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Microcontroller Based Remote Monitoring And Control Of Deluge Valves In Hydrant Fire Fighting System

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Abstract

In industries such as power plants or chemical plants fire management is essential due to very high operating temperatures and various factors like flammable chemical processing, different chemical reactions etc. For most fires, water represents the ideal extinguishing agent. Thus an automatic water sprinkler system for protection against industrial fires is necessary.

A type of automatic sprinkler system known as Deluge sprinkler system offers effective protection from severe hazards due to industrial fire. These deluge sprinklers system will control fire advancement within a few minutes of their activation and hence is best possible solution when it comes to industrial fires.

In this paper, designing of such a PIC microcontroller based remote controlled deluge automatic fire sprinkler system is explained in detail. The ability to identify and suppress fire may mean the difference between life and death and hence these deluge automatic sprinkler systems are needed.

1. Introduction

Fire extinguishing or fire suppression systems are essential in industries that are considered high hazard industries such as power plants, chemical plants, chemical storage or processing facilities etc. In these industries fire management becomes necessary because of high temperatures of operation, use of flammable chemicals in various process, different chemical reactions being carried out etc. Also because of the speed and totality of its destructive forces, fire constitutes one of the more serious threats. An uncontrolled fire can obliterate an entire room's contents within a few minutes and completely burnout industry in a couple hours.

Water is said to be the ideal extinguishing agent for most fires. Fire sprinklers utilize water by direct application onto flames and heat, which causes cooling of the combustion process and prevents ignition of adjacent combustibles. They are most effective during the fire's initial flame growth stage, while the fire is relatively easy to control. A properly selected sprinkler will detect the fire's heat, initiate alarm, and begin suppression within moments after flames appear. In most instances sprinklers will control fire advancement within a few minutes of their activation, which will in turn result in significantly less damage than otherwise would happen without sprinklers.

A type of automatic sprinkler system is Deluge sprinkler systems which offer effective protection from severe hazards, such as flammable liquids, where there is a possibility that the fire could flash ahead of the operation of closed automatic sprinklers The ability to identify and suppress fire may mean the difference between life and death and hence these deluge automatic sprinkler systems are needed. Deluge system offers the best possible solution when it comes to industrial fires.

Proposed work uses master-slave configuration and serial communication between them is performed using RS 485 standard. In this project there is one master module and 3 slave modules. The slave modules can be extended as per requirement. The master module and slave modules are unique boards with separate power supplies. The master module consists of RS 485 transceiver, PIC controller, 4x4 matrix keyboard and led indications. The slave module consists of RS 485 transceiver, PIC controller, two digital inputs, one relay, one buzzer indication and three LED indications.

2. Need of fire hydrant system

In industries such as petrochemical plants, power plants, chemical plants, chemical storage or processing facilities etc. fire extinguishing or fire suppression systems are essential. In these industries fire management becomes necessary because of high temperatures of operation, use of flammable chemicals in various process, different chemical reactions being carried out etc. Also fire must be controlled in order to avoid excess damage and ensure safety of the staff. Moreover in such systems human intervention is not preferable. Also remote controlling is necessary because Industrial application requires transmission of data between multiple systems over long distances over hostile environmental conditions. In such hostile environment remote access to the field side becomes essential. Thus it is necessary that: fire suppression related operations must be automatic and remote controlling from control room should be possible.

3. Introduction to Hydrant System

A hydrant is an outlet from a fluid main often consisting of an upright pipe with a valve attached from which fluid (e.g. water or fuel) can be tapped. Depending on the fluid involved, the term may refer to: Flushing hydrant, Oil depot or Fire hydrant.

A **Flushing hydrant** is a hydrant that is used for flushing a water line of silt, rust, debris, or stagnant water. Flushing hydrants typically only have one outlet in contrast to fire hydrants which normally have two or three. Flushing hydrants are commonly installed at the end of dead end water lines.

An **oil depot** is an industrial facility for the storage of oil and/or petrochemical products and from which these products are usually transported to end users or further storage facilities. Oil depots are usually situated close to oil refineries or in locations where marine tankers containing products can discharge their cargo.

A **fire hydrant system** is an active fire protection measure, and a source of water provided in most urban, suburban and rural areas with municipal water service to enable firefighters to tap into the municipal water supply to assist in extinguishing a fire. Hydrant fire protection system is designed to fight fire of huge proportions, in all classes of risks. It is designed to be in operation even if a part of the affected structure collapses. The hydrant system typically comprises of fire water source, pumps (diesel, electrical), control panel, system piping, control valves and hydrant valves with accessories.

Figure 1.Manual Fire Hydrant

Various fire extinguishing methods using water as extinguisher are dilution, emulsification, water mist and automatic sprinkling. From these methods, a system for industrial fire suppression using the automatic sprinkling method is discussed in this paper.

3.1 Automatic Sprinkler systems

An automatic fire-extinguishing system utilizing water, designed in accordance with fire protection engineering standards. The system includes a suitable water supply and a network of specially sized or hydraulically designed piping installed in a structure or area, generally overhead, to which automatic sprinklers are connected in a systematic pattern. The system is usually activated by heat from a fire and discharges water over the fire area. Automatic sprinklers often represent one of the most important fire protection options for most industries. A properly selected, designed and installed system will offer unexcelled reliability.

3.1.1 Operation of automatic sprinkler systems

Immediately after fire breaks out in a protected area, the intense heat rises rapidly under ceiling zone. As soon as the ambient temperature has reached the set release temperature, the glass bulb bursts and the sprinkler is activated. The sprinkler pressure tank contains fresh water, which being discharged into protected area, at a constant pressure level. When sprinkler nozzles are actuated, the sprinkler system is activated resulting in a pressure drop in

the sprinkler storage tank. Water supply is provided with adequate pressure by dedicated pump set which is arranged to start automatically when the pressure falls down below set point of the pump's start-up relay.

3.2 Types of Sprinkler systems

There are four types of fire sprinkler systems: wet pipe, dry pipe, deluge, and pre-action.

3.2.1 Wet Pipe Systems

Wet pipe systems use closed automatic sprinklers attached to a piping system containing water under pressure at all times. The wet pipe system is the most common type of sprinkler system in use unless there is danger of the water in the pipes freezing or when other special conditions require one of the other types of systems.

3.2.2 Dry Pipe Systems

Dry pipe systems employ closed automatic sprinklers attached to a piping system which contains air or nitrogen under pressure. When a fire occurs and an automatic sprinkler activates, the air or nitrogen escapes. This reduces the pressure in the system to a point at which the pressure on the water supply side causes the valve to operate, allowing water to flow through the system piping.

3.2.3 Preaction Systems

Preaction systems employ closed automatic sprinklers attached to a piping system which contains air, which may or may not be under pressure. When a fire occurs, a fire detecting device, such as a smoke or heat detector, activates and causes the water control valve to open and water to flow into the pipe system. Thereafter, when an automatic sprinkler activates, water is available to flow through the sprinkler immediately. It is similar to dry systems except that these systems require that a "preceding" fire detection event, typically the activation of a heat or smoke detector, takes place prior to the "action" of water introduction into the system's piping by opening the pre-action valve. Pre-action sprinkler systems are specialized for use in locations where accidental activation is undesired, such as in museums with rare art works, manuscripts, or books, Electrical equipment rooms and computer rooms.

3.2.4 Deluge Systems

A sprinkler system employing open sprinklers attached to a piping system connected to a water supply through a valve that is opened by the operation of a detection system is known as deluge system. When this valve opens, water flows into the piping system and discharges from all sprinklers attached thereto. "Deluge" systems are systems in which all sprinklers connected to the water piping system are open, in that the heat sensing operating element is removed, or specifically designed as such. These systems are used for special hazards where rapid fire spread is a concern, as they provide a simultaneous application of water over the entire hazard.

Figure 2.Operation of Deluge system

Water is not present in the piping until the system operates. Because the sprinkler orifices are open, the piping is at atmospheric pressure. To prevent the water supply pressure from forcing water into the piping, a *deluge valve* is used in the water supply connection, which is a mechanically latched valve. It is a non-resetting valve, and stays open once tripped. Deluge sprinkler systems work similarly to the wet pipe sprinkler system, except the system incorporates open sprinkler heads or nozzles that do not operate individually. Because the heat sensing elements present in the automatic sprinklers have been removed (resulting in open sprinklers), the deluge valve must be opened as signaled by a fire alarm system. When a fire occurs, a fire detecting device, usually a heat detector activates and causes the deluge valve to open. Water then will flow into the piping and discharge through all the open sprinklers. Deluge sprinkler systems offer effective protection from severe hazards, such as flammable liquids,

where there is a possibility that the fire could flash ahead of the operation of closed automatic sprinklers.

3.2.5 Potential benefits of automatic sprinklers are the following:

- Immediate identification and control of a developing fire.
- Reduced heat and smoke damage. Significantly less heat and smoke will be generated when the fire is extinguished at an early stage.
- Enhanced life safety. Staff, visitors and fire fighters will be subject to less danger when fire growth is checked.

4. Basic idea of the system

In this paper, designing of a deluge automatic sprinkler system which is a type of fire hydrant system is explained. To establish an automated fire hydrant system for industries, PIC microcontrollers are connected in master-slave mode. Master module is at the control room side whereas the slave modules are located at the field side. The master controller will send the data towards RS 485 using twisted pair wire and the slave controller to which the data is addressed will receive it and the relevant operation will be performed. Module at control room (Master module) consists of RS transceiver, controller, 4x4 matrix keyboard and led indications. This module sends command to the slave modules to select proper device and operate the relay. The status of relay shall be indicated by LED.

The module at field side (Slave module) is consisting of a relay card; this relay shall be operated when a command is given by a master module at control room thru RS485 bus. The change in relay state shall be indicated by LED. There is a keypad attached to the controller at the control room. There are several addressable slave cards at the field side, say around 5 for demo purpose. If key 1 is pressed on the keypad then the first card is selected and the relevant operation is performed, if key 2 is pressed second card is selected and so on.

RS-485 is a multipoint communication which allows multiple devices to be connected to a single bus. It is Master/Slave architecture. Master and Slave devices interchange packets of information. Each of these packets contains synchronization bytes, CRC byte, address byte and the data. Each Slave has unique address and receives only packets addressed to it. The Slave can never initiate communication. It is the user‘s responsibility to ensure that only one device transmits via 485 bus at a time. The RS-485 routines require the UART module. Pins of UART need to be attached to RS-485 interface transceiver, such as LTC485.

This system replaces multiple pairs of cables with just a single pair and can be used for bidirectional serial data communication over long distance and control all the inputs and outputs through the control room.

4.1 RS485 overview related to the system

In a 485 network the “master” will start the “conversation” with a “Query” addressed to a specific “slave”, the “master” will then listen for the “slave‘s” response. If the “slave” does not respond within a pre-defined period, (set by control software in the “master”), the “master” will abandon the “conversation”. Twisted pair cable is used. Communication is initiated (started) by a “Master” with a “query” to a “Slave”. The “Slave” which is constantly monitoring the network for “Queries” will recognize only the “Queries” addressed to it and will respond either by performing an action (setting a value for example) or by returning a “response”. Only the Master can initiate a query.

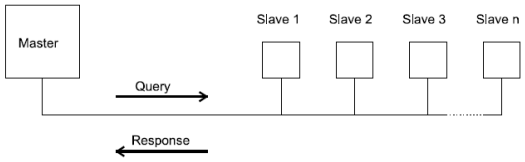

Figure 3. RS 485 overview of the system

4.2 Proposed system

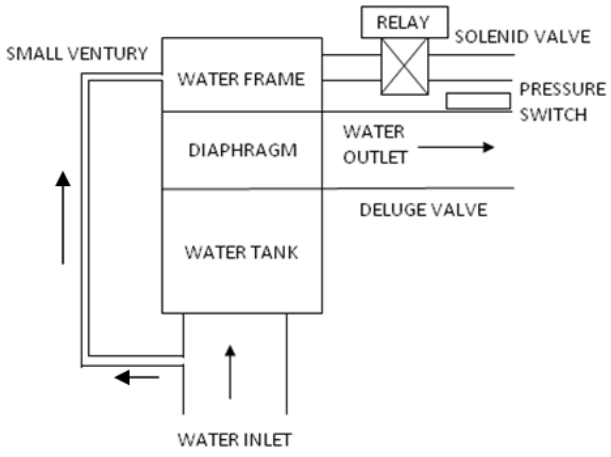

Figure 4. System block diagram

The water in the water frame and water tank is at the same pressure. The water frame and water tank are connected together by a diaphragm for pressure sensing. Hydrostatic pressure is resisted by diaphragm action. The relay is open and hence the solenoid valve remains closed. A small ventury runs from the water tank to the water frame. A pressure switch is mounted on the deluge valve which is the water outlet. The width of the ventury is very less as compared to that of solenoid valve. As long as the pressure remains the same, the deluge valve remains closed and hence no water flows out. If fire breaks, then the relay is turned ON which opens up the solenoid valve. As soon as the solenoid valve opens up the pressure in the water frame starts reducing. Now there is an pressure imbalance in the water frame and water tank so the diaphragm no longer resists the hydrostatic pressure and the deluge valve is opened up. A highly pressurized water flows out and can be provided in the fire affected area for fire suppression.

As soon as the deluge valve opens up, the pressure switch mounted on it is activated and this is indicated on the master module. Also the relay is opened and the solenoid valve is closed. By the time the pressure builds up into the water frame as an inlet is provided to it through a small ventury. As soon as the pressure in the water frame and water tank is equal diaphragm resists the hydrostatic pressure and pressure switch is reset. Then the system is restarted.

4.3Algorithm of the system

1. Read the input from the master module
2. Checking of address by all the slave modules
3. If address matches, switch on the solenoid relay, turn on the status LED on slave and indicate with a buzzer
4. Continuously monitor the status of the pressure switch
5. As soon as the pressure switch is activated send status to the master and indicate it through LED on the master module
6. Switch off the solenoid relay
7. Wait for the pressure switch to reset
8. If reset, Restart the system.

- **Specifications of the system**

Following are the specifications of the system:

1. Supply voltage: 230Vac/50Hz
2. Input voltage: 5Vdc
3. Communication: RS485 serial communication in master/slave configuration
4. Microcontroller: PIC16F628A
5. Operating frequency: 11.0592 MHz
6. RS485 transceiver: LTC 485

5. Block diagram of slave module

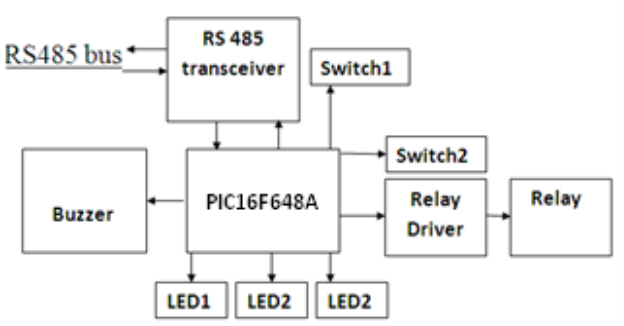

Figure 5. Block diagram of module at Field side

The module at field side is consisting of a relay card. This relay shall be operated when a command is given by a master module at control room thru RS485 bus. The change in relay state shall be indicated by LED. RS-485 is a multipoint communication which allows multiple devices to be connected to a single bus. It is Master/Slave architecture. Master and Slave devices interchange packets of information. Each of these packets contains synchronization bytes, CRC byte, address byte and the data. Each Slave has unique address and receives only packets addressed to it. The Slave can never initiate communication. It is the user‘s responsibility to ensure that only one device transmits via 485 bus at a time. The RS-485 routines require the UART module. Pins of UART need to be attached to RS-485 interface transceiver, such as LTC485.

6. Block diagram of master module

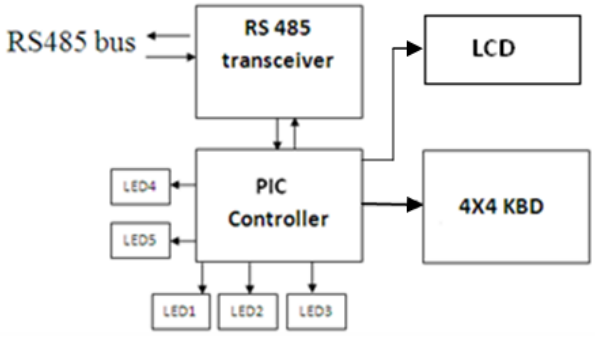

Figure 6. Block diagram of module at Control room side

Module at control room consists of RS transceiver, controller, 4x4 matrix keyboard and led indications. The 4x4 keyboard is used to select the desired slave module. This module sends command to the slave modules to select proper device and operate the relay. There are several addressable slave cards at the field side, say around 5 for demo purpose. If key 1 is pressed on the keypad then the first card is selected and the relevant operation is performed, if key 2 is pressed second card is selected and so on. The status of the pressure switch on slave circuit shall be indicated by the respective LED on the master module i.e. if slave circuit 1 is selected then LED 1 will turn ON when pressure switch is activated. If slave circuit 2 is selected then LED 2 will turn ON and so on. RS 485 transceiver is used to connect to RS 485 bus which communicates the data serially from master module to the slave module.

The ability to identify and suppress fire may mean the difference between life and death. Hence, the designing of a **microcontroller based deluge fire hydrant system** for protection against industrial fires is explained in detail in the above paper.

7. Advantages of the system

Microcontroller based remote controlling of fire hydrant systems offers several benefits. These benefits include:

- **Immediate identification and control of a developing fire:**
  This system responds at all times, including periods of low occupancy. Control is generally instantaneous.
- **Immediate alert:** In conjunction with the building fire alarm system, automatic sprinkler systems will notify occupants and emergency response personnel of the developing fire.
- **Reduced heat and smoke damage:** Significantly less heat and smoke will be generated when the fire is extinguished at an early stage.
- **Enhanced life safety:** Staff, visitors and fire fighters will be subject to less danger when fire growth is checked.
- **Design flexibility:** Greater utilization of exhibition and assembly spaces is usually a benefit.
- **Enhanced Security:** A sprinkler controlled fire decreases demand on security forces, minimizing intrusion opportunities.

References

[1] Fire sprinkler system monitoring applications guide
[2] Seaplus fire fighting systems and equipment technical manual
[3] Ma Shuling ,Sun Shaoguo ,Yang Tingwu , “Study on Remote Monitoring System of Fire Fighting”,IEEE(CASE),2011
[4] Wellman.C.M, Bowman. J.W, Christopher. R.H, “Sprinkler systems in electrical control rooms: for anxiety or responsible safety design?”,IEEE, 1994
[5] Edgar.J.A, “The effectiveness of fire detection and fire sprinkler systems in the central office environment”,INTELEC,1989
[6] Tyco fire and building products “Fire protection general products catalog”
[7] National fire sprinklers association technical manual