Automatic Water Sprinkler System with Fire Alarm Based on Design and Application of Microcontroller (MCU)

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NOMENCLATURE

MCU	Microcontroller units
FW	Fresh Water
LED	Light Emitting Diode
PDLP	Plastic Dual in Line Package
AC	Alternating Current
RISC	Reduced Instruction Set Computing
PIC	Peripheral Interface Controller

1.0 INTRODUCTION

Safety is the most important elements on board ships. This is because with the implementation of safety, can prevent from the injuries of the ship personal, loss of the wealth and death of innocent person. A fire sprinkler system is an active fire protection method, consisting of a water supply system, providing adequate pressure and flow rate to a water distribution piping system, onto which fire sprinklers are connected [4]. Although historically only used in factories and large commercial buildings, systems for homes and small buildings are now available at a cost-effective price. Fire sprinkler systems are extensively used worldwide, with over 40 million sprinkler heads fitted each year. In buildings completely protected by fire sprinkler systems, over 96% of fires were controlled by fire sprinklers alone [4]. Fires are classified into four classes; Class A which involves solid material, such as wood, clothes, papers,rubbers and plastics [5]. Class B involves inflammable liquids, oil, tars and flammable gases [5]. Class C involves gases [5]. Class D involves metals. Class K fires involve combustible cooking media such as oils and grease commonly found in commercial kitchens (Ted Boothroyd et al. 2005) [5].The safety type can divide into many categories that is safety during operation, safety during using the tools and safety during handle the emergency cases. The most concerned issue related to safety on board ship is safety during handle the emergency case like fire in engine room. The main source of the fire is machineries which contain fuel oil and lubrication oil such as Main Engine, Boiler, Purifier and Incinerator. This type of fire is big and need to handle carefully by implement the safe action.

ABSTRACT

Nowadays, the most accident happen on board ship is fire. Fire is caused by the combustible material like fuel oil & lube oil which exist in the machineries such as Main Engine, Boiler, Purifier and Incinerator. The fire which occur on board ship from these machineries is big. Therefore, every ship need a firefighting system that helps to prevent and fight fire. An automatic fire-fighting system includes a sensor capable of detecting combustion, alarm signaling devices, fire-extinguishing equipment, starting and stopping devices, and feeders for the fire-extinguishing substance [1]. Atomizers, foam generators, and pipe nozzles form and direct the stream of the fire-extinguishing substance, which may be a liquid, foam, powder, or gas [1]. Fire-extinguishing substances are fed into the system from a centralized supply, such as a water supply, or from self-contained or combined feeders [1]. The aim of these paper is to introduce the simple and effective system which designed based on the application of the microcontroller unit (MCU) based system [2]. These design will go through the simulation process by using the Proteus Software. Proteus contains everything you need to develop, test and virtually prototype your embedded system designs based around the Microchip Technologies TM PIC16 series of microcontrollers [3]. The unique nature of schematic based controller simulation with Proteus facilitates rapid, flexible, and parallel development of both the system hardware and the system firmware [3]. After simulation process, the system applied and test in the hardware model [2]. These system using PIC 8-bit microcontroller to control the process. PIC 8-bit microcontroller were programmed by using the program which is compiled in PIC C Compilers [2]. This paper represent the system which can enhance the automatic water sprinkler fire extinguish system that will alert the personnel in charged on board ship through signals [2]. The model is said to be fulfil the system demand by test it using simulator software [2]. Usage of the system can help the ship's crew to extinguish the fire immediately when the accident happen. The action from the system can reduce the loss of live and wealth on board ship.

Therefore, the ships need to be provided with automatic fixed fire extinguish system which can help the shipboard personal to handle this type of fire safely either they are in form of water, foam or dry powder. This paper introduce the automatic water sprinkler system.

1.1 SIMILAR SYSTEM
This section represent the system which have done by some researchers which are almost same with this project [2]. All the systems are using the same method of giving the alarm signal to alert the person and release the water from water sprinkler in the case of fire [2]. The personals able to monitor and operate the system remotely that can protect the persons from suffer the serious injuries when handle the fire [2]. There is another system that use the Microcontroller to provide the fire alarm to facilitate warning signal to the users and send the massage by using Android system to inform the users about the fire happen in their house [2].

Next comparative paper represent the improvement of the firefighting system which can automatically control by using microcontroller [2]. This type of firefighting system is portable [6]. They are consist of battery powered, independent suppression units, each including fire extinguishing fluid supply and fire detector [6]. When fire, the system response to the fire detector and the extinguish fluid automatically release from the system due to the individual unit's control circuit connection that build up a control circuit network [6].

Next project have the similar system as above system [2]. The system comprise of smoke and heat detector, fire alarm, air fan, pump, sprinkler nozzle, water sprinkler piping and valves system [5]. The differences of this system compare to the system above are they are consist of piping system that supply the sufficient pressure and flow rate of water to water sprinkler and air fan which take the smoke suction to the outside of the fire area [5]. The system begin to start when the smoke and heat detector detect smoke and increasing of temperature in the involved area and transmit the signal to the microcontroller to turn on the lamp, provide the alarm to alert the person in that area, switch on the air fan to suck the dangerous smoke from the fire area to outside of the building and lastly, start the pump to supply the sufficient pressure and flow rate of water to the water sprinkler nozzle through the pipe to extinguish the fire. There are time delay before the pump start [5]. This system able to automatic stop when the smoke detector goes off and degree of temperature decreasing [5].

1.2 CURRENT SYSTEM
Nowadays, most of the operations on-board ships are control by the automation mechanisms [2]. The functions of these automation mechanisms to control the operation of the auxiliary engines and machineries, to steer the ship to follow the correct and safe route, send the information regarding the matter which relate to the safety of the ship, spare parts purchasing and to operate the emergency equipment in emergency cases [2]. However, almost ship is facilitated with the water sprinkler system with operate manually by control button [2]. The shipboard personals need to press the control button and then, the water will release from water sprinkler in certain machineries spaces [2].

1.3 PROPOSED SYSTEM
Modern, easy to be install, simple in construction, provide the safe medium for the ship's crew, easy for maintenance, low cost of maintenance, fast reaction time, easy to operate [2].

2.0 METHODOLOGY

A Microcontroller will constantly observe the flame and heat sensors that attached to the buzzer and main FW sprinkler pump. The Sensors will be acting as the switches to complete the circuits, and eventually the MCU will then decide on the next course of action. Warnings will then be triggered by the MCU through its ports and ultimately will activate the Main FW sprinkler Pump that it is attached to with delay by time of period. This warning could be some combinations of LEDs and buzzers. Such LEDs which serves as indication light installed on the panel boards. This system could be realized by using lesser amount of mechanisms, the controllers also offers great performances with dense sized and low price MCU. When the buzzer sound in certain time of period without any rectification the motor automatically be activated to pump the liquid through sprinkler. The motor will be controlled by the MCU through a relay [2].

2.1 COMPONENT
The components of the system consist of PIC16F84A, this Microcontroller come with only 18-pins. The Plastic Dual In line Package (PDLP) that would perform as the brain of the system, Light emitting diodes (LEDs) to turn as visual response, Buzzer which function as the hearing response aids, and Sensors that is installed at the protected area, Motor that will be activated at certain time of period after buzzer was sounded, Relay which will be used to control the Motor and the Buzzer. Figure 1 illustrates the schematic diagram of the system design [2].

Figure 1: Simplified Schematic diagram

2.2 OPERATIONS
The operation concept is described below:
- o When Flame/Heat/Manual Call Point sensor is activated, indication LED will be on, Alarm will be triggered.
- o After the alarm buzzing in mean while10 seconds) the AC motor will be activated supply liquid to the sprinkler for extinguished the fire.
- o When the fire is extinguished, the sensor will be in open circuit and the Alarm and Motor will be cut OFF
- o The standby AC motor is manually activated when insufficient water pressure. This is to prevent delay in time for extinguish the fire.

Table 1, shows the logic of the operations [2].

Table 1: Truth Table

Input Ports		Output Ports		
Sensor Detector A0	Start Button A3	Alarm B5	Motor1 B6	Motor2 B7
1	0	ON	ON	OFF
1	1	ON	ON	ON
0	1	OFF	OFF	ON

2.3 MICROCONTROLLERS

MCU has the ability to function without other modules to be attached. PIC as a part of Reduced Instruction Set computing (RISC) manufactured by Microchip Technology from PIC1650 that developed by Instrument Microelectronic Division. PIC function as integrated circuit and frequently used to develop in controlling exterior device and lighting the load from the main CPU in the system. CPU likely like a brain meanwhile PIC represent like our autonomic nervous system. PIC16F84A in8-bit microcontroller is recommended as it is largely sufficient to act to the central control of the system [2].
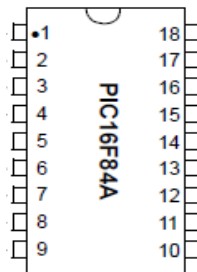
Figure 2: PIC16F84A Microcontroller Pin assignment (PDLP)

2.4 SOFTWARE

The "C compiler for the PIC MCU," are used for composing, editing, compiling and programming the codes for the microcontroller. This compiler empower /force the microcontroller to be customized in high level programming language altogether with PicKit2 programmer. The algorithm of the codes will decide the state of the part by choosing the microcontroller input/output port taking into account the particular task .The idea /concept of the capability of the entire system is to allow a timed with micro-second interim, to acknowledge the sensor input and to activate the output with role in play the alarm and the motor [2].

2.5 PROGRAMMING DESCRIPTION

This program is used to control the entire system that been keep in PIC16F84A microcontroller's C language. All the codes have been compiled and tested using CCS compilers [2].

2.6 SYSTEM FLOW

This system works in sensing the smoke and flame at the protected area, and send the signal to the Microcontroller Unit. The MCU then will intelligently decide on the next course of action to activate the motor after Alarm triggered in 10 seconds [2].
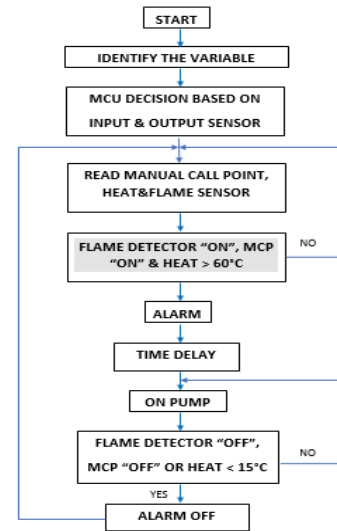
Figure 3: Flowchart of the System

2.7 CIRCUIT

The circuit have four main elements: the power source section, microcontroller segment, which comprises the system input parts, and the output parts. All these modules are integrated to the MCU unit [2].
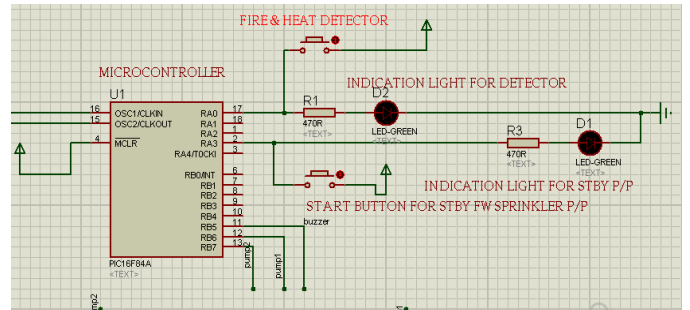
Figure 4: Input & Outputs

As in figure 4, Fire & Heat detector sensors and Manual Start button are connected using the Port A, and all the output of the system are connected using the Port B including buzzer [2].
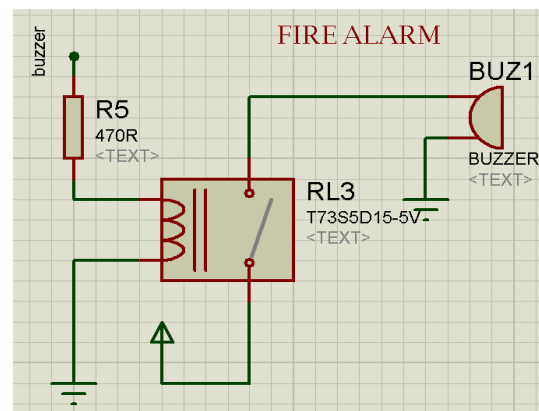

Figure 5: Alarm Circuit

Once the Flame/Heat detector sensor and Manual Call Point is activated, the alarm will automatically trigger by the MCU, to indicate an immediate attention is needed by the crew of the vessel. The MCU will be connected to the Alarm through a relay as in figure 5 [2].
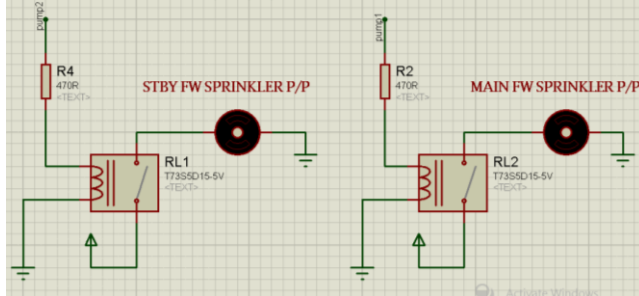

Figure 6: Sprinkler Pump Circuit

The Main Sprinkler Pump or Motor, will start automatically after 10 second Alarm triggered, and eventually stopped automatically when the fire were extinguished sensors in open circuit (Figure 6). The standby FW Sprinkler Pump or Motor is activated by manually if insufficient water pressure gets at local [2].

3.0 CIRCUIT DESIGN SIMULATION

The circuit was then replicated in the software Proteus v7.6. In this software, the entire components of the circuit which is essential were carefully chosen from the software library and the connections were done by lines. The program was later compiled using CCS C compiler. The output, hex file of the program is loaded into PIC microcontroller using the PicKit2. Finally, the simulation is tested for all the conditions. The circuit used for simulation is given in Figure. 4. The connection to the microcontroller separated into 3 parts of circuits. The inputs from the sensors were connected to RA0 and RA3 pins (using Port A) of the microcontroller while the outputs of the system were connected RB5 for the Buzzer / Alarm, and finally RB6 and RB7 is used to connect to the AC Motor relay (figure 6). All the output pin is connected through (Port B) of the controller [2].

4.0 RECOMMENDATION AND PROSPECTS

Fire incident is one of the main factor of the total damaged to the cargo on board and loss of life of the marine crew. According to Allianz news and insight 174 cases reported due to fire and explosion on board. This number of incident was recorded on 2018. In this project the members presented operation of the microcontroller in fire controlled system. System demonstrated detection of fire and how to overcome the problem when fire accident occur [2].

5.0 CONCLUSIONS

Thus, this system will contribute the company to comply zero incident on board and increase safety on board according to prevention from fire incident. The duty officer will detect early of starting of fire so it will increase a chance to overcome the fire combustion or explosion on board [2].

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