Design of an Arduino-based home fire alarm system with GSM module

IOP Conf. Series: Journal of Physics: Conf. Series **1019** (2018) 012079 doi:10.1088/1742-6596/1019/1/012079

Design of an Arduino-based home fire alarm system with GSM module

N N Mahzan, N I M Enzai, N M Zin and K S S K M Noh

Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM) Terengganu, 23000 Dungun, Terengganu, Malaysia
najwa.mahzan@uitm.edu.my, nurid333@tganu.uitm.edu.my, adzianie@uitm.edu.my, kusyahidah@uitm.edu.my

Abstract. This paper describes the design of a home fire alarm with Arduino-based system by means of GSM Module. The project purposely is for house safety where the main point is to avoid the fire accidents occurred to the residents and the properties inside the house as well. It utilizes Arduino Uno board in conjunction with ATmega328 chip. The main controller used is certainly the ATmega328 which controls the home fire alert subjected to the temperature sensor. An LM35 temperature sensor is used to detect the heat from the fire. An alert message will be sent to the user via short message service (SMS) via GSM module. When the system detects the temperature of 40^0C or more, it will immediately display an alert notification on LCD display and simultaneously sending an SMS alert to the users upon the high raise temperature in the house. Results from the test are documented and discussed. Through this system, it can help users to improve their safety standards by having immediate response in preventing accidents. This will eventually allow the users to protect their lives and the properties as well from the disaster.

1. Introduction

Amongst the occurred disasters happened in the resident area, fires have been known as the dangerous tragedy that could cause destruction, property and life losses [1]–[4]. In many disasters, fires have become recurrent, destructive and most influential disasters if compared to others hazards. With the rapid development of urban construction, the occurrence probability of the great fire and other special disaster also increased year by year [5]–[7]. Fires in the early detection and early warning are two important ways to extinguish the fire promptly and avoid great casualties and property loss. Therefore, the requirement of placing intelligent fire alarm system is important within buildings especially in the buildings where contain many people inside or valuable belongings.

According to the statistic stated by Fire and Rescue Department of Malaysia (JBPM), in 2016 only, almost 5500 of fire cases reported are concerned with the households followed by transportations, electrical appliances and leaking gasses [8]. Fires in the households are often triggered by many common factors investigated which are from cooking equipment, smoking in the house, electrical appliances, candles, curious children, faulty wiring and many more. If the fire occurs when the residents are in the house, the possibility to extinguish the fire is a bit high. It is because the residents themselves can take immediate precaution from the fire to be spread all over by using fire extinguisher or call the fireman

instantly. The main concern of this project is when the residents are not at home or are not aware of the existence of the fire in the house. Having said that, the home fire alert is purposely designed to alert the house residents whenever any possibilities for having fire disaster prompted in their house.

For this project, the development of home fire alert is built based on Arduino board as the main controller board that interacts with GSM module which works in the communication part. The interaction is for the user to know the current situation in the house. This system works totally on wireless network communication as GSM module is performed by sending an SMS to the user. The microcontroller inside the Arduino board is used as the mastermind of the circuit where it controls the circuit flows and execute all the decision as well.

The GSM Module is responsible for the communication part of the circuit. It takes information from the Arduino on where to send information and what information needs to be sent. It uses a GSM SIM card for communication purposes. It is basically just a modem which uses serial communication to interface with and needs Hayes compatible AT commands for communicating with the Arduino. The alert message and the phone number of the recipient are given by the user through the project codes. As soon as fire is detected (temperature will hit certain temperature limit) an SMS will be sent to the recipient's phone number from the SIM card inserted into the module for giving information to the user upon fire detection in the house.

2. Methodology

Basically, the design and development of this project are divided into two main parts which are hardware architecture and software details. In the hardware architecture, the design of the circuit was constructed and the prototype of the project was built. While in the software development, the whole complete prototype was operated via programming codes.

2.1 Hardware architecture

Since Arduino is the main board, microcontroller on it which is ATmega328 is used as the main controller to manage the circuit accordingly. It is a well-known open source microcontroller-based kit for creating digital devices and interactive tool that can interact with LEDs, LCD display, switches, buttons, motors, speakers and many more. The Arduino system offers a set of analog and digital pins that can be integrated to many other boards and circuits which absolutely have different functions in a design. Arduino board provides a USB serial communication interfaces for loading the codes from computer. To do the codes, Arduino has prepared its own software called integrated development environment (IDE) which completely supports C and C++ programming languages. Figure 1 shows the Arduino UNO board that is used throughout the project.

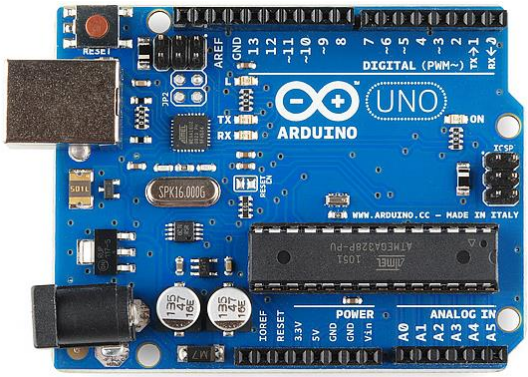

Figure 1. The Arduino UNO board which uses microcontroller ATmega328 onboard.

For GSM module, GSM SIM900A type is selected to carry the task in communication part. It can operate on Dual-Band 900-1800 MHz and designed solely for outside Europe and USA usage. It has an established performance, industrial grade interface standard plus embedded TCP/IP protocol which makes it to be presentable and suitable for the electronics project [9]. Since it consumes small of power in its operation, thus it is said able to communicate with any low power consumption microcontroller. It can be interfaced by using many interfaces which some are I2C, SPI interface, PWM, antenna pad, two serial interface and so forth. Figure 2 shows the GSM SIM900A device before connecting to the Arduino board.

Figure 2. The GSM SIM900A module to communicate with Arduino board.

Other than the two main components mentioned, another component which is essential in this project is the temperature/heat sensor. LM35 is chosen for measuring the temperature since it is an analog and linear temperature sensor which has a linear relationship between output voltage and temperature changes (^{o}C). Besides, the LM35 does not require external calibration to deliver the accuracy of ±(1/4)^{o}C at room temperature or ±(8/4) ^{o}C at the temperature range of -55^{o}C to +150^{o}C [10]. Due to its low-input impedance, linear output, and accurate inherent calibration of LM35, it does make the sensor's readout and control circuitry interfacing become easy [10], [11]. The device is usually used with single power supply or with plus or minus supplies. It can receive an input range of -2V up to 35V and result the output voltage range of -1V to 6V. Figure 3 displays the LM35 sensor which is used to measure the temperature for this project.

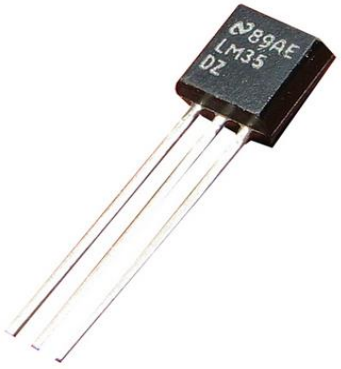

Figure 3. LM35 sensor by Texas Instrument.

Figure 4 presents the block diagram for the home fire alert while figure 5 displays the hardware architecture of the system. The hardware design entails of two main components which are the connections between Arduino UNO and the GSM SIM900A and Arduino UNO with the temperature sensor, LM35. When a fire has broken out in the house, LM35 will trigger the heat. Upon reaching the temperature of 40°C, it will directly send signal to the Arduino informing the high temperature. The increased temperature will make the Arduino to alert the user about the situation through GSM module. An SMS will be sent promptly to the user to let the user know the existence of the fire in the house. At the same time, existence of the fire will be notified as well on the LCD display.

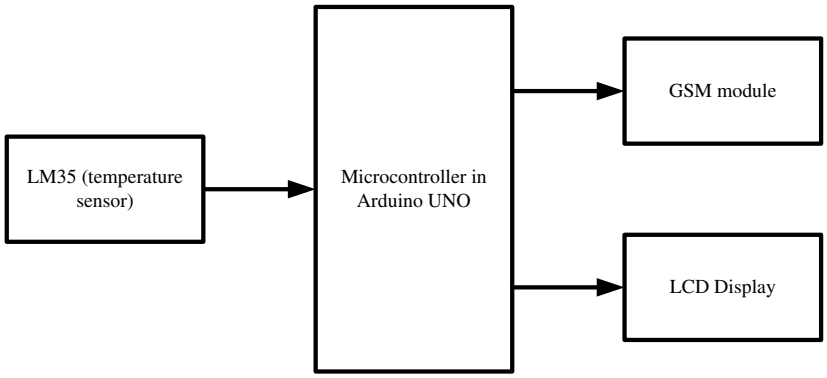

Figure 4. Block diagram of the home fire alert system.

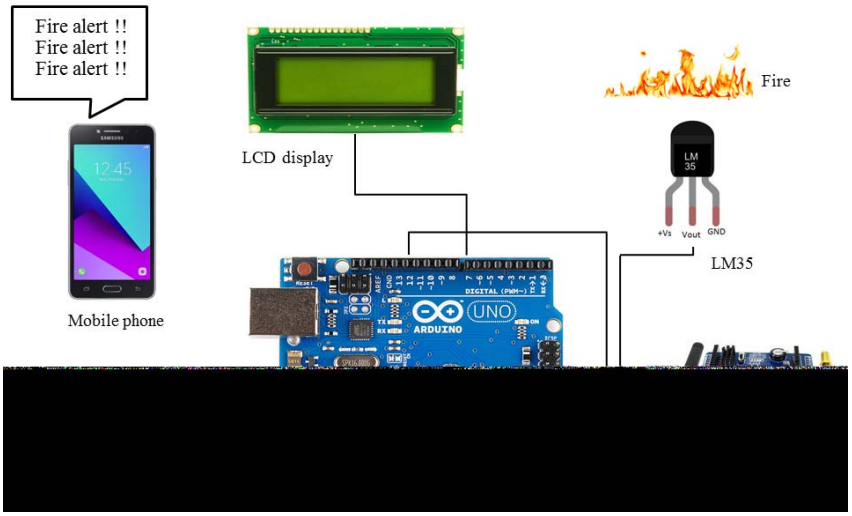

Figure 5. Hardware architecture of the home fire alert.

2.2 Software development

The software of the project is based on the flow chart in figure 6. When the system begins, LM35 will always sense the surrounding temperature. Whenever a fire is broken out, even a small little fire, a temperature rise is occurred. When that happens, LM35 can detect the temperature value instantly. At the time when the temperature reaches 40°C or above, microcontroller on the Arduino UNO board will notify

GSM module to send an alert message to the user. Value of temperature limit that can be triggered by LM35 can be changed in the code upon request by the user. The limit is not constrained to any value since the LM35 sensitively senses any surrounding heat with regards to the temperature range it can count (-55^{o}C to +150^{o}C). During hot weather in Malaysia, the temperature can reach up to almost 38^{o}C. Thus, the limit temperature to be detected; 40^{o}C is definitely agreeable in accordance to the Malaysia's weather. Figure 6 and 7 illustrate the flow chart of the home fire alert and the pseudo codes it represents for the project respectively. By referring to both figures, the complete program can be constructed later in Arduino IDE software.

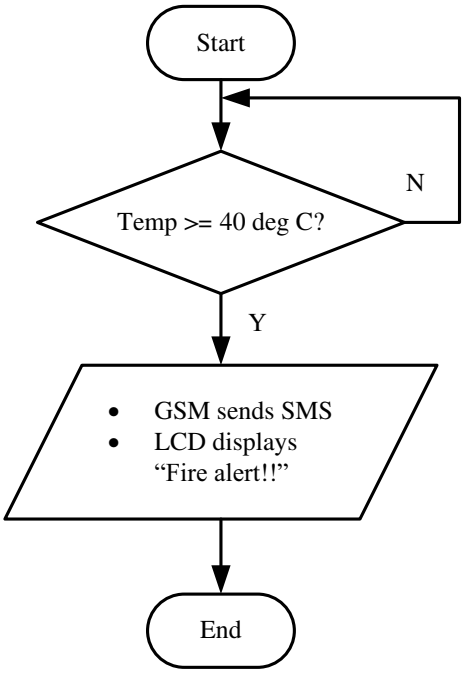

Figure 6. Flowchart of the home fire alert system.

```
START
    IF TEMPERATURE >= 40 DEG
        GSM ACTIVATED
        SEND SMS TO USER
       DISPLAY "FIRE ALERT!" ON LCD
       DISPLAY
    ELSE
        CHECK TEMPERATURE AGAIN
```

Figure 7. Pseudo code for the project based on the flow chart.

2.3 Schematic diagram

The overall project schematic diagram is shown in figure 8. While figure 9 illustrates the connection schematic diagram between Arduino UNO board with LM35 and GSM module. Since the Proteus© software does not have the GSM module component, it is replaced with the input connector available which the connector pins will be attached directly to the Arduino UNO board. For the particular part of detecting fire from LM35, the code is written and portrayed in figure 10. In the code, measured temperature from surrounding is basically identified in voltage. It is because LM35 is an analog sensor which values voltage unit. The voltage unit received will then be converted into knowable standard SI unit; degree Celcius in the subroutine called 'CheckTemp()'.

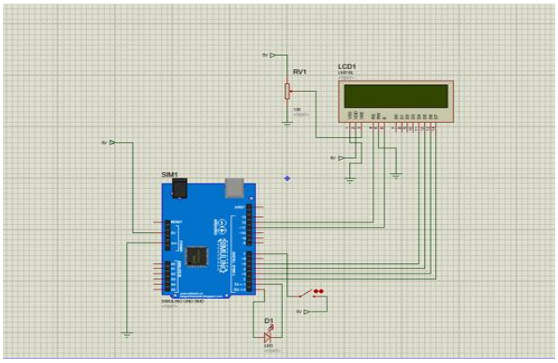

Figure 8. Project schematic diagram.

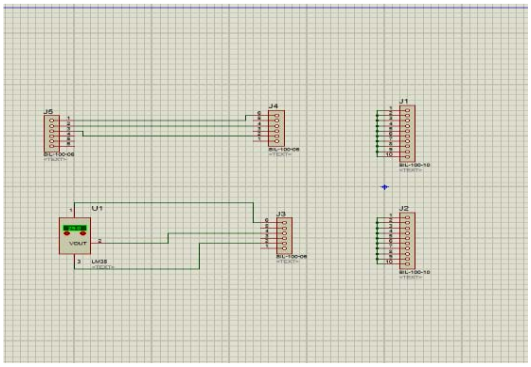

Figure 9. Schematic diagram for connection between Arduino UNO board with GSM module and LM35.

```
void CheckFire()
{
lcd.setCursor(0,0);
lcd.print("Fire Scan - ON");
Temp_alert_val=CheckTemp();
if(Temp_alert_val>165)

{
 Fire_Set=1;
lcd.setCursor(0,1);
lcd.print("Fire Alert! SMS Sent!");
while(sms_count<3) //Number of SMS Alerts to be sent
{
SendTextMessage(); // Function to send AT Commands to
GSM module
}

}
}
```

Figure 10. The program code for measuring temperature.

```
float CheckTemp()
{
temp_read=analogRead(sensor); // reads the sensor output
(Vout of LM35)
temp_read=temp_read*5;    // converts the sensor reading to
temperature
temp_read=temp_read/10;  // adds the decimal point
return temp_read; // returns temperature value in degree
celsius
}
```

Figure 11. The program code for checking temperature and converting it to degree Celcius.

3. Result and discussion

Few tests were done to observe the system's performance. The tests were completed by applying heat near to the LM35. Figure 12 shows the condition which the LM35 is in ready mode (ready to detect fire but detect none). Figure 13 displays when the LM35 detected fire and alert message will appear on the LCD display. While figure 14 exhibits the condition after the fire has been put out. Figure 15 reveals the SMS received by the user when fire alert is notified by the system.

Figure 12. When fire is still not detected but LM35 is in ready mode.

Figure 13. When fire is detected.

Figure 14. When the fire has been put out.

Figure 15. SMS received by the user to notify the fire existence.

Table 1 shows the analysis of the output temperature during the test measurements. When fire is noticed, LCD display only shows the readiness of LM35 sensor to detect fire. As soon as LM35 detects fire, LCD display will notify user on the display screen “Fire alert!” which is synchronized with the SMS sent by GSM module to the user alerting the fire existence. After fire has been stopped, LCD display will show “Fire shut! Safe now” on the screen.

Table 1. The analysis of the output temperature on LCD display and GSM module.

Components involved	Before detecting fire	When detecting fire	After detecting fire
LCD Display	"Fire scan – on"	"Fire alert!"	"Fire shut! Safe now"
GSM	-	Fire in HOUSE!	-

4. Conclusion

This project has been made in order to help building owner to overcome the problem which is fire spreading whenever the owner is not in the building. The unpredictable situation or critical situation always occurs in the building or resident areas without the residents' notice. Based on the results obtained, the home alert system is doable and functional to the residents to protect their houses. In fact the system built is cheap in value compared to other existing alarm system in the market and easy to apply to the houses. The ability to detect heat or high temperature is undeniable because of the use of LM35 in the system. This device can be applied in varied areas due to its flexibility and simplicity in handling; for instance in houses, hostels, hotel industries, factories, vehicle industries and many more areas which are related to the crowd, people or beneficial things. Users can simply apply the device in their interested area to protect the area from the existence of fire. Whenever the temperature reaches the limit (40^{o}C), the device will instantly alert the users by sending a message via GSM. This will make the users become aware of the dangerous situation and can easily prevent it from happening by quick prevention (use fire extinguisher, call firemen etc.).

Acknowledgements

We would like to thank all technicians in the FKE lab UiTM Cawangan Terengganu Kampus Dungun for their assistance throughout this project. The help and comments for the project have greatly improved the manuscript.

References

[1] L Chun-yuan, "Design of Intelligent Fire Alarm System Based on GSM Network," no. Iceoe, pp. 393–396, 2011.
[2] M Faris, M Fuzi, A F Ibrahim, M. H. Ismail, N. Syakira, and A. Halim, "HOME FADS : A Dedicated Fire Alert Detection System Using ZigBee Wireless Network," pp. 53–58, 2014.
[3] S Suresh, "Home Based Fire Monitoring And Warning System," 2016.
[4] L I U Fei, Z Zhe, Y A O Hao-wei, and L Dong, "Application of Aspirating Smoke Detectors at the Fire Earliest Stage," *Procedia Eng.*, vol. **52**, pp. 671–675, 2013.
[5] H Elbehiery, "Developed Intelligent Fire alarm system," *Jounal Am. Sci.*, vol. **2**, no. August, pp. 1016–1025, 2012.
[6] K Sen, J Sarkar, S Saha, A Roy, D Dey, and S Baitalik, "Automated Fire Detection and Controlling System," *Int. Adv. Res. J. Sci. Eng. Technol.*, vol. **2**, no. 5, pp. 34–37, 2015.
[7] H Mori, "Configuration-Free Propagation System for Early Fire Alerts," 2016.
[8] J B dan P Malaysia, "Statistik Kebakaran Mengikut Jenis Kebakaran 2016," 2016. [Online]. Available: http://www.data.gov.my/data/ms_MY/dataset/jbpm-statistik-kebakaran-mengikut-jenis-kebakaran-2016. [Accessed: 20-Jul-2017].
[9] Z Jifei, "Intelligent power failure alarm based on ATmega128 and SIM900A," *Knowledge Guide*, 2014.
[10] Texas Instruments, "LM35 Precision Centigrade Temperature Sensors," 2016.
[11] P Y Mulge, "Remote Temperature Monitoring Using LM35 sensor and Intimate Android user via C2DM Service," vol. **2**, no. June, pp. 32–36, 2013.