Design, Modelling and Application of Microcontroller (MCU) on Ballast Water System

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ABSTRACT

Onboard ship there is ballast water treatment plant [1] , where the prior to loading and discharging, the ballast water would pass through 3 stage of process prior loading of discharge. The purpose of this paper is to create a differential pressure system for the main strainer in loading ballast water. This is an essential step to eliminate particles and sediment from entering the ballast tank. We would be using a microcontroller to monitor the inlet pressure and the outlet pressure from the main strainer. Comparing the data of the inlet and outlet pressure[2]. When there is a difference in pressure. The microcontroller would stop the loading ballast water into the system and begin backflush of the strainer. The process shall be repeated till the inlet and outlet pressure difference is below set limit.

KEY WORDS:*PIC Microcontroller, MCU, Differential Pressure Relay, Pump, Buzzer*
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NOMENCLATURE

CPU Central Processing Unit
IP Inlet Pressure l
OP Outlet Pressure
DP Differential Pressure
LED Light Emitting Diode
MCU Microcontrollers

1.0 Introduction

Ballast water is pump on-board by ships for stability and adjusting the trim on-board after loading or discharging cargo activities at port [3]. However ballast water contain thousands of aquatic or marine microbes, plants and animals, which are loaded at port A and discharge at port B which can be in a different continent of the world . Untreated ballast water released at the ship's destination could potentially introduce a new invasive marine species. Hundreds of such invasions have already taken place, sometimes with devastating consequences for the local ecosystem. This can cause algae bloom in a region maritime ecosystem, and may result major consequences.

Ballast Water Management has been increasingly important in the maritime industry. Although it has not been recognized in the Maritime Pollution Prevention Act (MARPOL). It is still an important aspect in the maritime industry. Because 90% of the world cargo it's been carrying by ships to different continent of the world. Hence it is important to ensure that all ship onboard its compliance with the Ballast Water Management without endangering the ecosystem of the sea. As the impact can affect the community and the economy of the region. We would be highlighting a simple idea to improve the efficiency of the ballast water management plan onboard to ensure that the ballast water loaded onboard or discharge are free from harmful particles and sediment that can cause damaged to an ecosystem [4].

1.1 Similar System

The inspiration for this system is from a pressure differential system that is using a microcontroller as a controller. The operator has set a input value to the microcontroller to allow the system to operate in a safe and efficient manner without causing interruption to the operation. Valves are used to control conditions such as flow, pressure, temperature, and liquid level. The opening or closing of the valve is depend on the signals received from the controllers that compare a set point to a process variable where the value is obtain from the sensor that monitor the change of conditions. Besides, the opening and closing of the control valve is done by electrical, hydraulic or pneumatic system. A valve also can vary in design, pressure range and temperature range of the operation, application suitability and cost.

1.2 Current System

Although the ballast water management has been implanted by the International Maritime Organization (I.M.O.) on 8th September 2017. That all new built ship after the year September 2017 required to have a ballast water treatment plant. Ships built after the year 2014 are required to follow suits by either installing a ballast water treatment plant or by having a ballast water plan where it should be well stated how the ship would be loading and discharging the ballast water. Therefore most of the ship owner are in a dilemma in either scrapping their ship or purchasing a new ship due to high cost required in the designing and modification of a new ballast water treatment plant.

1.3 Proposed System

The idea of this paper is to propose a simple and cost saving method in the first stage of the ballast treatment plant. By having a strainer, it can reduce the sediment and plankton up to a 10 ppm in the ballast water. This would greatly help the efficiency of the UV Sterilize to work in a more effective manner to disinfect the reminder microorganism in the ballast water to ensure it's clean and safe for discharging at other region

2.0 Methodology

A microcontroller will constantly observe the differential pressure between the inlet pressure of the strainer and the outlet pressure from the strainer. Probe would be place between the pressure gauge. The signal from the probe would be continuous fed into the MCU for decision making. Warnings will then be triggered by the MCU through its ports and ultimately will activate the external peripherals that it is attached to. This warning could be some combinations of LEDs and buzzers. Such LEDs which serves as display purposes could be 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. Once the differential pressure is above set limit, the pump would stop pumping ballast water into the ballast tank. And the backflush pump would be activated, by pumping fresh water from the storage tank to clean the strainer. All the valves would be automatically changed over by the MCU. The changeover of pump would also be controlled by the MCU.

2.1 Component

The components of the system consist of (1) PIC16F84A [6], this Microcontroller come with only 18-pins[5]. The Plastic Dual In line Package (PDLP) that would perform as the brain of the system, (2) 4N25 Optocoupler to be used to safeguard the microcontroller from electricity over supplies, (3) light emitting diodes (LEDs) to turn as visual response, (4) Buzzer which function as the hearing response aids, and (5) Sensors that is installed to the main tanks , (6) Motor that will be activated when needed, (7) Relay which will be used to control the Motor and the Buzzer. Figure 1 illustrates the schematic diagram of the system design.

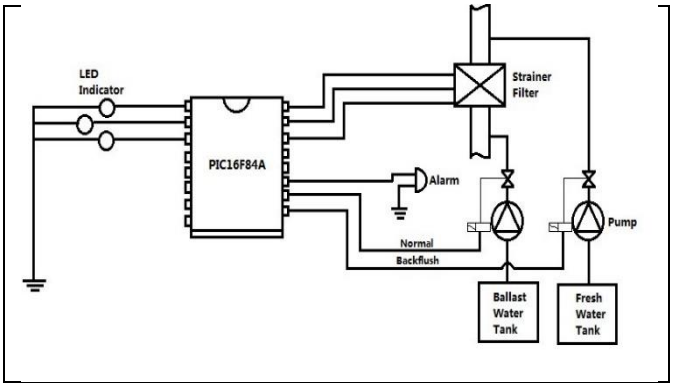

Figure 1: Simplified Schematic Diagram of Circuit.

2.2 Operations

The operations concept is describe as below:

- When in Normal Condition (N.C.) the ballast water would operating following into the strainer, The LED light would be indicating the normal condition (L.N.V).
- When in Partially Clogged condition (P.C.), the LED for the change-over (C.O.) valve would be activated and followed backflush valve LED (L.B.V).
- When in Totally Clogged condition (T.C.), the sound (S) would be activated, and the operation of loading ballast water would be stopped. This requires the ship crew to carry out appropriate maintenance before resuming the system by changing the new strainer.

TABLE 1: TRUTH TABLE

Table 1: Truth table of the operation

INPUT PORT			OUTPUT PORT					
PC A0	NC A1	TC A2	LBV B0	CO B1	LNV B2	S B5	N B6	BF B7
1	0	0	1	1	0	0	0	1
0	1	0	0	1	1	0	1	0
0	0	1	0	0	0	1	0	0

2.3 Microcontrollers

PIC16F84A (Figure 2), is used for this system. This MCU is used as the brain of the system, it has the ability to function without other sophisticated modules to be attached. PIC is a family of reduced instruction set computing (RISC) microcontrollers manufactured by the Microchip Technology which is resultant from the PIC1650 that is formerly developed by General Instrument's Microelectronics Division. PIC is the integrated circuit which was frequently used to develop in controlling exterior devices and lightening the load from the main CPU in the system. Matched to a human being, the main CPU act as a brain and the PIC is same to our autonomic nervous system. Hence, it is recommended that 8-bit PIC16F84A microcontroller which is sufficient enough to act as the central control of the system.

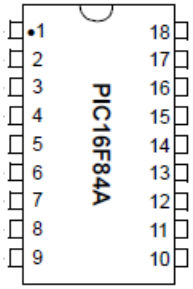

Figure 2: PIC16F84A Microcontroller Pin assignment (PDLP).

2.4 Software

The "C compiler for the PIC MCU," is utilized for composing, editing, compiling, and programming the codes for the microcontroller. These compiler, which empowers the microcontroller to be customized in high level programming languages, together with PicKit2 programmer. The algorithm of the codes will decide the state of the parts by actuating the microcontrollers input - output ports taking into account the particular tasks. The fundamental capability of the entire system is to allow a timed with micro-seconds interim, to acknowledge the sensor inputs, and to activate the outputs with enacting the Alarm or the Motor.

2.5 Programming Description

The program used to control and monitor the operation of the system is program onto PIC16F84A microcontroller's C language. All the codes have beencompiled and tested using CCS compilers.

2.6 System Flow

This system works by measuring the differential pressure between the flow inlet pressure sensor (I.P.) and the flow outlet pressure sensor (O.P.) from the main strainer. The differential reading would be sent to the Microcontroller Unit for processing. The MCU would then monitor and decide the next course of action by activating the alarm and buzzer. It would also activate the changeover valve for backflush to clean the main strainer.

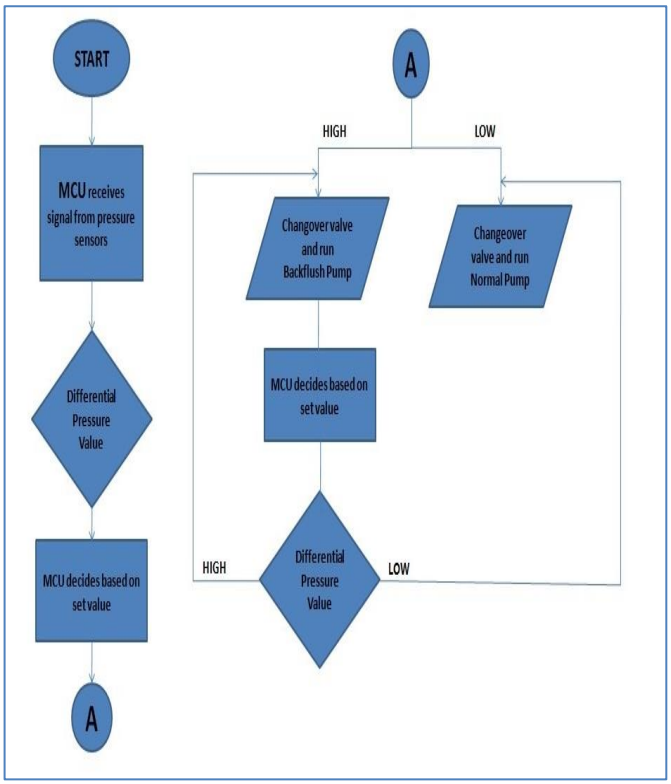

Figure 3 :Flowchart of the system.

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.

When in normal operating condition the relay would close and let the ballast water pump continue to pump ballast water in the tank. There won't be any interruption to the system.

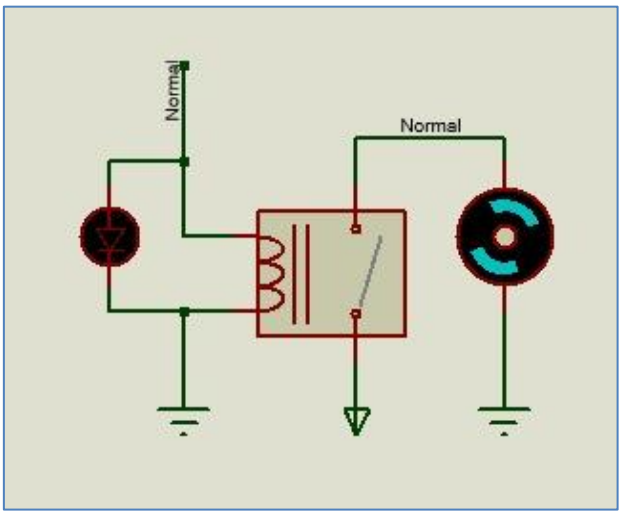

Figure 4: Circuit in Normal Operating Condition.

When the main strainer for the ballast water is clogged. It creates a differential pressure which exceed its set value. It would stop the ballast pump and change over the valve.

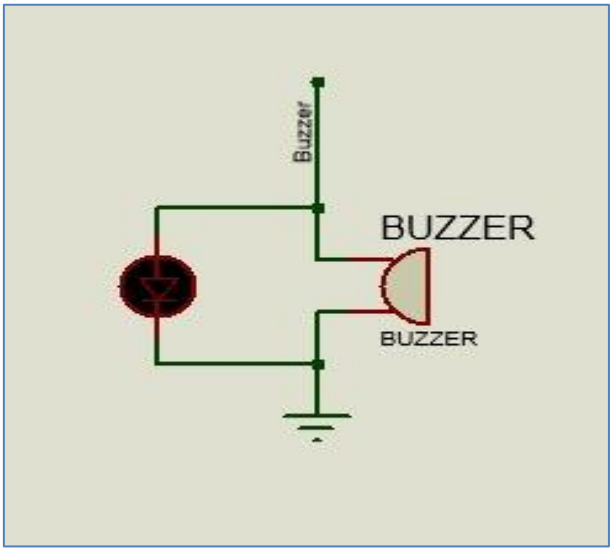

Figure 5: Circuit when the filter is totally clogged.

When the valve is change over, the fresh water pump would be activated and it would pump fresh water from the storage tank to clean the strainer.

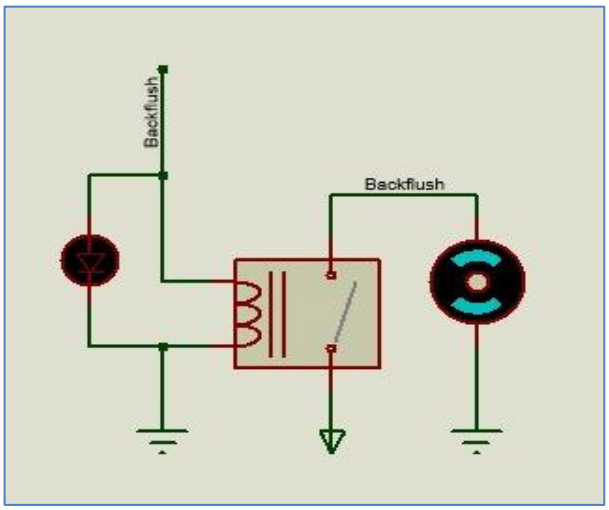

Figure 6 : Circuit in Partially Clogged condition.

The system would be in used whenever there is a ballasting operation ongoing on board. The engineer would be able to see the indication from the LED lamp to identify if the system is running in the either 3 condition normal condition, partially clogged condition or fully clogged condition. The MCU would assist the engineer on watch to backflush the valve when is needed. This can save time when the ship is required to discharge large amount of ballast water without any disruption.

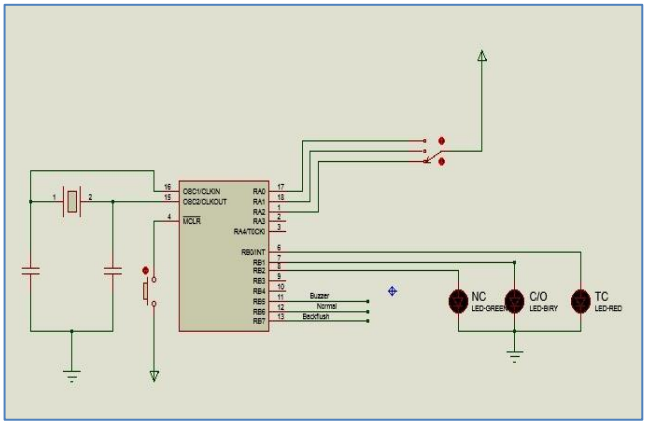

Figure 7: The overall operating system.

3.0 CIRCUIT DESIGN SIMULATION

The circuit was then replicated in the software Proteus version 8.0. The entire components of the circuit which is important for the project was 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 shown on figure 7. The connection to the microcontroller separated into 3 parts of circuits. The inputs from the sensors were connected to RA0 till RA3 pins (using Port A) of the microcontroller while the

outputs of the system were connected RB0 through RB2 for the display units (LEDs), and RB5 is connected to the buzzer (figure 5), the RB5 is used to connect to the AC Motor relay (figure 6) in normal operating condition. If high differential pressure the relay in RB6 would be activated and the backflush pump would start, All the output pin is connected through (Port B) of the controller.

4.0 RECOMMENDATIONS

The findings from this paper presented the operation of a differential pressure controller system. Besides, it is demonstrated to utilize a savvy various input and output operational MCU as the part to a circuit for differential pressure detection and controls. This circuit checked and controlled the input and output pressure of the main strainer and utilized LED for signals. From the equipment circuit, only few external peripherals are used. In addition, the MCU could be reprogrammed to suit the regular regulation changes on board. Every one of these components are controlled and intelligently decided by the PIC16F84A - MCU and more application cases could be further explored.

5.0 CONCLUSIONS

Thus, this proposed system will ensure the occupational safety on board and the environment by minimizing the risk of an ecosystem mishap. As shipping carries 90% of the world cargoes. It's the seafarer and the ship owner's responsibility to look after the environment. This system could further be improved in near future by adding two or more strainer in stages prior loading ballast water to improve the efficiency of removal of plankton and other species.

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