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INTELLIGENT FIRE DETECTION SYSTEM USING MOBILE WIRELESS NETWORK

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ABSTRACT

To protect lives and valuables against colossal loss due to fire outbreak in any society, provision of proper safety measures is sine qua non. This has been achieved through installation of adequate fire extinguishers in strategic visible places, installation of smoke sensors and provision of human security personnel. These methods are not only cost prohibitive, but most times fail to provide required hazard preventive measures at appropriate time. In this paper, we present an intelligent photoelectric fire detection system to provide prompt and adequate notification mechanisms to the occupants and relevant authorities about possible outbreak of fire via existing mobile wireless networks. The result from the implemented model shows how intelligent photoelectric fire detection system can help minimize possible consequences from the risk of fire outbreak.

Keywords: Photoelectric, Safety, Microcontroller, Fire, Smoke detector, Wireless network

1.0 Introduction

In most organizations, several safety measures are taken to improve safety and reduce risk related to human health and damage to property. Dominant out of these measures is the safety of both life and property against massive loss due to the event of fire outbreak or from any similar occurrence. Fire safety measures include those that are planned during the construction of a building or implemented in structures that are already standing, and those precautions to be observed by the occupants of the building. According to survey carried out by The National Fire Protection Association (NFPA), 85% of fire deaths occur in the home, making fire prevention a top priority in every home (NFPA, 2006).

Since it is naturally believed that there is no fire without a smoke and prevention is better than cure. Many losses of lives and valuables to fire outbreak could have been curbed if proper smoke detectors had been in place. Smoke is a dispersion of small solid particle or suspension of particles in

a gaseous medium (it could be white, gray, or black in appearance), it results from chemical process majorly complete or incomplete combustion of substance with chemical combination of carbon, hydrogen and oxygen with carbon having the highest percentage.

Smoke detector are devices mounted on the wall capable of sensing the presence of smoke or other products of combustion which could lead to fire and alert the occupant of the building. They evolve out of the need to have a well-secured safety measure against the occurrence of fire outbreak. Most smoke detectors work either by optical detection (photoelectric) or by physical process (ionization), but some of them use both detection methods to increase sensitivity to smoke and to reduce false alarms (NFPA, 2006). Most smoke detectors are classified based on their principal technique of detection. They are usually powered by battery (as a power supply backup) while some are connected directly to mains power supply. One of the reliable detections is photoelectric smoke

detector because its response is much faster than the ionization smoke detector (Liu and Kim, 2003; Cleary, 2009). In addition to the characteristics of the smoke detection, notification mechanisms, the fire itself, the occupants' location, condition and behavior, and exit availability all play a role in determining the final outcome of fire prevention (Ahrens, 2008).

This paper presents an intelligent fire detection system capable of fire detection via smoke with improved notification mechanisms. The intelligent module comprises of a microcontroller that is able to make voice calls and trigger text alerts to occupants and relevant agencies using available services provided by mobile wireless networks.

2.0 Related Works

A number of related works has already been carried out in the area of fire detection technology over the last decade. Advances in sensor, microelectronics, greater research frontiers in fire physics as well as information technologies have contributed substantial progress. Some of them are described as follows;

The performance and effectiveness of home smoke alarms and of victim characteristics in home fires with and without operating smoke alarms based on statistical analysis of actual fire experience data was reported by (Ahrens, 2008). Special studies on other factors affecting smoke alarm performance, audibility, and nuisance alarms were also discussed. Progress in research and development in fire detection technologies was reviewed by (Liu and Kim, 2003). Technologies reviewed included emerging sensor technologies (like computer vision, distributed fiber optic, temperature sensor and intelligent sensor), fire signal processing, real time monitoring technology and integrated fire detection system. Some problems and future recommendations related to these fire detection technologies were

discussed. Issue of reliability, capability and selection criteria of automatic fire detection systems was addressed in Gupta (1985). Automatic fire detection (AFD) systems differentiate intelligibly between the presence and absence of fire. False alarms due to the fault of the system or some external factors could amount to substantial losses to an organization. Also, failure to detect the fire could result in loss of human lives and business. In Gupta (1985), the events which lead to the malfunctioning and proper functioning of AFD systems were categorized and the time periods between these events, for the date collected from various sites, were analyzed using Weibull distribution.

Abdulkadir et al. (2006) presented a remotely monitored and controlled personal computer based smoke detection system. In the system, a light obstruction smoke detector designed around a light source and a photo sensitive receiving device was enhanced by connecting it to the personal computer's (PC) parallel port and integration of wireless technology like infra-red technology and GSM mobile wireless network. The system provided a good improvement to the chance of reducing risks of fire to life and property. However, the proposed system will be affected by high initial costs, bulkiness and increased dependence on maintenance. Hence the need for the current work which provide simple, low cost, portable and maintenance free alternative.

3.0 System Overview

The initial system design of the intelligent fire detection system using mobile wireless network is shown in Figure 1. It comprises of power supply section, photoelectric detection unit, the microcontroller (PIC16F84) and mobile phone connected to mobile wireless network. All these units make up the system hardware while the program instructions stored in the PIC16F84 serves as the software.

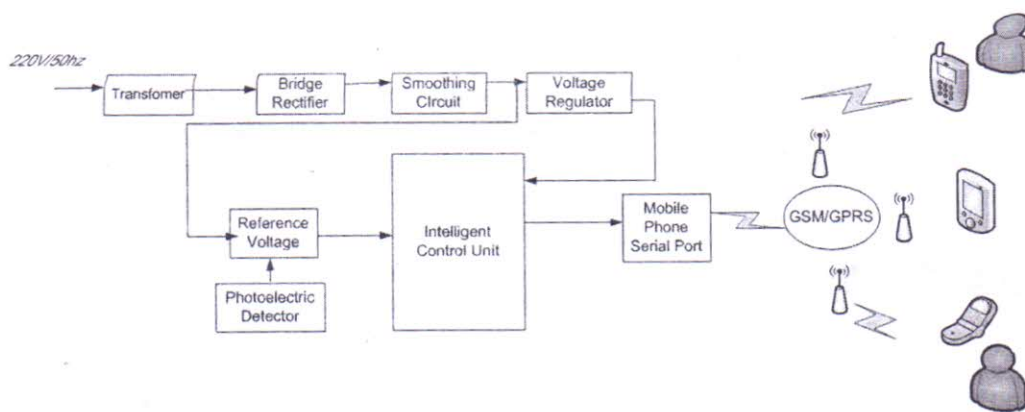


Figure 1: The initial system design

3.1 The Hardware Design and Implementation

The detail hardware design of the system is shown in Figure 2. The implementation consists of the interconnection of all the units after testing at unit level for correct functionality.

Power Supply Unit

This unit serves as the interface between the power supply mains and the other units in the system. The output of this unit is rectified, filtered and regulated dc power supply.

The Input Transducer Unit

This unit can also be called the sensor or detector stage, it takes in an input whose magnitude is determined by the variation in the intensity of light to generate the respective output. This unit comprises of two major components, which are the light source and the light detector to detect smoke due to reduction in the light reaching the detector. Light Dependent Resistors (LDR) and light emitting diodes (LED) were used as light detector and the light source respectively. The output of the detector is biased with a reference voltage so as to increase or reduce the sensitivity of the detector.

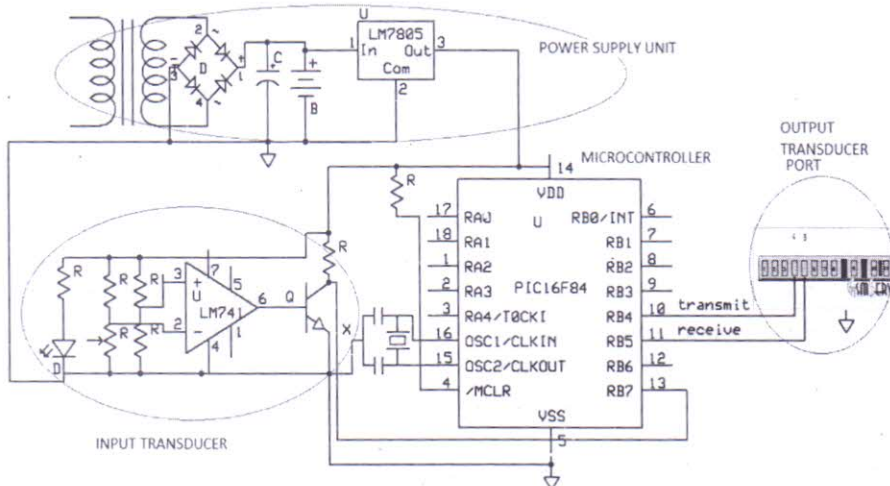


Figure 2: The circuit diagram of the system

The Microcontroller

Microcontroller; are programmable semiconductor circuit whose memory can be programmed and reprogrammed to solve a particular task, and there are different types. For this work, PIC16F84A was used because of its low cost and it serves as the master controller for the system. It sends signal to and receives signals from

the mobile phone based on the input signal from the input transducer. The PIC16F84A belongs to the mid-range family of the PICmicro® microcontroller devices. There are 13 input/output (I/O) pins that are user-configured on a pin-to-pin basis.

The Output Transducer

The output transducer unit helps to convert the output of the microcontroller into voice call and text messages understandable by human. The phone used was *Sony Ericsson T68i* phone model. This was selected because of its ability to

understand attention command (AT command) and ease of interfacing to the microcontroller. Any phone with serial universal asynchronous receiver and transmitter (UART) interface could be used. The serial port of the phone is shown in Figure 3.

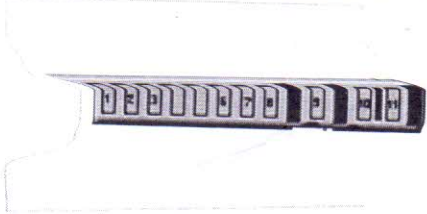


Figure 3: Serial port numbering for the phone

Pins numbered 4, 5 and 10 were used to send data to, receive data from the mobile phone and for grounding respectively. The phone numbers of the occupants of the house or the relevant authorities are stored on the phone memory location one to five. The phone number of a nearby fire station

may be included, but prior to this inclusion the fire station must have been first notified. The final hardware implementation of the system is shown in Figure 4.

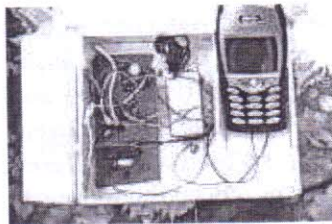


Figure 4: Mobile wireless network based fire detection system

3.2 The Software Design

The basic software tools used for programming the PIC16F84 were the mikroBasic PRO for PIC and the IC-Prog. The mikroBasic PRO for PIC is a powerful high level language, feature-rich program development tool for PICmicro® microcontroller devices. The IC-Prog was used to download program written in mikroBasic into the PIC16F84 program memory. The basic functions of the program were to detect the presence of smoke via one of the input pins of the microcontroller and to initiate voice calls and text messages to the occupants via the mobile phone using the AT commands. The program also enables audible and visible alarms via the unused microcontroller's port pins.

4.0 Testing and Results

The implemented system was tested in the presence of smokes from different sources such as cigarette, paper burning, cooking, etc. During testing, the sensitivity of the detector was adjusted so as to detect smoke from different sources at low concentration. when the system

was powered on, in the absence of smoke, it was observed that the phone was not dialing any number. In the presence of smoke, which persist for few seconds the phone indicated a dialing signal on the screen. The first five numbers on the phone's memory were dialed twice and a text message "POSSIBILITY OF FIRE ACCIDENT AT 15 Lnyx Road ..." was sent to each of the phone numbers. It was discovered that at higher detector sensitivity, there were more false fire alarms. The testings were satisfactory to the objectives of this work.

5.0 Conclusion

Several fatalities of lives and valuables should not have happened or minimized, if proper working smoke detectors with adequate notifications had been put in place. This would give room for early notification of a developing fire, allowing intervention before a fire has developed beyond the smoldering stage thereby increasing the time available for evacuation and probably enabling emergency firefighters to arrive earlier and minimize fire damage. This work has presented a

simple design and implementation of fire detection system based on mobile wireless network that is capable of sending intelligent notifications to those concerned. To improve the overall reliability of this system, it is suggested that two mobile phones with different network operators be employed due to network failures in this part of the world. Conclusively, the more we can protect and preserve our properties against risks such as fire, theft, vandalisms, etc, the more wealthy we become.

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