International Journal of Academy of Engineering Research and Theory (IJAERT), ISSN: 2545-5931
Aderanti, A. T., Oni, O. O., Adegbesan, A. S & Kayode O. O.
Open Access Vol. 2, Issue 1, February. 2022, Pp 1-6
http://perfectengineeringassociates.com In Partnership with EBSCO https://www.ebsco.com
http://ijari.org.ng

Construction of Automatic Heat Detector and Microcontroller-Based Fire Alarm System

[1*] Aderanti, A. T [2] Oni, O. O. [1] Adegbesan, A. S and [1] Kayode O. O.
[1] Department of Computer Engineering, Gateway (ICT) Polytechnic, Saapade, Nigeria.
[2] Department of Computer Science, Gateway (ICT) Polytechnic, Saapade, Nigeria.

Corresponding Author's Email: rantitaiwo64@gmail.com

Abstract:
Fire alarm system is used to avoid the incidence of fire outbreaks and to protect lives and property. They find direct applications in the protection of the premises of industries, private and commercial buildings. Meanwhile, an ideal fire alarm system should be able to sense the required heat or high temperatures, transmit signals, and give alert with notification when there is an occurrence of fire. Previously proposed fire alarm systems come in one form or the other, but some of them are based on unfounded assumptions and without any practical foundations. Few with related design features lack human factors and ergonomics in their design and no basis for evaluation. Thus, proposed in this work is an automatic heat detector and microcontroller-based fire alarm system. It employs the use of detection system that operates as the fire detector, buzzer for alarming and motor pump to stop the fire and the entire system is controlled by microcontroller. The microcontroller is programmed using C-Programming in such way that the system can detects smoke, light, flame, heat etc. The prototype of the system was tested in real-life and it was found to work perfectly, the detail of its development was explained while recommendations for its full-scale implementation were also given.

Keywords*: Temperature Sensor, Microcontroller, Fire, Buzzer, LCD, Power, Automatic and C-Programming*

Introduction

A *fire alarm system* is usually designed to warn people (Habib et al., 2019), when there is a detection of smoke, fire, carbon monoxide, or other combustible sources. Fire accidents could lead to the destruction of properties, serious injuries, or even death. The essence of the fire alarm systems is to avoid the incidence of fire outbreaks and to protect lives and property (Zhang et al., 2010). Most fire alarm systems basically operate using the same fundamental principle and framework by providing audible and visual alarm signals when a sensor detects smoke, heat, or fire (Sansolis et al., 2021).They find direct applications in the protection of the premises of industries, private and commercial buildings. There are various extant studies that have proposed fire alarm systems in one form or the other, but some of them are based on unfounded assumptions and without any practical foundations. Few with related design features lack human factors and ergonomics in their design and no basis for evaluation. Meanwhile, an ideal fire alarm system should be able to sense the required heat or high temperatures, transmit signals, and give alert with notification when there is an occurrence of fire (Idris et al., 2019). Thus, proposed in this work is an automatic heat detector and microcontroller-based fire alarm system. The heat detector ensures that there is real-time smoke and heat detection while the microcontroller unit sensed the signals and pass this to the output part for alarm as notification in the system. The main purpose of this work is to present an automatic heat detector and fire alarm system designed with the intention of being more user friendly, easy to operate and cost effective (Perilla et al., 2018)

Design and Development of Heat Detection and Fire Alarm

The majority of the earlier proposed fire alarm systems are simulated and based on unrealistic assumptions. For instance, fuzzy logic (Sowah et al., 2014), fuzzy decision tree algorithm (Iswanto et al., 2019), and using simulators such as MATLAB (Habib et al., 2019) are common methods in previous studies. However, the real-world application should be based on the design, development, and use of hardware for proper implementations (Kharisma & Setiyansah, 2021; Obanda, 2017; Zhang et al., 2010). A number of heat detecting devices are available in the market. They include thermistor, thermocouple, resistance temperature device (RTD), and diode-based temperature sensor (DTS). These devices have different advantages and disadvantages. There are certain features that should be considered when choosing the temperature sensor for use. So, our target here is to select the particular device which best suits our requirement. To start, LM35 Heat Sensor is a change IC chip that functions to determine the temperature of an object or room in the form of an electrical quantity (Kharisma & Setiyansah, 2021), with an output voltage linearly proportional to the centigrade scale. This sensor is fully rated from -55 ºC to +150 ºC and with the linear scale factor of 10mV/ºC. It operates from 4 to 30 V, has less than 60 μA drain current and has low self-heating (0.08 ºC in still air).

This study used an N-Chanel (N-MOSFET) enhancement mode standard level field-effect power transistor in a plastic envelope using trench technology. BC548 is general purpose silicon, NPN, bipolar junction transistor. It is used for amplification and switching purposes. The current gain may vary between 110 and 800. The maximum DC current gain is 800. A relay is used for electronic to electrical interfacing i.e.it is used to switch on or off electrical circuits operating at high AC voltage using a low DC control voltage. Finally, the work is coupled through an Arduino which is open-source electronics prototyping platform based on flexible hardware and software. The Arduino is a simple yet sophisticated device which is based on Atmel's ATmega microcontrollers. The software language is based on AVR C programming language and can be expanded through C++ libraries. The microcontroller is a low-power CMOS (Complementary Metal Oxide Semiconductor) 8-bitmicrocontroller based on the AVR enhanced RISC (Reduced Instruction Set Computer) architecture (Zhang et al., 2010). As Output Appliance this study will use LED, Motor and Fire alarm. The entire output appliance will work according to the command embedded in the controller. At the alarm phase, the buzzer used for this project is a 5-12 V buzzer and has got enough alarm sound to be used in a fire alarm system. This project uses a 12 V dc motor for emergency exit, for flowing water to the affected area and for reserve water in the Tank 12V 6,500 RPM DC Electric Motor. The ratings and parameters of the DC Motor is given in Table 1.

Table 1: Parameters of the DC Motor

DC Motor	No Load	At Stall	At Max Frequency	Dimensions
Torque 1300 g.cm	Speed (rpm): 13000	Torque (g.cm): 1200	Efficiency (%): 55.1	Diameter: 35.8mm
Voltage (V): 12	Current (A): 0.6	Current (A): 17.2	Power (W): 26.5	Total Length: 71mm
			Speed (rpm): 10489	
			Torque (g.cm): 246	
			Current (A): 4	

A 16x2 LCD display used in this work is very basic module, very common, economical, easily programmable with no limitation of displaying special and custom characters (Idris et al., 2019). It is used to display character in the ASCII code form which it mean the data for character that is been sent by the controller to the LCD should be in 8-bit ASCII representation. Here, we use LCD Display (16x2) and the model Number is MIS-00010.

Construction of a Heat Detector and Microcontroller-Based Fire Alarm System (HDMiFAS)

The Architecture of the proposed HDMiFAS

The simple block diagram of the proposed system is as shown in Figure 1.

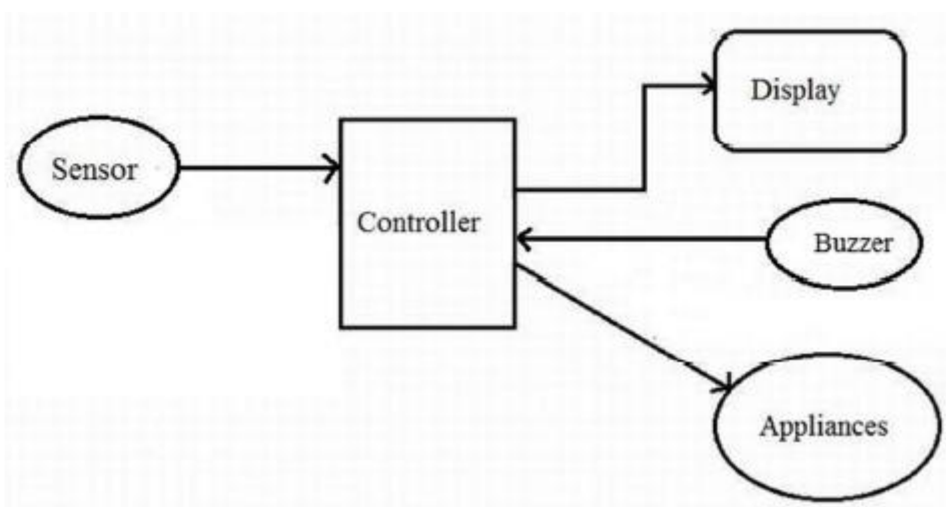

Figure 1: Block Diagram of the System Design

The sensor basically will be the input that will be trigger by the controller to control the motor by certain condition or programming. The controller is set to decide how the output will be produced from the motor and will be displayed at the display part. The integration of the modules is producing the system which is more or less can be divided into two phases in which the first phase is the output smart Appliance system and the second phase is the monitoring system. Figure 2 shows the separated phase through the boxes. The microcontroller, sensory and appliance modules are in the first phase of the system and LCD module is in the second phase monitoring system.

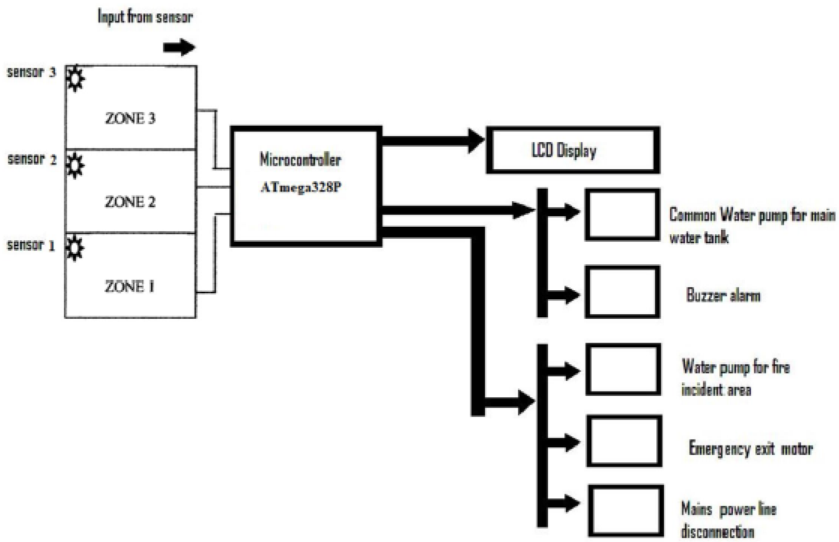

Figure 2: Architecture of the proposed system

This automatic fire alarm system will produce the output in three different areas that are at the same level when input is sensed. Each level is sensed by the input which will trigger the same level of output and the status of the output and temperature view on the LCD panel. The design methodology of the system was based on the functional requirements (Kharisma & Setiyansah, 2021).

Implementation Procedure

The Arduino board is a common microcontroller because it is as an open-source electronics platform based on easy-to-use hardware and software (Obanda, 2017).. As microcontroller need a clock, so for two capacitors and a crystal is used which will produce 16 Mhz speed which are connected to pin number 9 and 10 of microcontroller. Then LM35 temperature sensor was used as the heat detector in the system. It is used as a basic centigrade temperature sensor which can sense the temperature from +2 ºC to +250 ºC. The microcontroller reads the output voltage of the sensor every second by using the function Analog read. LCD is used to Display Temperature output. The microcontroller also needs constant 5 volts to operate so there is need for a voltage regulator circuit. We used IC 7805 along with two polar and two non-polar capacitors for this purpose. The Arduino board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. In this work we use 12 V 7.2 Ah Lead Acid Battery for power supply. The prototype of the system is shown in Figures 3 and 4.

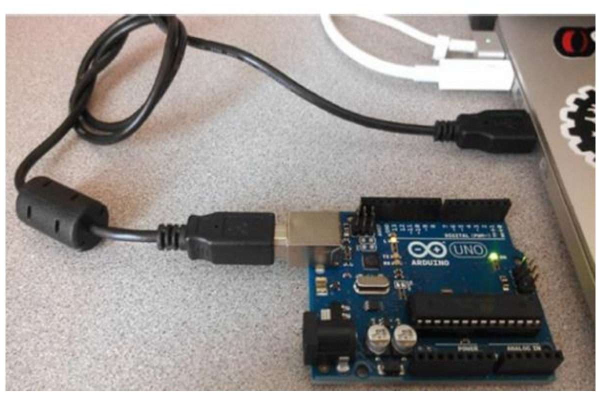

Figure 3: Interfacing ARDUINO-UNO R3 Programmer

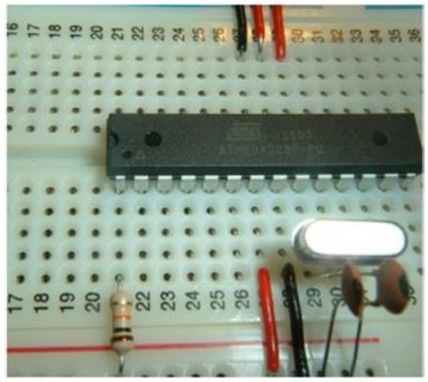

Figure 41: Capacitors connected with crystal

The Development and Implementation of HDMiFAS

The premises are divided into zones and sensors are setup in the separate zones. When a sensor sets up for zone 1 sensed primary fire source (Smoke) it will get activation in zone 1 and microcontroller will receive this signal as high pulse, so the input pin of microcontroller will be high and the response at the output pin connected LCD display will show "*On Fire: 1*" consequently, output pin gets activation to power on a water pump and emergency exit motor. There is common Output pin for every zone as buzzer alarm. One could control and detect as per above description for other zone or area. To detect multi way we can also use temperature sensor and light or flame sensing devices.

Circuit Diagram of The System

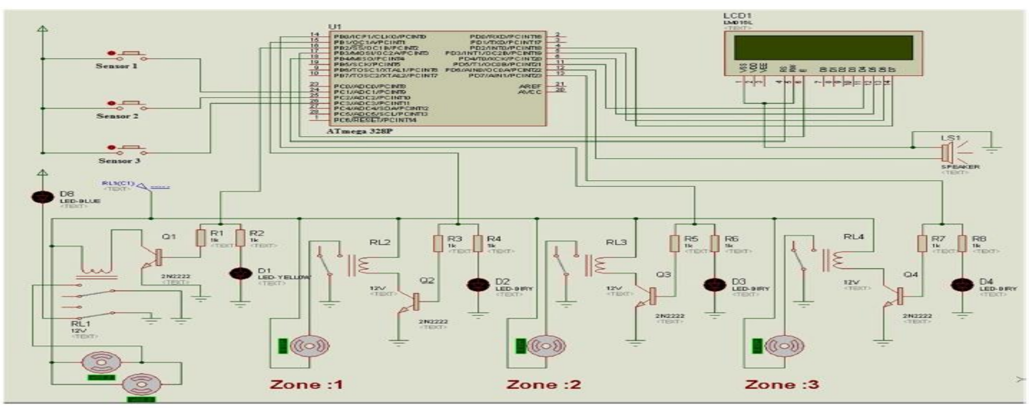

Figure 5: Schematic Circuit diagram of "Automatic Fire control and specific fire location

System Development

The system is operated when sensor 1 gets activation in zone 1, the input pin of microcontroller C.1 will be high as per defined program and the response at the output pin D.0-D.7 connected LCD display will show "On Fire: 1" consequently output pin B.1 and B.2 will get high pulse which is given to a bipolar switching transistor's base. This pulse creates base emitter forward bias which is responsible for transistor activation. This transistor activates a relay to power on a water pump for specific fire location, main power disconnect by magnetic contactor and a motor will get ON for open an emergency exit.

Software Configuration

All programming of this work was done through the ARDUINO-IDE (Zain et al., 2020). The required software was with ARDUINO IDE named arduino.exe. The system is implemented on Arduino platform using the Arduino Uno Board.

System Result, Testing and Evaluation

The images of the final prototype of the system under construction are as given in Figures 6 and 7. Figure 6 shows the image of the completed system design while in Figure 7, the image of the system design is tested to ensure it conform with all specifications.

Figure 6: The Completed design

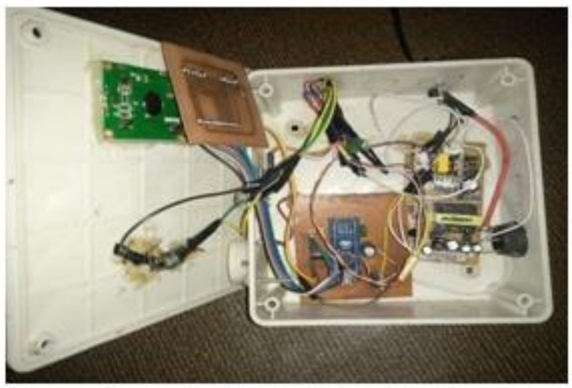

Figure 7: System under testing

Firstly, the hardware parts of the system were tested and it was ensured that they were in a good working condition. Then, each and every unit were interfaced and implemented individually with the microcontroller board and drove with the software according to the necessity of the application. It was easy to figure out the bugs and the problem of the system as the behaviour of each unit was known while testing it. It would be impossible to figure out the problems and the bugs in the system if the system was developed and tested after it was completed. This project was engineered from the scratch and it was discovered to meet its design objectives and goal. The components of the designed system were obtained both locally and international through Alibaba website. Instructions for the design were followed to the latter and precautions were also observed strictly. Following the method adopted in Perilla et al., (2018) and Sansolis et al., (2021), the prototype was subjected to tests, retests, and further evaluation to ensure it performe appropriate and adjustments were made where necessary. Table 2 presents the outcome of the test conducted for 25 members of the Polytechnic community where the system was tested to determine the efficiency, usefulness, helpfulness and learnability of the proposed system using the Linkert scale of strongly agree as 4 points, agree as 3 points, disagree as 2 points, strongly disagree with 1 point while undecided takes 0 point.

Table 2. Evaluation of the HDMiFAS

Linkert Scale Rating	Efficiency/% rating	Usefulness/% rating	Helpfulness/% rating	Learnability/% rating
Strongly Agree	19/76%	21/84%	17/68%	2/8%
Agree	5/20%	4/16%	5/20%	4/16%
Disagree	1/4%	0/0	2/8%	9/36%
Strongly Disagree	0/0	0/0	1/4%	8/32%
Undecided	0/0	0/0	0/0	2/8%

From the evaluation results as shown in Table 2, all respondents agreed that the system was found to be very highly usable, efficient, and helpful. As expected, only the system’s learnability has the highest overall percentage ratings of strongly disagree and this can be interpreted as fairly difficult to learn at first use. This result is in agreement with what was found in Perilla et al., (2018).

Conclusion

In this work, we have designed an automated heat detector and fire alarm system using microcontroller. The development methodology follows step-by-step approach in which the functional requirements were first conducted and the prototype was tested to know if it conforms to specifications. The results obtained from the evaluation of the system show that the system work very well and the following recommendations are put forward for its adoption: that the system prototype can still be constructed to be more portable so that it can have wider applications; that the system prototype should be produced with the use of graphical LCD panel so that the number of channels and Zones can be increased to monitor more sensor outputs; that the components for the construction of designed system should be made available for ease of production.

References

Habib, M. R., Khan, N., Ahmed, K., Kiran, M. R., Asif, A. K. M., Bhuiyan, M. I., & Farrok, O. (2019). Quick fire sensing model and extinguishing by using an arduino based fire protection device. *2019 5th International Conference on Advances in Electrical Engineering, ICAEE 2019*, 435–439. https://doi.org/10.1109/ICAEE48663.2019.8975538

Idris, F., Hashim, N., FauzanKadmin, A., & Yee, L. B. (2019). Intelligent fire detection and alert system using labVIEW. *International Journal of Electrical and Computer Engineering*, *9*(3), 1842–1849. https://doi.org/10.11591/ijece.v9i3.pp1842-1849

Idris, M., & Polytechnic, K. S. (2019). *MICROCONTROLLER BASED FIRE OUTBREAK SMOKE*. *5*(11), 176–187.

Iswanto, Purwanto, K., Hastuti, W., Prabowo, A., & Mustar, M. Y. (2019). Smart smoking area based on fuzzy decision tree algorithm. *International Journal of Advanced Computer Science and Applications*, *10*(6), 500–504. https://doi.org/10.14569/ijacsa.2019.0100665

Kharisma, R. S., & Setiyansah, A. (2021). Fire early warning system using fire sensors, microcontroller, and SMS gateway. *Journal of Robotics and Control (JRC)*, *2*(3), 165–169. https://doi.org/10.18196/jrc.2372

Obanda, Z. S. (2017). *Multi-sensor fire detection system using an Arduino Uno microcontroller*. *10*(03), 23–26. http://su-plus.strathmore.edu/handle/11071/5686

Perilla, F. S., Villanueva, G. R., Cacanindin, N. M., & Palaoag, T. D. (2018). Fire safety and alert system using arduino sensors with IoT integration. *ACM International Conference Proceeding Series*, 199–203. https://doi.org/10.1145/3185089.3185121

Sansolis, E., Dumpit, K. A., & Feliprada, C. A. (2021). Smart fire monitoring system for a city: design and development. *Technium: Romanian Journal of Applied Sciences and Technology*, *3*(10), 37–47. https://doi.org/10.47577/technium.v3i10.5094

Sowah, R., Ofoli, A. R., Krakani, S., & Fiawoo, S. (2014). Hardware module design of a real-time multi-sensor fire detection and notification system using fuzzy logic. *2014 IEEE Industry Application Society Annual Meeting, IAS 2014*, 4–9. https://doi.org/10.1109/IAS.2014.6978415

Zain, A., Hartono, R., & W, S. H. (2020). Design of Microcontroller Based Fire Detector with Output Warning SMS Information and Automatic Extinguisher. *INTEK: Jurnal Penelitian*, *7*(2), 109. https://doi.org/10.31963/intek.v7i2.2639

Zhang, K., Hu, S., & Li, J. (2010). Automatic fire alarm system based on MCU. *Proceedings - International Conference on Electrical and Control Engineering, ICECE 2010*, 517–520. https://doi.org/10.1109/iCECE.2010.133.