cheap, standardized hardware which are compatible with Arduino and have extensive supply with various features and capabilities. Using an Arduino reduces the cost and components and easy hardware and software development because the circuit hardware platform is already available, and programming is allowed via serial communication over USB, and hence we need not any external programmer [5].

II. PROBLEM STATEMENT AND OBJECTIVE

A. Problem Statement

Most human feels the need of automated switching of the appliances when the room temperature changes. Also this to be cheaper and efficient, so the programmed relay controlling framework that consequently switches the electronic appliances according to the indicated is prescribed to be fabricated for solving this issue.

B. Objective

The main objective of this project is to analyze different ways of relay control and also according to the temperature and display the temperature. When the sensed temperature goes beyond certain limit then control relay to reduce waste of energy. The objective of this project is to develop a low cost, user friendly automated temperature controlled relay based application which reduces power consumption and also help people who are unable to control the appliances from their locations. Our objective is to design a multi way techniques to control a relay based on temperature sensing and could be used for various temperature control applications in industries and home automation.

III. HARDWARE IMPLEMENTATION

We are going to design relay module for temperature control applications. Any Temperature Controlled Switch consists of three parts: Sensor, main control unit and the switch. The hardware components required are as follows:

A. LM 317

The LM317 is a three terminal monolithic IC with variable positive-voltage regulation. It is designed for the load current of more than 1.5 Ampere and an output voltage adjustable over a 1.2 Volts to 37 Volts range [7].

As you can see it has three pins,

1. ADJUST –To this pin the variable resistor is connected which controls the output voltage
2. OUTPUT – At this pin we will get the regulated output
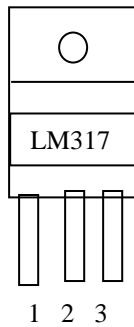3. INPUT – This is where we give the unregulated input

Fig.1. LM317 Pinout

B. RELAY

A relay is an electrically operated switch. Relays may operate mechanically called as electromagnetic relay and some are solid-state relays. Where ever it is necessary to control a device or circuit by a small-power signal, relays are implemented and they also provides electrical isolation between sensing circuit and actuating circuits, or where multiple circuits are to be controlled by one signal [1]. We have used here the electromagnetic relay which is having the moving part called as the COM (Common) connection of a relay. The ON and OFF condition for this relay is as follows:

a. When a relay is OFF, NO (Normally Open) connection of the relay is not connected and the COMMON is connected to the terminal NC (Normally Closed).

b. When the relay turns ON or get energized, the plunger (COMMON) terminal move from NC to NO. Mechanical relays creates a sound of Clicking that shows the transition of the plunger.
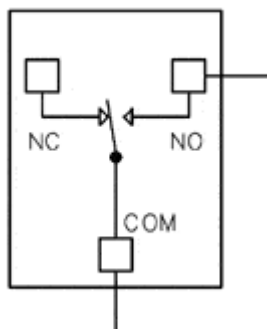

Fig.2. Relay setup

C. OP-AMP CA3140:

Another IC used in the circuit is a CA3140 operational amplifier IC that is used in comparator mode here. A relay switch and an LED are connected to the output pin 6 of the IC. A buzzer can also be connected between the pin 6 and ground if desired. The operating voltage of the circuit is 5V to 12V DC.
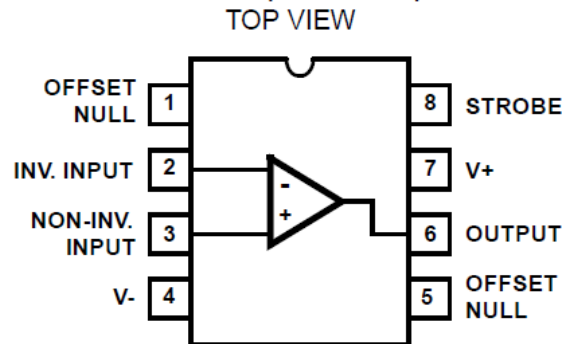

Fig.3. Pinout of Op-Amp CA3140

D. LM 35

LM 35 is a precision centigrade temperature sensing integrated circuit whose output voltage is linearly varies with the Celsius Temperature. The operating range of this sensor is from -55° Centigrade to +150° Centigrade with a linear scale factor of +10mv/° C and most suitable for remote applications. It has three terminals V_{CC}, GND and OUTPUT. This sensor has voltage range from 4V to 30V and provides corresponding temperature voltage at the output. Its current consumption is only 60 microAmpere due to which it is ideal for battery operation.
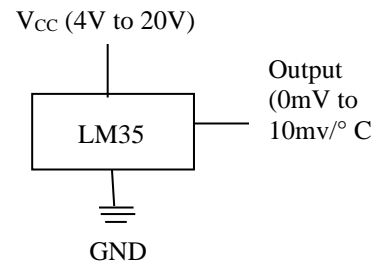

Fig.4. Pinout of LM35

E. Liquid Crystal Display (LCD)

LCD (Liquid Crystal Display) screen is an electronic display module and it find a wide range of applications in automation systems. In a 16x2 LCD display there are 2 lines to display 16 characters per line.

In this LCD the pixel matrix size is of 5x7 which is used to display each character. There are two different types of registers are available in LCD for storage that is, Command register and Data register. The command instructions are stored in the command register which are given to the LCD and the data register stores the data to be displayed on the LCD. The data format is the ASCII value of the character which is to be displayed.
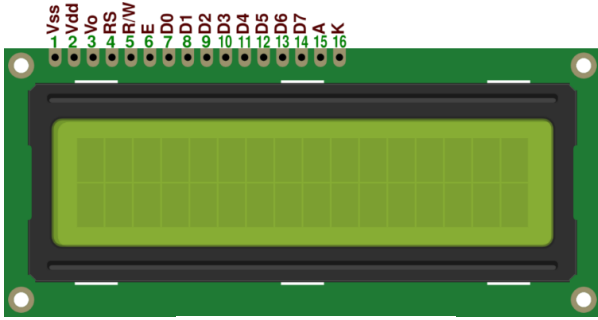
Fig.5. 16x2 LCD Display

E. ARDUINO UNO

Arduino is an open-source hardware development platform consists of microcontroller which is the physical programmable circuit board and a section of software, or IDE (Integrated Development Environment) that actually runs on the computer, which is used to program and upload computer code to the physical board [2].

The Arduino is a microcontroller board based on the ATmega8 microcontroller. It has fourteen digital -input/output pins out of which some pins can be used as PWM (Pulse width modulation) outputs, six analog inputs, a 16 MHz ceramic resonator. It also have a USB connection, a power jack, an ICSP header, and a reset button. It contains every feature needed to support the microcontroller; what we need is to connect it to a computer with a USB cable or power it with AC-to-DC adapter or battery to get started.
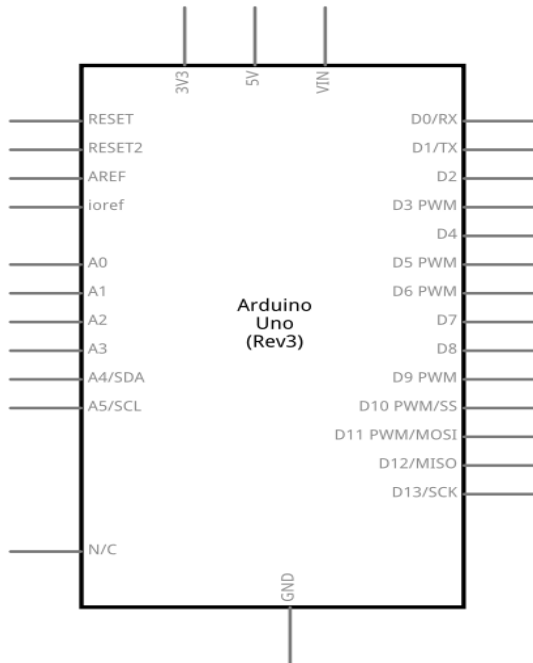
Fig.6. Pinout of Arduino UNO

IV. DESIGN AND CONSTRUCTION

The Whole project is designed in three different sections whose design, construction and working are as follows:

A. Relay control using Variable Regulation LM317

To construct constant current DC power supply circuit first we need to build Rectifier circuit for converting AC to DC by implementing step down transformer and Bridge Rectifier. Here 230V input primary, 0-12V AC secondary step down

transformer used and 1N4007 diode used to form Bridge Rectifier. Filter capacitor C, placed to remove AC ripples from DC supply, then IC LM317 added to regulate the current output.

LM317 is an adaptable and highly efficient adjustable voltage regulator which can provide up to load current of 1.5A with a large heat sink. The Adjust terminal of LM317 is connected with potentiometer load after R1 (reference) Resistor and it acts as a current feedback.

$$Iout = Vref/R1$$
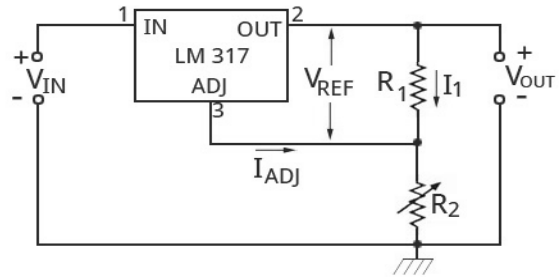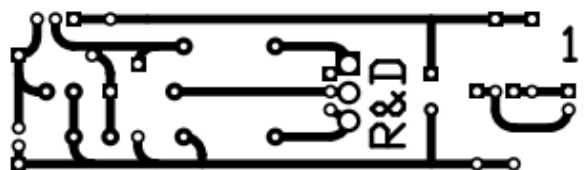
Vref= 1.25 V for LM317

Fig.7. LM317 connection setup

Then this voltage is used to control the relay operation and also we have connected DMM to take the reading of resistance at which the relay gets OFF.

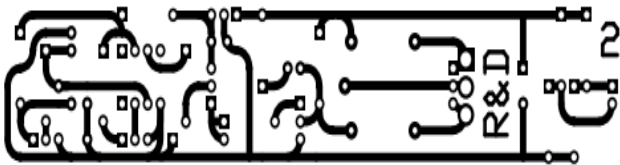The experimental Connection on breadboard is as follows:

Fig.8. Experimental setup for Relay controlling
PCB layout for the above setup is:

This layout is designed for above setup in ExpressPCB.

B. Relay control using Op-amp and LM35

First stage of this circuit is Power supply having Rectifier (bridge rectifier) which is used to convert the AC into DC and Regulator (IC7805) unit. This is used to stepdown the high voltage AC (110 – 220V) supply to 12V AC with the help of step down transformer and then rectified into DC through bridge rectifier, capacitor works as filter circuit to remove ripples or fluctuations then linear fixed regulator IC 7805 regulates DC voltage and gives constant 5V DC supply.The project of a temperature controlled switch using LM35 and CA3140 ICs is designed and tested on breadboard. The circuit can be used for variety of temperature sensing applications. A relay switch is used at the output of the circuit that can control or switch ON and OFF any AC and DC appliances on the desired temperature. Relay coil is connected between positive voltage supply and collector terminal of transistor. When the output voltage is greater than 2.5V, the transistor turns ON through operational amplifier hence the coil gets energized and makes the contact closed that is plunger moves from N/O (normally open) contact to N/C (normally closed) one. In this way we can control electrical load or appliances automatically as a factor of temperature. The PCB layout for this setup is as follows:

As concluded from the figure of breadboard setup, when room temperature goes beyond 49.2 Degree Celsius, output voltage of LM35 at pin 2 also goes higher than 0.5 volt or 500mV. Output of LM35 is connected to Pin 3 of Op-amp LM3140. And as we have set the reference voltage (voltage at Pin 2 of LM3140) to 0.5 volt, so now voltage at Pin 3 (non-inverting input) becomes higher than voltage at Pin 2 (inverting input) and output of op-amp LM3140 (PIN 1) becomes HIGH. Output of LM3140 connected to the base of NPN transistor, so BJT also becomes ON and energize the relay.
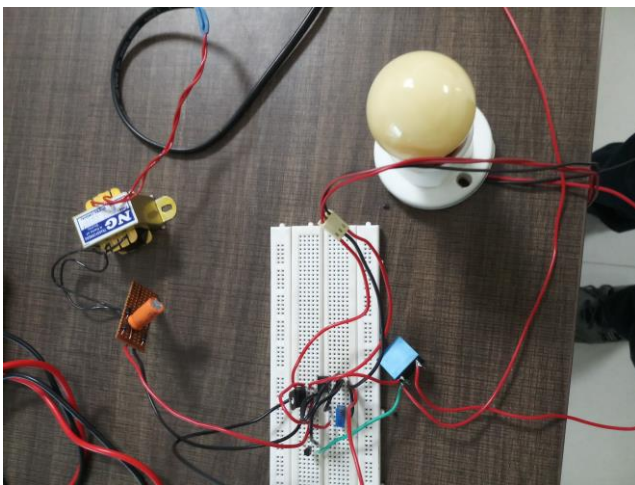

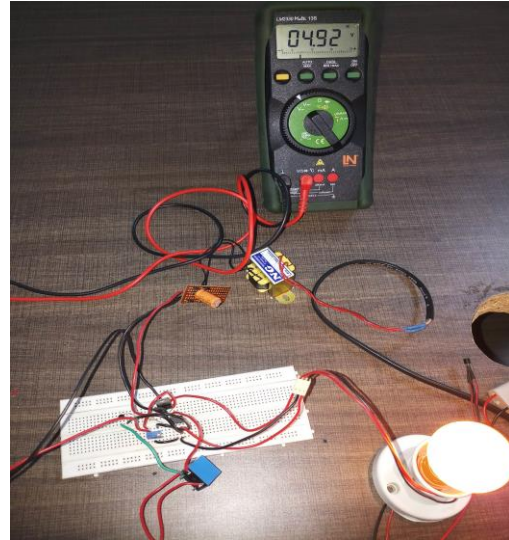**Fig.9. Experimental Setup for Temperature below setup point**

Fig.10. Experimental Setup for Temperature above setup point

C. Relay control using Arduino UNO and LM35

In this application we have used 16X2 LCD to display the real time temperature and the set value of temperature.

The LM35 temperature sensor and red led are powered with 5V from the Arduino board.

The Arduino is a microcontroller board and the special feature of Uno boards is that it does not use the FTDI USB-to-serial driver chip but, it features the Atmega16U2 programmed as a USB-to-serial converter [6].

Arduino IDE

The open-source Arduino Software (IDE) helps to make program or code and upload it to the development board. It runs on Windows, Mac OS X, and Linux. The environment of IDE based on high level language that is Java and based on Processing and other open-source software. This freely available software can be used with any Arduino board. The Arduino development environment consists of a text editor for code editing, a message area, a text console, a toolbar with buttons for common functions, and a series of menus. It provides interface to the Arduino hardware and to upload programs and communicate with them. Software written using Arduino are termed as sketches which are written in the text editor. Sketches are saved with the file extension .ino.

SYSTEM FLOWCHART:

1. Connect the hardware LCD & LM 35 according to the schematic below.

2. For the software part, we programmed it using Arduino IDE.

3. Reading the analog input from LM35 temperature sensor input pin.

4. LM35 are designed to give the exact value of temperature in Celsius and finally loaded the code into Arduino UNO [6].
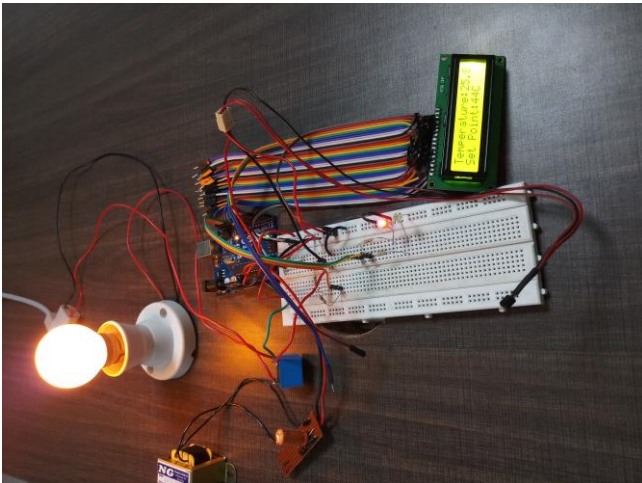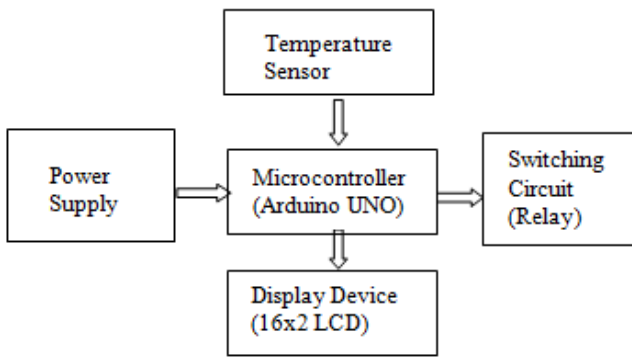
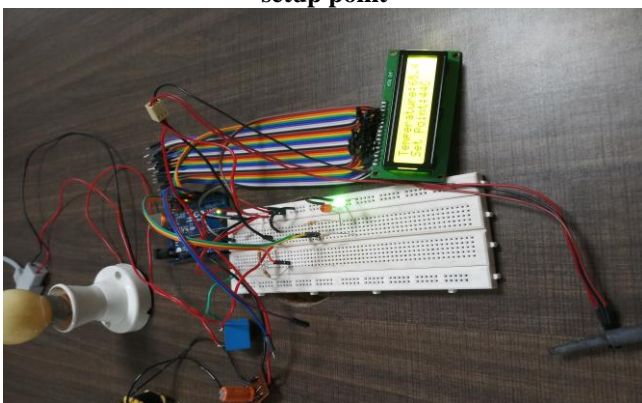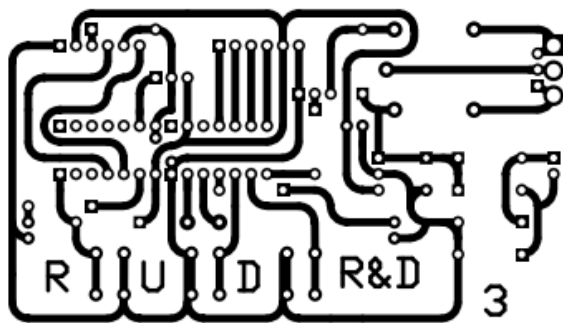**Fig.11. Experimental Setup for Temperature below setup point**

Fig.12. Experimental Setup for Temperature above setup point

V. EXPECTED OUTPUT

After designing the whole circuit we tested it. Expected outputs are as follows:-

a) LCD should display the actual room temperature.

b) Relay should be ON before reaching the set point.

c) Relay should be OFF as the temperature exceeds the set point

VI. RESULTS

a) First setup is used to control relay via variable voltage regulator LM317 and done it successfully.

b) Second setup is used to control rely via temperature sensing. When temperature is not reached upto set point (i.e. 49.2 degree Celsius) the relay is on. Consequently, Lamp connected across it is OFF and as soon as the temperature goes beyond this limit the lamp gets turned ON.

c) Third setup is used for relay control via Arduino and found that when temperature exceeds set value (44 degree Celsius) the relay is OFF. As a result, Lamp connected to it is turned OFF.

VII. CONCLUSION

In our project, we designed and implemented three different and easy ways of relay controlling by temperature monitoring with an Arduino board. Results were verified for all three different methods and by presetting the temperature and it was examined that the lamp turn on and off when the device transit the set temperature value. It is very helpful for the people who are specially abeled and not able to move physically. There is still possibility for modification for future development and enhance the system but has only the drawback that its efficiency may decrease due to temperature variation after sometimes.

We have also provided the PCB layout design which will help to manufacture the IC and design application.

Advantages

• This project can be applied in Industry as well as in Home automation.

• It can be implemented to monitor the harsh environments that is not compatible for humans

• Provides energy saving by controlling the relay operation to control the cooling appliances.

• It may assist people who are specially abeled to manage cooling device automatically

FUTURE SCOPE

Adjustable voltage regulator based Relay controller is a simple and helps the learner to understand its concept. Also the Op-Amp based relay operation is simple circuit to implement. Arduino based temperature controller can be made useful in practical area like for a water heater by presetting the value of temperature or where the circuit can be connected to a device whose temperature has to be controlled at a predefined limit. In future the circuit can be further modified by interfacing a GSM Module to the Arduino based circuit which can increase the range of operation and controlling for industrial applications when a particular appliance or device exceeds the preset value of temperature, the information can be send to the control room by sending SMS, or else a call to control so that any hazardous situation in industries can be avoided by disconnecting the overheated equipment using GSM technology.

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Smita Prajapati received M.Tech degree in Digital Communication from RTU in 2014 and currently pursuing P.hD from IET, DAVV. She has 9 years of teaching experience in Engineering. She has research domain in wireless communication systems and have various publications in National and International Conferences and Journals. Her areas of interest are Digital Circuits and Communication systems, Wireless systems.