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An Enhanced Automatic Room Temperature Control System

Adamu Murtala Zungeru, Mmoloki Mangwala, Joseph Chuma and Baboloki Gaebolae
Department of Electrical, Computer and Telecommunication Engineering,
Botswana International University of Science and Technology,
Private Bag 16, Palapye, Botswana

Abstract: This study presents the design and implementation of an automatic room heater control system. An automatic room heater control system is a self-regulating temperature system which uses a set point or value to maintain the temperature of a room. This system allows the user to set a desired temperature which is then compared to the room temperature measured by a temperature sensor and with the help of a microcontroller, the system responds by turning on any of the two loads (cooler or a heater) automatically depending on the temperature difference. The cooler is triggered on when the room temperature is higher than the set temperature and the heater is triggered on when the room temperature is lower than the set temperature. The system was designed and simulated using Proteus 8, a circuit building software used for building electronics system. For coding the PIC microcontroller, micro-c compiler was used. A 5 V DC power supply was designed in order to provide a biasing voltage to most of the active devices used in the system design circuit. The DC power supply was designed and simulated using Multisim software. For testing and simulation of the circuit design in Proteus, the micro-c hex file was loaded on the Proteus schematic design. The system was simulated and working according to the design specifications.

Key words: Design, room heater, control system, multisim, proteus, simulation, cooler, temperature sensor, heater, microcontroller

INTRODUCTION

With the advancement of technology, automation has become part of our lives. The home is usually the most occupied place in any culture. Areas in the home that are usually occupied by people such as the living room and bedrooms need to be maintained within habitable temperature ranges. The human body has an optimum temperature of about 27°C. Temperatures that are higher or lower that the set temperature of the home body can result in damage to some body organs or tissues and eventual death. These issues become more pertinent in areas of the home that are occupied by infants. Adults could possibly find their way around “thermal discomforts” but infants may not. Other areas of the home that are used as storage areas for perishable food items also need to be thermally regulated in order to prevent accelerated decay of such items. This makes necessary the need for a temperature control system within the home.

The idea of programmed room heater control systems goes back in the eighteenth century and this thought was first secured in Norman School, Oklahoma by an educator named Warren S. Johnson. Before that time, Janitors were compelled to go in every classroom to check the temperature of the classes and after that control the dampers in the S-basement in like manner. Johnson looked for an approach to end or possibly limit the classroom intrusions of the janitors and increment the solace level of the understudies. The automatic temperature control system was to meet this very need which prompt Warren S. Johnson stopping instructing and beginning his electric administration organization which was gone for outlining programmed control systems. Warren S. Johnson initially built up the pneumatic temperature control framework which took into account temperature control on a room by room premise in structures and homes. By the mid 20th century the automatic temperature control system creation ended up noticeably famous in enterprises and homes. As of late, a considerable measure of work is being finished by organizations in this field. A great deal of automatic room heater system business items are promptly accessible in the market and this includes devices such as AIRCONS (Johnson *et al*., 2006).

Corresponding Author: Adamu Murtala Zungeru, Department of Electrical, Computer and Telecommunication Engineering, Botswana International University of Science and Technology, Private Bag 16, Palapye, Botswana

Weather is forever varying and changes on short intervals and as a result, the external conditions always have an influence changes on the indoor conditions. The temperature control systems that are currently in use have limitations. One of these limitations is that the user has to adjust the system every time the external conditions change. This is very tiring and proves out not to be an effective way of controlling temperature of a room. Also, disabled people get to face a lot challenges when they want to operate temperature control system in their houses because this systems require them to use physical contact or some hand remote devices to operate them. To reduce the need to do this, a system that works automatically needs to be put in place.

This study presents an automatic room heater control system. This is an air-conditioning system which monitors the room temperature and controls the circulation of fresh air inside the room without human intervention. This design uses a microcontroller and a temperature sensor to monitor and control the temperature of a room. At first the user will have to set the system temperature to a desired value that he or she wants to maintain in that room. The temperature sensor will then sense measured surrounding temperature and communicates with the microcontroller. The micro controller reads the temperature every 10 sec and compares it with the desired value. If the measured value is less than the desired value, then the heater will be automatically be triggered on to warm up the temperature of the room until it returns back to the desired value and turns off. If the measured value is greater than the desired value, the cooler/fan will be turned on to cool the room temperature back to the normal set point and turns off once it is at that set point (Anonymous, 2017). By Bell (1992), self-programmable thermostat is presented. In a related work, researchers by Tate and Ries (1990), Poll (2006), Agarwal (2006), Nagata (1996), Fiedler and Landy (1959), Hedges (1947), Chengxiang *et al.* (2011) and Fu *et al.* (2010) highlighted on the benefits of using temperature adjustable and fan temperature control systems.

MATERIALS AND METHODS

The automatic room heater control system comprises of three main subsystem: power supply unit, the sensor unit and the control/switching unit as shown in the system block diagram in Fig. 1.

Power supply: The power supply system supply a 5 V DC and 12 V DC power supply to the other units which is

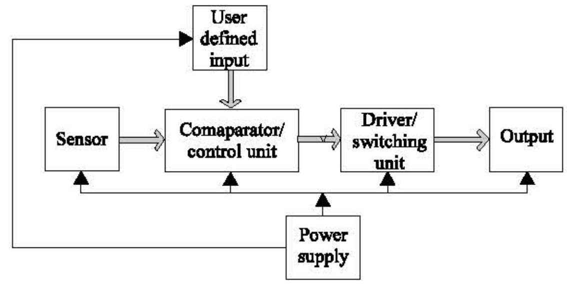

Fig. 1: Block diagram showing the major parts of the system

stepped down with a transformer (240-12 V). This power supply include a full wave rectifier (4 of 1N4001) which converts AC-DC power and a filter (capacitor) to smoothen the output from the rectifier. Voltage regulators were also included in the power supply in order supply regulated DC voltages to the other main units (LM7805 (5 V) and LM7812 (12 V).

Sensing unit: This study of the system include a temperature sensor (LM 35). A temperature sensor is a device that is temperature sensitive and it responds to changes in temperature.

Control/switching unit: The control/switching unit houses the microcontroller which will receive temperature status from the sensor unit and ensures that it does not compromise the set value by initiating the correct sequence of action. This unit consist of microcontroller, two transistors and two relays to switch on and off a fan and or a heater. At first the user is prompted to input reference temperature that he or she wants to maintain in their room. The temperature sensor will then measure surrounding temperature and communicates with the microcontroller. The micro controller reads the temperature every 10 sec and compares it with the desired value. If the measured value is less than the desired value then the heater will be automatically be triggered on to warm up the temperature of the room until it returns back to the desired value and turns off. If the measured value is greater than the desired value, the cooler/fan will be turned on to cool the room temperature back to the normal set point and turns off once it's at that set point. The measured room temperature from the temperature sensor is analog in nature. The microcontroller has an in built Analog-to-Digital (A/D) converter which convert the analog signal into digital signal because the microcontroller is a digital device, it can only work with binary numbers.

Power supply: The power supply was designed considering the available resources while meeting the design specifications. Most of the components operates on 5 V DC while relays operating at 12 V were used, hence, the need to step down the normal power supply voltage from mains (Approx. 240 V AC) to a reasonably voltage that will have to be rectified (convert to DC) and further filter to remove unwanted pulsation. The 240V AC power was stepped down to 12 V AC (12 V RMS value wherein the peak value is around 17 V) as can be seen from the calculation that follows and the 17 V was further regulated using a voltage regulator (LM7805) to 5 V and (LM7812) to 12 V. A transformer of turn ratio of 20:1 was used for the purpose of stepping down the voltage and rectifier diodes (IN4001) were also used for rectification. Using the turn ratio:

$$\frac{N_p}{N_s} = \frac{V_p}{V_s}, \text{ i.e., } \frac{20}{1} = \frac{240}{V_s}$$

$$V_{RMS} = V_s = \frac{240V}{20} = 12 \text{ V} \quad (1)$$

$$V_p \; 12\times\sqrt{2} = 16.9705 \approx 17 \text{ V} \quad (2)$$

Assuming a ripple voltage of 20%:

$$dv = \frac{20}{100}\times 17 = 3.4 \text{ V} \quad (3)$$

$$df = \frac{1}{2f} = \frac{1}{100} = 0.01$$

$$C_1 \frac{1\times 0.01}{3.4} = 2.94\times 10^{-3}\text{F} \quad (4)$$

A preferred value of 3300 μF was however employed for the filtering of the assumed ripples as the value is higher than the calculated value, hence will filter much more than expected. Figure 2 shows the designed power supply circuit.

The block diagram showing the major parts of the system circuit is as shown in Fig. 1. Figure 2 is the complete power supply circuit showing all the components and the results gotten from simulation. Figure 3 gave the logical operation of the automatic room heater control system (flow chart) (Fig. 4). Figure 1 consist of 6 different block each housing several components: transmitter and receiver subsystem. The sensor block consists of a temperature sensor (LM35), the user defined

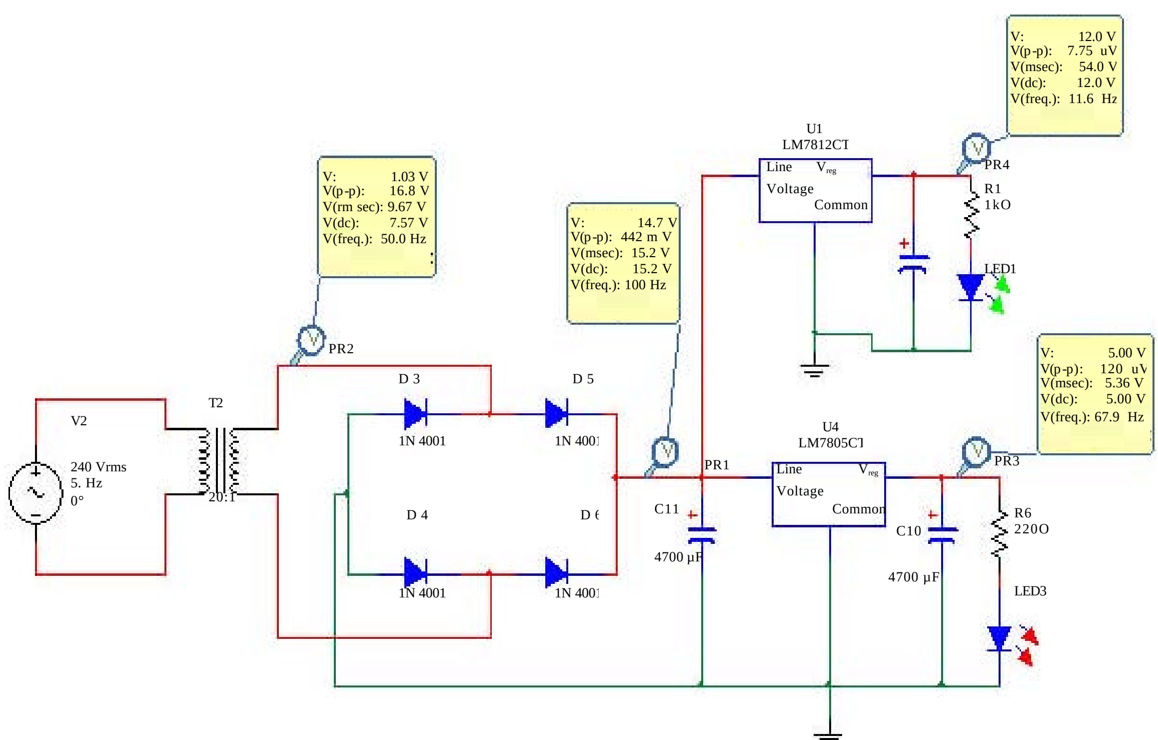

Fig. 2: Power supply circuit

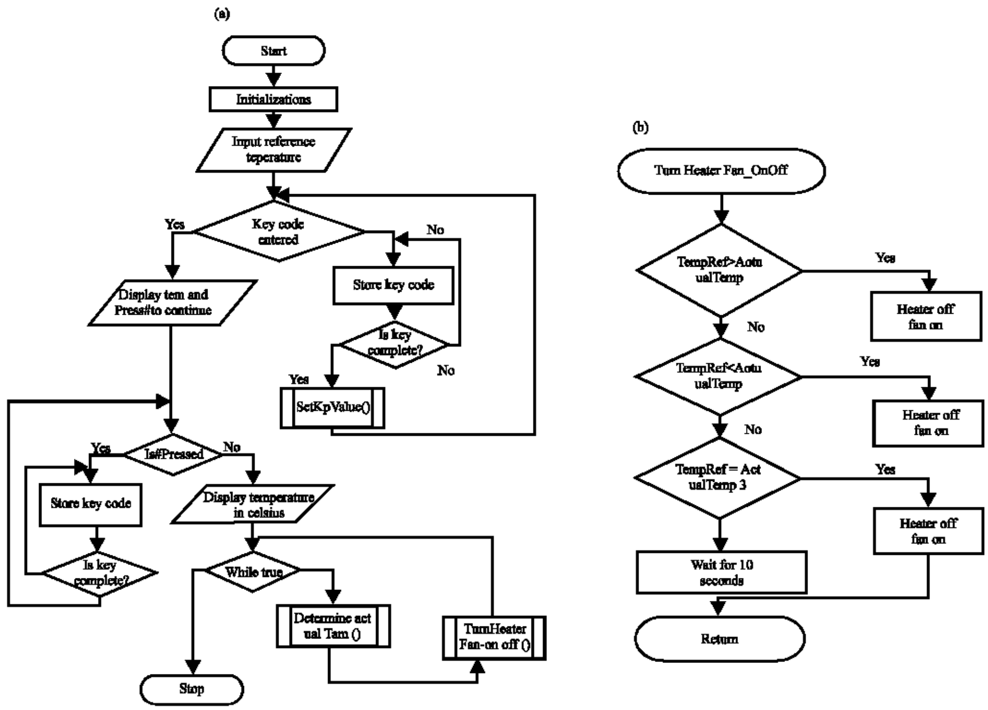

Fig. 3: System flow chart

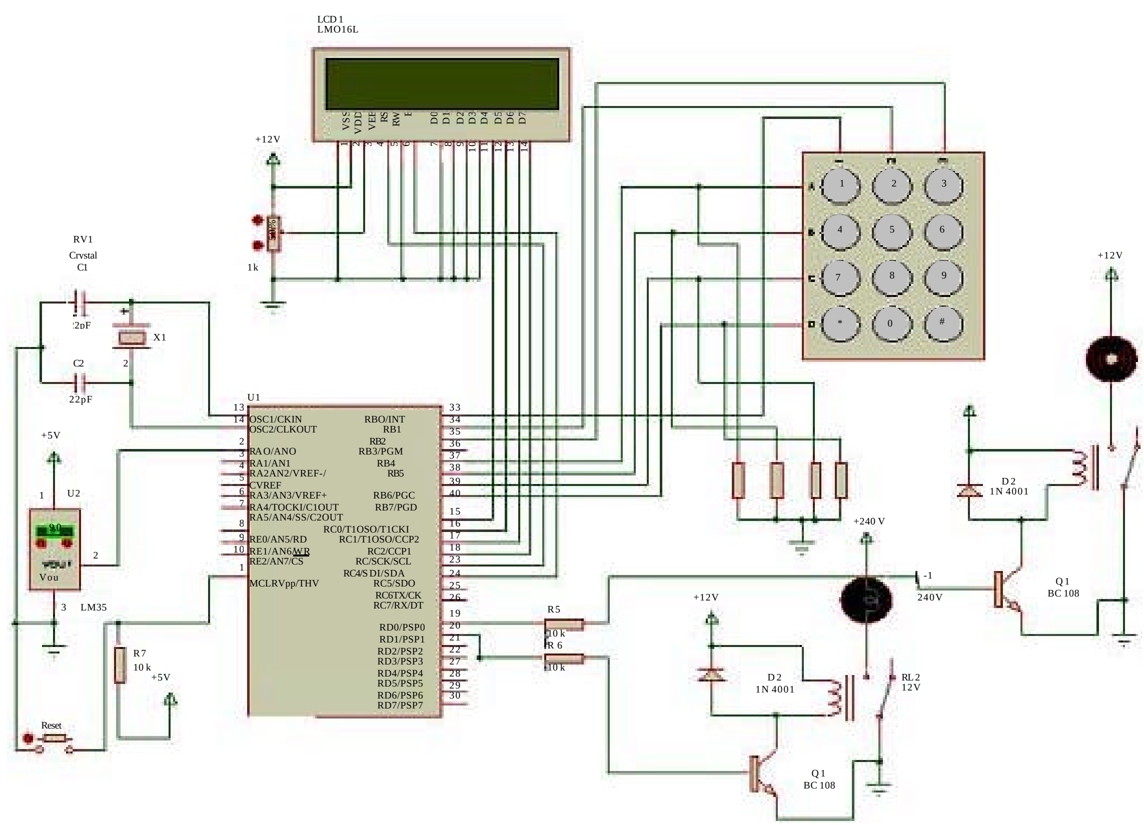

Fig. 4: Circuit diagram of automatic room heater control showing all components of the system

input consists of a keypad, the comparator/control unit is basically the heart of the system that consists of the microcontroller. Generally, the system circuit comprises of the PIC16F877A micro-controller, LM35 temperature sensor, LCD display, crystal oscillator, 4 by 3 keypad for display, 2 transistors for switching purpose, 2 relays also used to support the transistor in the switching effect, a bulb modelled as a heater and a Dc fan. The microcontroller is clocked by the crystal oscillator as it does not have an internal clock. Connected to the microcontroller is a temperature sensor LM 35 which measure the room temperature and give the value reading to the microcontroller for reading. The 2 loads of the microcontroller switched on and off by the relays. The relays are not directly connected to the microcontroller but rather transistors as switches are place in between the microcontroller and the relay to prevent the relay from damaging the microcontroller. The resistors connected in every component of the system are used to limit the amount of current passing to that particular component. The LCD is connected to the microcontroller for displaying the data feed into the microcontroller. The brightness of LCD is controlled by the variable resistor as seen in Fig. 4.

RESULTS AND DISCUSSION

Automatic room heater control system is designed, simulated and analysed in this research. From Fig. 2, it is seen that the calculated results agreed with the simulation results. From PR2 in Fig. 2, it is seen that though the value not exactly equal to the calculated result but approximately equal to the value. If we then compare the peak voltage of the simulation result, 16.8 V, the value is approximately equal to the calculated value of 17 V as can be seen in Eq. 2. As can be seen from Fig. 2, U1 and U4 gave +12 V and +5 V, respectively when deployed voltage regulators (LM7812 and LM7805).

Figure 5 shows the result of a user prompted to enter reference temperature. As can be seen, both RL1 and RL2 are disconnected from Lamp (L1) and the fan motor as loads. In Fig. 6, user entered 12 as the reference temperature which is higher than the room temperature 9.27°C as can be seen from temperature sensor (LM35). But in this case, the microcontroller had not sent any signal to both loads, since, the user has not press the hash key to enter the value 12. For Fig. 7-9, the room temperature measured by the TEMP sensor is 9.27°C and

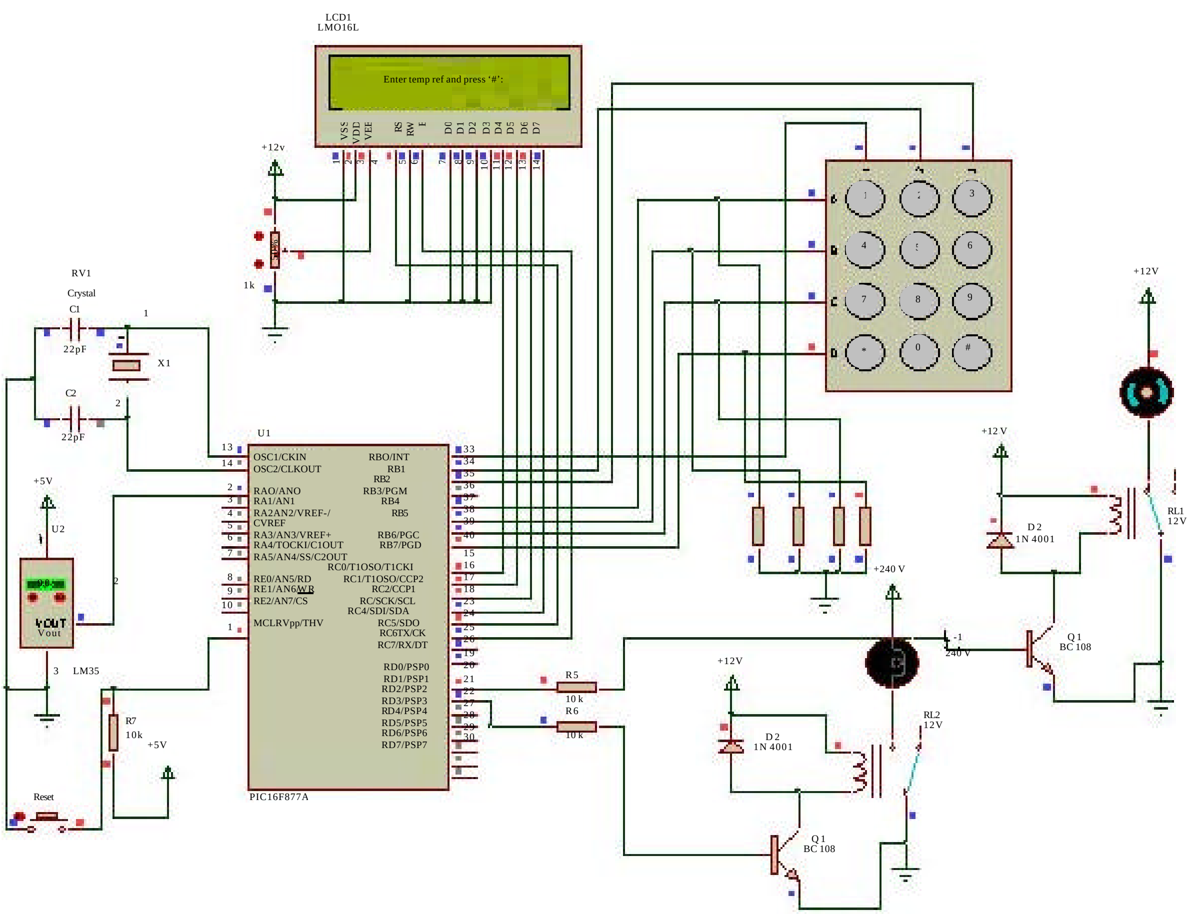

Fig. 5: Result of user prompted to enter a reference temperature

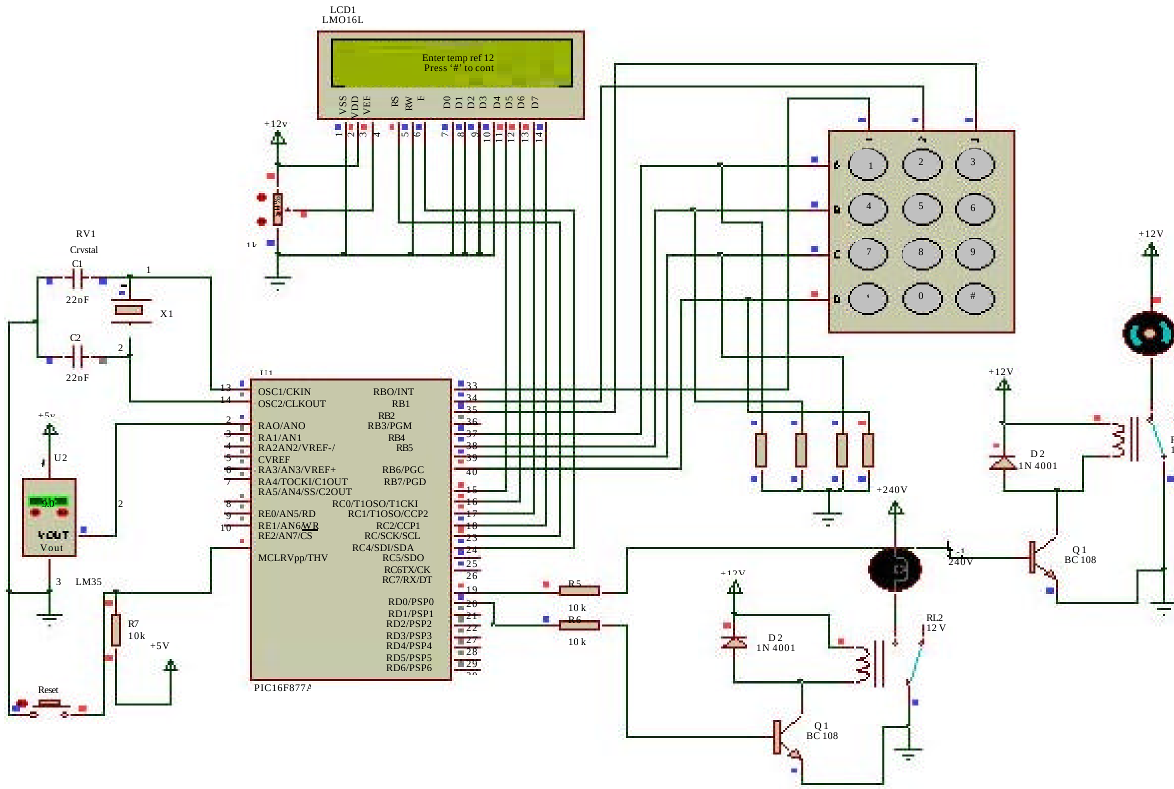

Fig. 6: Result of user entered 12 as the reference temperature

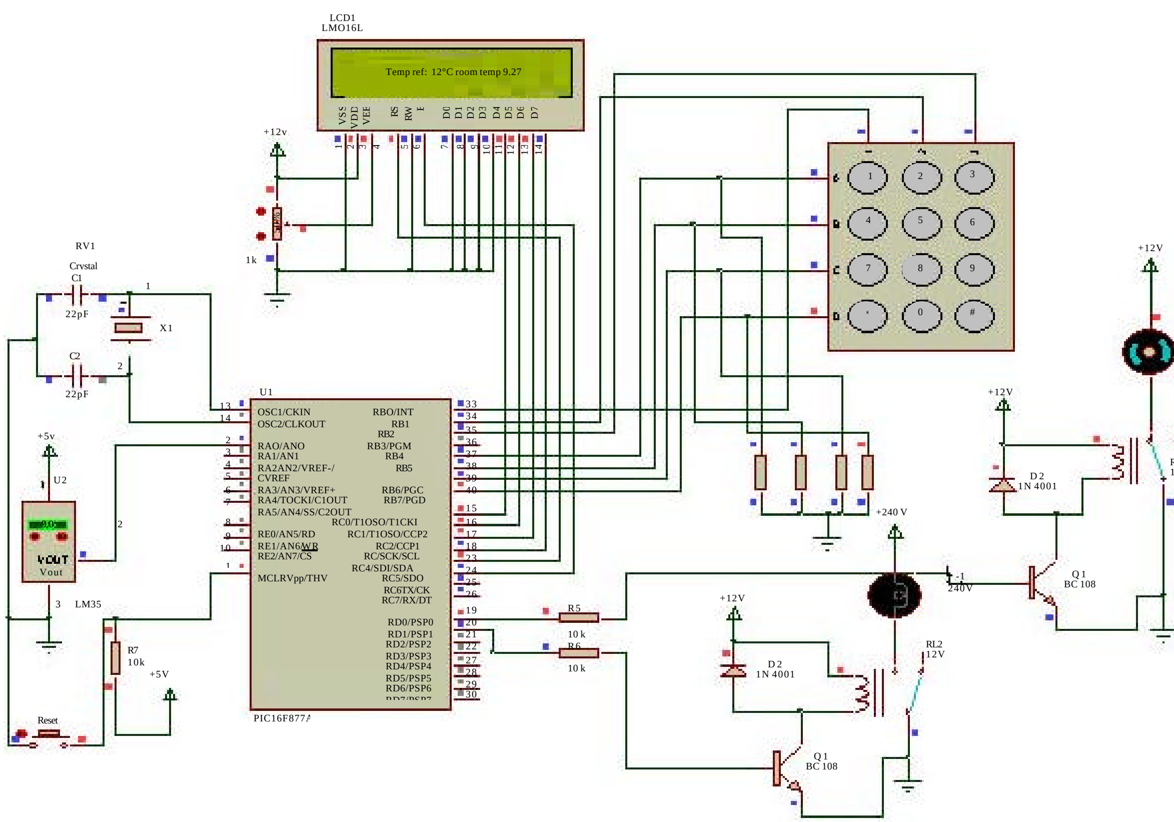

Fig. 7: Result of user entered 12°C as the reference temperature and Heater (L1) switched ON

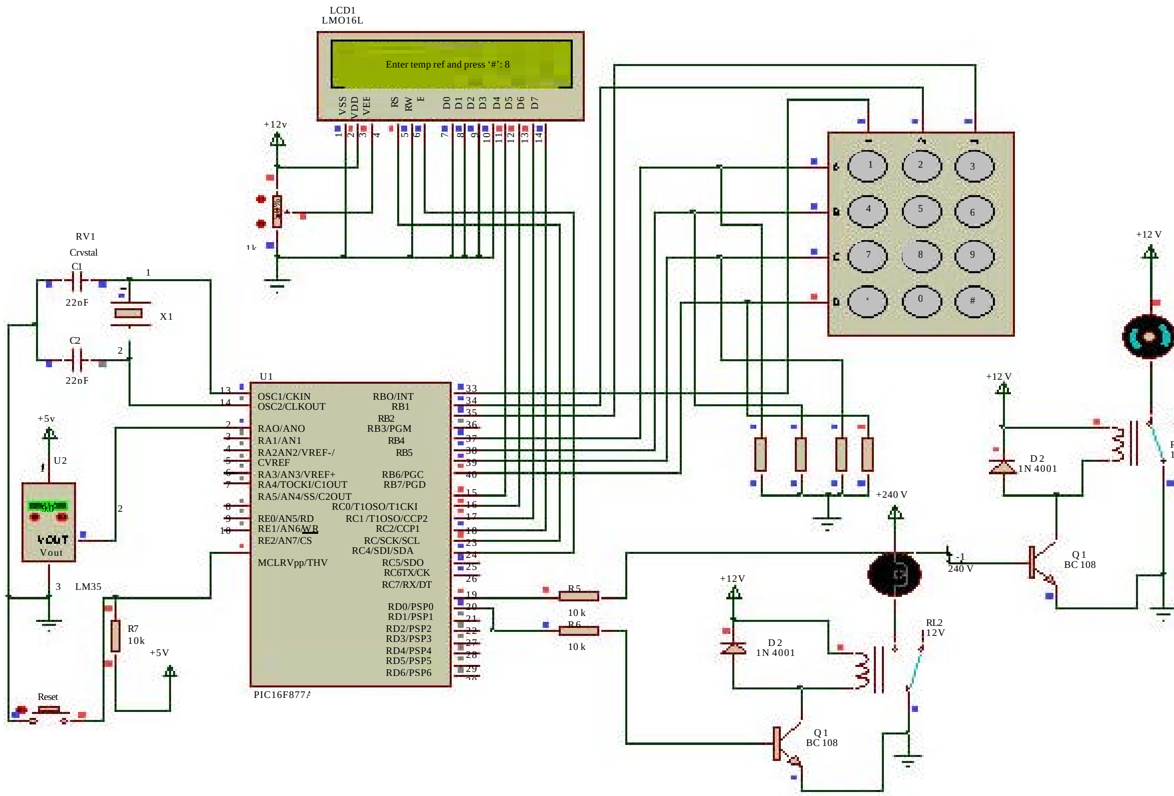

Fig. 8: Result of user entered 8°C as the REF temp, then entered # on the keyboard to continue

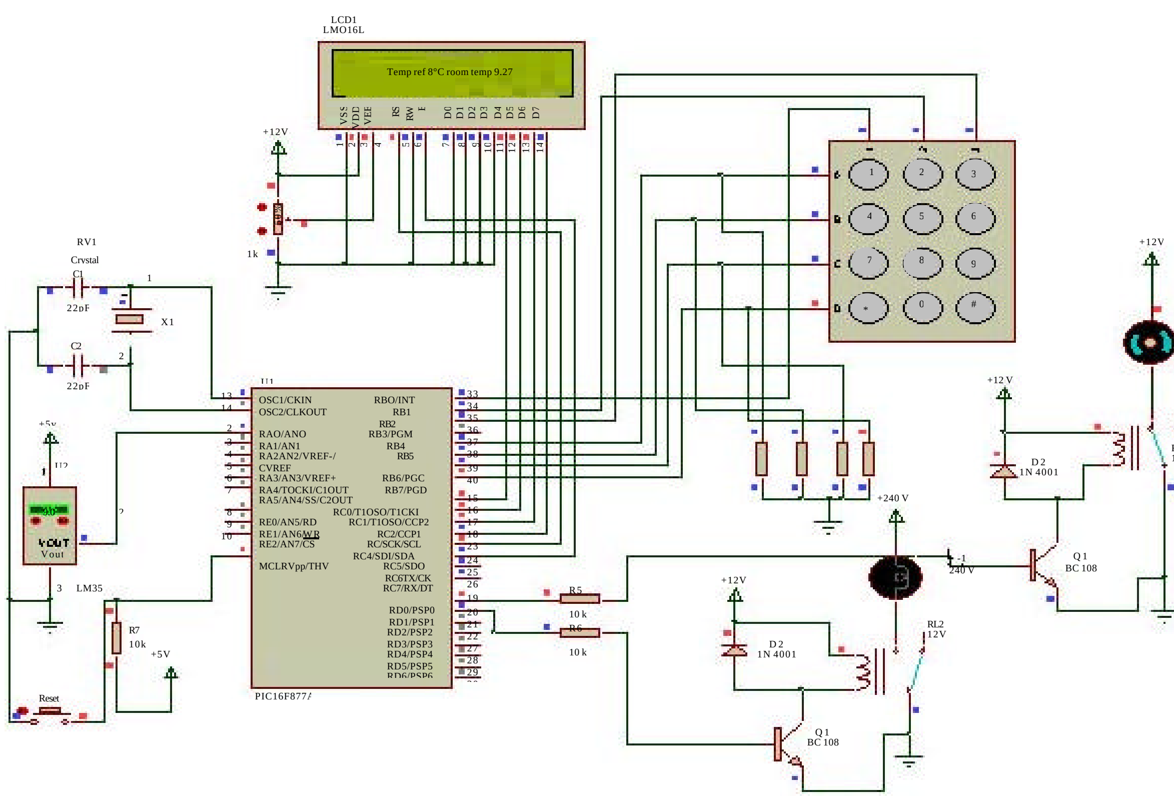

Fig. 9: Result of User entered 8°C as the reference temperature and Heater (L1) switched ON

the REF temp is 12°C. The microcontroller compared the two temperatures and switch the heater ON, since, the REF temp was higher than the room temperature this is when the user has pressed the hash key. As seen from Fig. 7, the bulb is ON as an indication that the heater has been triggered on.

Figure 8 shows the result when the user has entered 8°C reference temperature but the hash key has not been entered which means the microcontroller has not been instructed to compare results.

Also from Fig. 9, when 8°C and was entered as the REF temp and hash key pressed and the Room measured to be 9.27°C, the microcontroller again compares the 2 temperatures values and turn on the fan because the REF temp is lower than the room temp.

CONCLUSION

In this study, we present the design, simulation and analysis of an automatic room heater control system. The system uses PIC 16F877A microcontroller for the control unit and LM35 as the temperature sensor. The output was varied by setting the temperature at various levels and it was discovered that the bulb turn on and off when the system temperature either exceed or less than the predetermined temperature. The system is exceptionally helpful for people who are disabled. This system can be utilized as a part of industry and in addition in home. The system was designed using Proteus and Multisim Software. The system was simulated and working according to the design specifications.

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