A Low-cost R-type Fire Alarm System for Old Houses

Song-Shyong Chen[1], Luke K. Wang[2], Wei–Hsuan Li [2] and Wen-Ping Chen[2,3,*]

[1]Hsiuping University of Science and Technology, Department of Information Networking Technology
[2]National Kaohsiung University of Applied Sciences, Department of Electrical Engineering
[3]Kaohsiung Medical University, Graduate Institute of Clinical Medicine
[1]No.11 Gongye Rd, Dali Dist., Taichung City 412-80, Taiwan, R.O.C
[2] No.415 Chien Kung Road, Sanmin District, Kaohsiung 80778, Taiwan, R.O.C.
[3] No. 100, Shih-Chuan 1st Road, Kaohsiung, 80708, Taiwan, R.O.C.
*wpc@kuas.edu.tw

Abstract

The proposed system is using low-cost Arduino MEGA 2560 Development Board, synthesizing with PLC module, facilitated with QPSK modulating capability. A generic R-type fire alarm system is hereafter constructed, with a master-slave architecture connecting to fire sensors. No extra modification/rehabilitation is needed for those old buildings because the proposed fire alarm system is mounted on buildings' wiring system. Wiring and labor costs are substantially reduced, and the protection of both human and property are assured and guaranteed.

Key words: Fire Alarm, R-type, Powet Line Communication, Arduino

Introduction

Reporting on the media, newspapers, and magazines, old buildings/constructions often cause unexpected deaths and thus the loss of property and casualty. By discovering the problem, we can correct the misunderstanding of people's conception of the installation of fire alarms systems. Not only do families overlook the importance of the system, but there aren't any strict law enforcements in Taiwan; causing almost all old buildings to not have a fire alarm system mounted. Furthermore, to add a fire alarm system to an old building, new wiring and plumbing work are needed. The inconvenience and extra money needed causes homeowners to be unwilling to install a new fire alarm system, despite the risks of losing their lives.

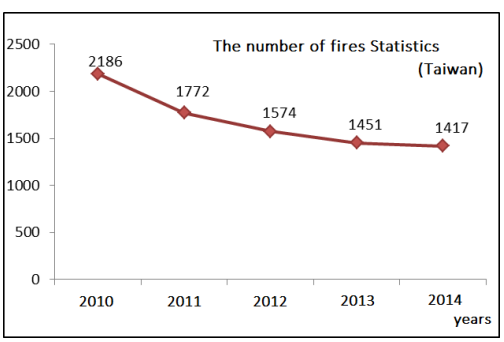

Fig.1. The statistics of the fire counts between 2010 and 2014 in Taiwan.

In the past few years, the fire alarm systems have attracted a lot more attention. Various researchers across the world have brought up the idea of the security cameras, recognizing the color and shape of the flame [2], etc. After recognizing the potential of the newly discovered system, it has not only sparked the interest of fire system installation but it also reduced the total number of accidents and fire occurrences. On the other hand, old constructions-especially privately owned properties take up a large percentage of the total number of fires. For example, in fig. 2, during 2015 the ratios of fire occurrences were 42.7%.

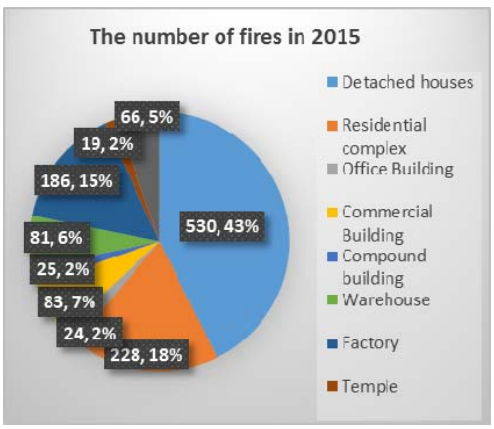

Fig.2. The statistics of the fire counts of buildings of Taiwan in 2015.

The problem with old building and residents adjusting to the placement of a fire alarm system and the pipes has been thankfully resolved under the development of technology. Using the AC power, power line communication, and the carrier technique can then form the long distance information transfer[3], allowing one to solve the installation problem, the costs, as well as the appearance. Furthermore, the cost of an automatic fire alarm system is an estimate of multiple thousands of dollars; this is certainly not in every home owners' price range. In January of 2015, two professors (David Cuartiells and Massimo Banzi) from Milan Design Institute devised an electrical controller with the size of the human palm. Later on, the controller used the Atmel AVR's microcontroller unit (MCU) which is an open source software/hardware platform. Based on the open sources of the simple I/O, by using similar languages to the Java C's processing and wiring, it can open up the development environment. This printed circuit board (PCB) has an open sources environment and is easy to use.

Arduino is more popular than any other normal micro controllers when it regards to entrance levels, perfect for the users with none related electrical background [4]. Therefore, this research will utilise the Aruino's board (low cost R-type fire alarm system) for homeowners equipped with AC power, associated with PLC and the carrier technique to transmit the information within the internal of the fire alarm system; thus a suitable fire alarm system with low cost for old buildings is created.

Methods

The goal is to construct a "low cost R-type fire alarm system for old buildings." The proposed system components, including Arduino's communication technology, APSK modulation technology with PLC and the Master Slave design software are all apart of the R-type fire alarm system. The system architecture (fig.3) has a Master, numerous Slaves and fire sensors. The Master and Slave both have an Arduino controller and a CJ-06 PLC module, utilizing the PLC module and the QPSK modulation technique [5-6] to achieve data communication job. The Master-Slave architecture is described as following,

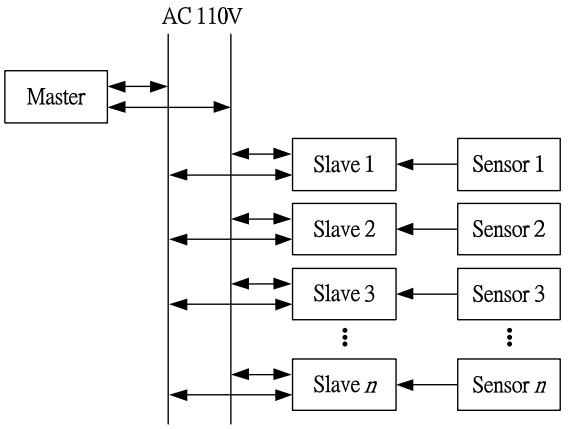

Fig.3. The schematics of the proposed low-cost monitoring /controlling fire alarm system.

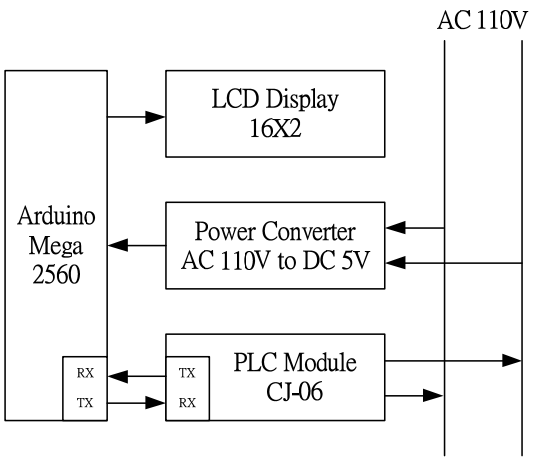

Fig.4. The block diagram of the Master site.

A. The Master site

(a)MCU–using Arduino Mega2560 (multiple I/O pins), which can be directly connected to LCD and power-line transmission module (TX/RX pin).

(b)Power-line communication (PLC)–power-line carrier development board with USB interface, whose model number is CJ-06.

(c)Power level converter–model number CZ-P001, come with power module, AC 110V-220V/DC 5V.

(d) LCD display –16×2 resolution.

B. The auxiliary Slave site

We make use of Arduino Atmega328 CPU due to the fact that Slave doesn't require large number of I/O ports as Master does.

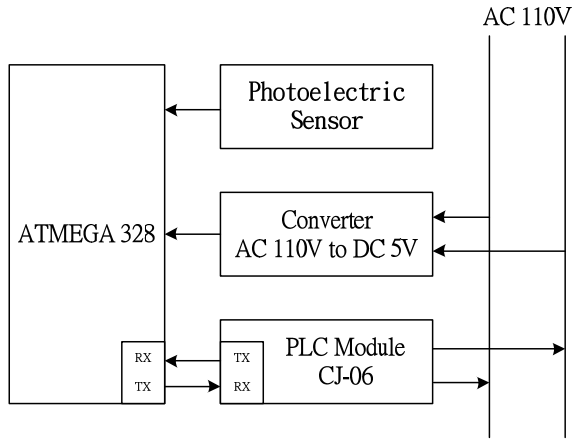

Fig.5. The block diagram of the auxiliary Slave site.

Test and Results

Fig.6 is the schematics of the R-type fire alarm system, with one Master and three Slaves.

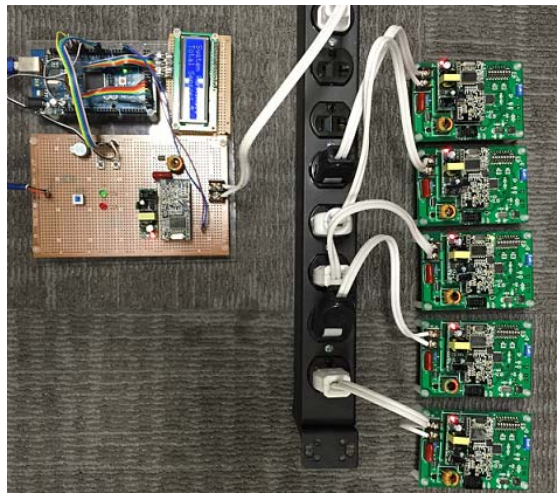

Fig.6. The realization of the R-type fire alarm system based on Arduino MCU.

The proposed system is composed of three parts, Master(s), Slave(s), and a system test. The corresponding test/verification procedures are listed as below.

A. Master Mode

The operation of the Master mode – ID obtaining and normal operation

ISBN 978-1-5090-3869-5

A1. The ID obtaining mode – All the Slaves must have an ID, and a Master must have a function of snapping the Slave's ID. Initially, the ID push button on the Master is depressed, shown in fig.7; the Master will be reset, and finally theID snapping job of the Master is therefore activated.

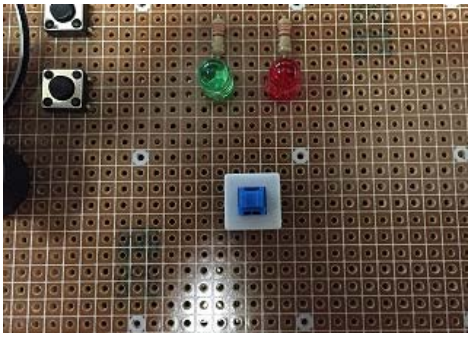

Fig.7. The ID snapping push button.

Once entering the ID snapping stage, the captured ID number will be displayed on a LCD module. The ID snapping is basically a polling process. The ID snapping status of the Master is shown in fig.8.

Fig.8. The status of entering ID snapping stage of a Master.

When a Master collects all Slave's IDs in all loops, it will display all related information. As shown in fig.9, there are five Slaves in the loop, and the number of Slaves, their associated ID values, and the current status of the Master/Slave will be stored in the EEPROM of an Aduino Mega2560 board. Concurrently, the ID push button can be reset and the Master mode can be reset as well (i.e, entering normal operation mode.)

Fig.9. The count of the Slave ID.

Fig.10. the system's initialization.

A2. The normal mode

All Slave IDs need to be identified and stored in Master's EEPROM under this mode of operation. Firstly, Master(s) will enter the initialization stage and the number of Slaves will be an inquiry from the Master's EEPROM. The LCD also shows the current status of the system, i.e., initialization, as shown in fig.10.

Fig.11. The monitoring status of the fire alarm system.

The system enters the monitoring state after polling all possible Slave IDs. Fig.11 shows the status of the system.

B. Slave test mode

Intrinsically, all analog sensors attain inaccuracy. In order to comply with the fire system facilities regulation of Taiwan, Slaves must go through a calibration process; user has to shift the switch on the back of the Slave to the "ON" position, as shown in fig.10. Next, the Slave is switched on. Five pieces of data are read through A/D pins; their averaged values are calculated. The LED on the Slave is blinking, showing that the calibration is completed. The associated parameters are being calibrated. The blue switch can be put to a neutral position to reset the system. Each Slave's ID is set up by an 8-pin switch. This switch is illustrated in fig.12.

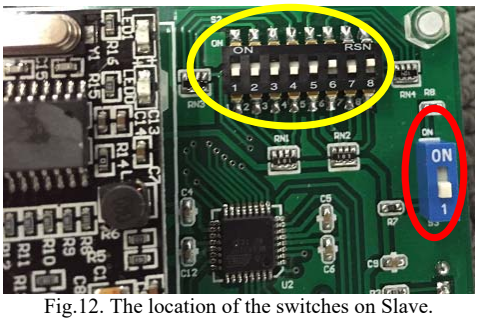

Fig.12. The location of the switches on Slave.

C. Test of the system

Because the sensor of the Slave is photoelectrical & scattering, smoke or spray can be employed to conduct the simulation of actual fire scenarios as shown in fig.13. The #5 sensor is being sprayed to serve as a field test. When the smoke concentration reaches a designated level, the light beam emitted from the infrared transmitter will go through the smoke and arrive at the receiver. The received infrared signal is processed in an A/D converter; the Slave will jump to the fire alarm mode if the received signal's level after A/D conversion exceeds the prescribed threshold (while waiting for the reply from the Master.) As soon as the Master receives the signal of the fire alarm at address #5, the buzzer will go off. The LCD will display the address/location of the fire, as shown in fig. 14.

The proposed system is also designed with both automatic and manual reset functions. When the fire hazard disappears, the proposed system will command all Slaves to enter reset mode, forcing the system to go back to the monitoring status. On top of that, if any of the Slave(s) are disconnected or out of order, the Master will display its ID to let the user fix the problem. For example, by unplugging the #3 Slave, the LCD will display the ID of the disconnected Slave.

ISBN 978-1-5090-3869-5

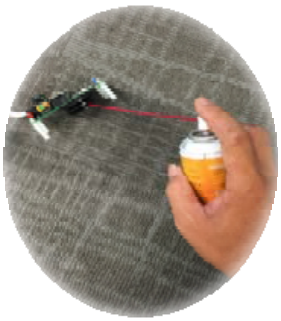

Fig.13. the test of the fire alarm.

Fig.14. the address of the fire.

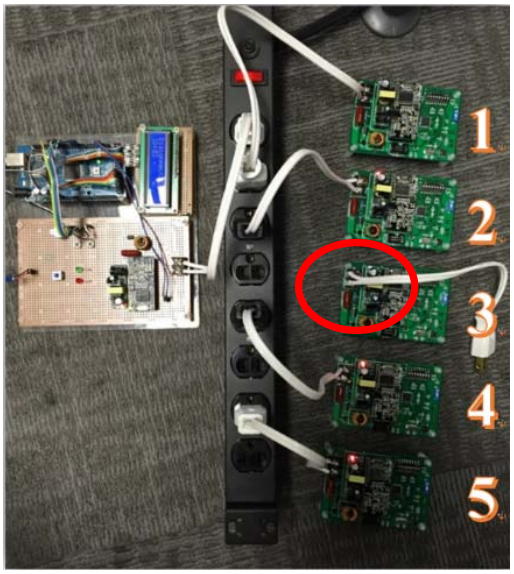

Fig.15. The display of the disconnection to the system.

Conclusion

The proposed system has been successfully using both Arduino's controller board and PLC module to facilitate the fire alarm system for old building/houses, resolving the issues of rewiring and costs. According to the results from the field tests, Master can successfully identify the correct number of connected Slaves as well as execute polling action once those ID's of the connected Slaves have been assigned.

Whenever a Slave detects the occurrence of smoke or disconnection for unknown reason, Master can always locate the fire scene (by the Slave ID.) The Master can obtain its status; the display shows the system status, namely, fire alarm system, disconnection, and Slave ID. A simple and applicable fire alarm system is therefore prototyped.

Acknowledgment

This work was partially supported by the National Science Council of Taiwan, Republic of China under MOST 104-2221-E-151-004-

References

[1] National fire agency, Ministry of the interior(Taiwan)：http://www.nfa.gov.tw/main/List.aspx?ID=&MenuID=342

[2] P. h Huang, J. y Su, Z. m Lu, J. s Pan " A Fire-Alarming Method Based on Video Processing" *2006 International Conference on Intelligent Information Hiding and Multimedia,* pp. 359-364, 2006

[3] C. Becker, H. Frank, M. Stuhler, and K. Fleischmann, "Alarm transmission for distributed energy resources over power line communication," *2012 IEEE Power Engineering and Automation Conference (PEAM)*, pp.1-6, 2012.

[4] Arduino-Official website：https://www.arduino.cc/

[5] A. Mathur, M.R. Bhatnagar, and B.K. Panigrahi, "Maximum likelihood decoding of QPSK signal in power line communications over Nakagami-m additive noise," *2015 IEEE International Symposium on Power Line Communications and Its Applications (ISPLC)*, pp.7-12, 2015.

[6] T. Richter, M. Kroh, J. Wang, A. Theurer, C. Zawadzki, Z. Zhang, N. Keil, A. Steffan, and C. Schubert, "Integrated Polarization-Diversity Coherent Receiver on Polymer PLC for QPSK and QAM signals", *2016 International Symposium on Power Line Communications and its Applications (ISPLC)*, pp.64-69, 2016.

 ISBN 978-1-5090-3869-5