Ethernet based Addressable Fire Alarm System

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ABSTRACT
This paper describes a simple and low cost design of Ethernet based addressable fire alarm system. Each fire zone system consists of a microcontroller, Ethernet controller and fire detection and alarm circuit. Fire detection circuit reads the status of the fire and sends signal to the microcontroller. Ethernet controller, ENC28J60 enables the communication between microcontroller and Ethernet IEEE 802.3 protocol. The various fire zone systems are connected in different areas of the premises. The status of each fire zone is monitored by main system. Each fire zone system has its unique static IP address and MAC address. The main system is designed in such way that, it collects the status of each fire zone system and displays on a single webpage. It can be accessed from anywhere, once its connected to the internet. In industry, during the installation of building Ethernet connectivity is an important part. Hence there is no need of any special wiring to set up the fire alarm system.

Keywords— IEEE 802.3 protocol, microcontroller, Ethernet controller, addressable system

I. INTRODUCTION
Nowadays industries have grown enormously with innovation in the technology. Misfortune and fire accident can walk out at any time. Security and safety is a significant issue of any industry. The fire alarm system is installed to deliver an early warning of fire as soon as possible. So that people can be evacuated and immediate action can be taken to stop firing and prevent the fire accidents.

Generally the fire alarm system is installed for protection of life, property and mission. In order fire alarm system to be useful, it must be able to perform these functions:

- Operate other safety functions
- Heat and smoke detectors are the most commonly used fire detection devices [1].
- In an addressable fire alarm system each detector is provided with an address. The identification of fire alarm status is done by zone and by address. Thus addressable detectors allow a main control panel, to know the exact location of the fire occurs. In such system graphical representation of the premises is provided for better visual understanding.
- Ethernet is useful and most popular network in workplaces and industrial premises. It provides an excellent solution for industrial applications. It gives a cost-effective and reliable solution to monitor and control the devices and equipment remotely.
- This paper describes the development of an addressable fire alarm system using Ethernet network. In a nutshell, we focus on fire zone system is monitored and controlled from main system.

The remaining part of this paper is organized as follows: Section II discusses overall design of addressable fire alarm system. Section III gives detailed hardware prototype. Software requirements are mentioned in section IV. In Section V, result and future scope are given. Section VII concludes this paper.

II. OVERALL SYSTEM DESIGN
The overall design of addressable fire alarm system is shown in figure 1. There are three main building blocks: fire zone system, Ethernet LAN and Web server.
A. **Fire zone system**

Fire zone system is made up of fire detectors, fire alarm or sounders, actuators, ATmega 328 microcontroller and ENC28J60 Ethernet controller. Fire detectors read the status of fire and send it to the microcontroller. Microcontroller takes the relevant action from the status signal. In case of fire or manual call points pushed, fire alarm and sounders goes ON. It is an indication to people to evacuate the premises as early as possible and to respective authority to take immediate admirable decision. ENC28J60 Ethernet controller establishes communication between microcontroller and Ethernet network.

B. **Ethernet LAN**

Due to the flexibility and capability of Ethernet network, it is most widely used and popular network in workplaces and industries. It is one in a group of IEEE standards that describes technologies for use in local area and metropolitan area networks.

Ethernet is a data link and physical layer protocol defined by the IEEE 802.3 specification. Ethernet is fast. It supports speed from 10 Megabits per second to 10 Gigabits per second. Ten Megabits per second is adequate for many embedded systems. The hardware to support slower speed is generally less expensive, but the higher speeds are there if needed [2].

In Ethernet network all data travels structures called frames. An Ethernet frame has defined fields for data and other information to help the data get to its destination and to help the destination system to determine where the data has arrived intact.

C. **Web Server (IIS 7)**

The Web server required for this system is designed by using IIS 7 (Internet Information Services 7). IIS is default Web server in Windows operating system.

It provides a secure, reliable, and easily managed application server on which you can host sites over an intranet, the Internet, or an extranet. IIS helps you create a platform of dynamic network applications, allowing you to use the latest Web standards to develop, implement, and manage your Web applications [3]. IIS 7 has a completely modular setup design that enables control over the footprint of a Web server. The GUI, command line, and unattended setup options available in IIS make it easy to manage the security and servicing footprint of an IIS Web server [4].

The developed system needs HTTP protocol for communication. IIS 7 fulfills this requirement precisely.

III. **HARDWARE prototype**

The hardware prototype of the system is shown in figure 3. It mainly includes four to five major parts: Ethernet controller ENC28J60, fire and fault detection network, Microcontroller ATmega 328P, fire alarms/sounders and actuators. Fire and fault detection network is input to the microcontroller. Fire alarm and sounder acts as output for microcontroller. ATmega 328P acts as heart of all system. It is main central processing unit of this system. Ethernet controller ENC28J60 is used to ensure the communication between microcontroller and Ethernet topology. Isolation transformer provides electrical isolation in between Ethernet controller and LAN. RJ45 cable is used as communication medium.

A. **Fire alarms/sounders**

The fire alarm or sounder goes ON, when there is a fire or smoke exists in the building. The building has to be evacuated and the fire alarm panel will indicate the source and the area of the fire. Fire alarm gives the early warning of fire to evacuate the people and to alert
authority related to the fire department. Hooter or sounder is used for audible indication and for the visual indication purpose LED or bulb is used.

B. Fire and fault detection network

Fire and fault detection network is an electronic resistive circuit. It is used as standard industrial practice for fire alarm system. It consists of comparators and resistor network. The circuit is designed in such way that, depending upon the status of zonal devices, the voltage will change; accordingly the output of the comparator will change. The output of the comparator is given to microcontroller ATmega 328P. Generally fire, cable open, cable short and normal status are used in any fire alarm system.

C. Microcontroller ATmega 328P

It has high performance; low power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega 328P achieves throughputs approaching 1 MIPS per MHz allowing the system-designer to optimize power consumption versus processing speed.

The 28-pin DIP ATmega328P has 32K bytes of In-System Programmable Flash with Read-While-Write capabilities. It has 23 programmable I/O lines [5].

D. Ethernet Controller ENC28J60

The ENC28J60 is a stand-alone Ethernet controller with an industry standard Serial Peripheral Interface (SPI). It is designed to serve as an Ethernet network interface for any controller equipped with SPI.

The ENC28J60 meets all of the IEEE 802.3 specifications. It incorporates a number of packet filtering schemes to limit incoming packets. It also provides an internal DMA module for fast data throughput and hardware assisted checksum calculation, which is used in various network protocols [6]. Ethernet controller converts the data available on SPI pins of microcontroller to Ethernet readable format.

IV. SOFTWARE REQUIREMENT

To develop this system two software is required. HTML (Hyper Text Markup Language) is used to design the GUI (Graphical User Interface) of system. Arduino 1.6.1 is used to program microcontroller unit of the system.

A. Arduino 1.6.1

The IDE (Integrated Development Environment) used to write and execute the microcontroller program. Arduino 1.6.1 is used to develop the programming for microcontroller ATmega 328P. It is open source software [7]. It has strong features like inbuilt facility to dump the program in IC.

B. Hyper Text Markup Language

HTML is a fundamental language used in designing of any webpage or website. It used to design the front end of this system. The main focus is on the frame tags of HTML. The frames tag of HTML is used to divide the webpage in different section. As system is addressable so i-frame tag of html is used to load the webpages from the fire zone system, which acts as embedded web server.
TABLE I PERFORMANCE OF THE SYSTEM (TIME BASED)

<table>
<thead>
<tr>
<th>Zone Circuit NO.</th>
<th>Status of the zone displayed on Web page</th>
<th>Actual response time of message in second (including refresh time =1 second)</th>
<th>Average Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>T1</td>
<td>T2</td>
</tr>
<tr>
<td>1</td>
<td>CABLE OPEN</td>
<td>1.58</td>
<td>1.59</td>
</tr>
<tr>
<td></td>
<td>CABLE SHORT</td>
<td>1.60</td>
<td>2.10</td>
</tr>
<tr>
<td></td>
<td>FIRE</td>
<td>2.70</td>
<td>2.57</td>
</tr>
<tr>
<td></td>
<td>NORMAL</td>
<td>1.42</td>
<td>1.89</td>
</tr>
<tr>
<td>2</td>
<td>CABLE OPEN</td>
<td>2.23</td>
<td>1.45</td>
</tr>
<tr>
<td></td>
<td>CABLE SHORT</td>
<td>2.56</td>
<td>2.12</td>
</tr>
<tr>
<td></td>
<td>FIRE</td>
<td>1.79</td>
<td>1.89</td>
</tr>
<tr>
<td></td>
<td>NORMAL</td>
<td>1.60</td>
<td>1.65</td>
</tr>
<tr>
<td>3</td>
<td>CABLE OPEN</td>
<td>3.00</td>
<td>3.52</td>
</tr>
<tr>
<td></td>
<td>CABLE SHORT</td>
<td>1.52</td>
<td>1.96</td>
</tr>
<tr>
<td></td>
<td>FIRE</td>
<td>2.10</td>
<td>3.96</td>
</tr>
<tr>
<td></td>
<td>NORMAL</td>
<td>2.45</td>
<td>2.12</td>
</tr>
<tr>
<td>4</td>
<td>CABLE OPEN</td>
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<td>1.78</td>
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<tr>
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<td>2.45</td>
<td>2.41</td>
</tr>
<tr>
<td></td>
<td>FIRE</td>
<td>2.63</td>
<td>2.96</td>
</tr>
<tr>
<td></td>
<td>NORMAL</td>
<td>2.56</td>
<td>1.45</td>
</tr>
</tbody>
</table>

V. RESULT AND CONCLUSION

The result of Ethernet based Addressable Fire Alarm System is shown on GUI which is developed by using HTML frame tags. In this system mainly four fire zone circuits are used. The result of each one is in between Cable Open, Cable Short, Fire detect or Normal. The performance analysis of the present system is given in Table I. As the system is real time, the time response is calculated. The control panel of Ethernet based Addressable Fire Alarm System is developed to display the status of each fire zone simultaneously. Operation of this system is absolutely user friendly and power consumption is very low and maintenance of the system is well within the range of common user. This system is well suited for offices, educational institutes, big moles, banks, industries etc. As the Ethernet network is available everywhere in the building, so there is no need to set up extra wiring to install the system.

REFERENCES

[4] www.iis.in