Using PIC16F84A Microcontroller (MCU) In Marine Fresh Water Generator System

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ABSTRACT

The goal of this project is to add a safety trip system based on a simple and cost-effecting microcontroller unit to an existing Fresh Water Production System onboard ships. With this design, the distillate pump in the system will automatically stop by means of a microcontroller which will get inputs on the reading of a salinometer sensor. The microcontroller also will control the direction of three-way valve which either goes to Fresh Water Tanks or Bilge Well depending on the salinity of the output water which will be sensed by means of a sensor. By doing so, the author of this project wishes to minimize the risks of polluting the distilled water used in boilers of a conventional Steam Ship.
The proposed design has been simulated using the Proteus software. The program was compiled in PIC C Compilers and programmed into the microcontroller using a programmer for PIC 8-bit microcontrollers. The proposed microcontroller functioned well during simulation.

KEY WORDS: *Microcontroller, Fresh Water Generators, Distilled Water Salinity, Boiler Water Quality*

NOMENCLATURE

CPU	*Central Processing Unit*
PPM	*Parts Per Million*
FWT	*Fresh Water Tank*
BW	*Bilge Well*
LED	*Light Emitting Diode*
MCU	*Microcontrollers*
PDLP	*Plastic Dual In Line Package*
PIC	*Peripheral Interface Controller*
FWG	*Fresh Water Generator*
FW	*Fresh Water*

1.0 INTRODUCTION

In the Marine Shipping Industry there are provided with evaporators to produce distilled water for commercial and industrial use onboard ships. As the sea water is being distilled using evaporation process [2], there are possibilities that the salinity of the fresh water produced can vary from time to time. This is critical in Steam vessels where the distilled water salinity must be within a controlled parameter to avoid damage of equipment and severe accidents for examples failures of boiler tubes due to acid chloride assaults and failures of steam turbine blades due to chloride stress corrosion [1].

1.1 Current System

The idea of this design came to the author based on some research carried out on the system which already exist in the industry. As a safety precaution there is a three-way valve which controls the water output whereby if the salinity is within range, the distilled water directed to the tanks or if the salinity is out of range, the distilled water is directed to bilge wells or overboard. There are still possibilities for the water to slip through the three-way valve and directed to the tanks even when the salinity is high. This maybe due to the three-way valve being not intact or three-way valve is malfunction. Most of the system still do not have a safety trip system added to stop the distillate pump when the salinity of the distilled water produced is higher than the controlled range. Therefore, in this paper, the author proposes a simple and cost-effective way using microcontroller to be able to add safety trip in Shipboard Fresh Water Generator System.

2.0 METHODOLOGY

In this design, the salinometer is connected at the distilled water outlet pipe to the Water Tanks. The sensors serve as switches to complete the loops, and the MCU will finally determine what to do next. The MCU will then send out warnings through its ports, which will unlock the external peripherals to which it is connected. A mixture of LEDs and buzzers may be used to issue this alarm. On the panel boards, LEDs that act as displays are mounted. The overall control mechanism is realized with a small number of components and provides excellent performance at a low cost. If the salinity of the distilled water continues to increase, then the FW Motor will automatically stop, and the distilled water will cease to be pumped from the FWG.

2.1 Components

The proposed controller system comprises of following main components.

(1) This Microcontroller, the PIC16F84A, has just 18pins. The Plastic Dual in Line Package (PDLP), which would serve as the system's brain.
(2) light emitting diodes (LEDs) to turn as visual response
(3) Buzzer which function as the hearing response aids.
(4) Switches as Sensors that is installed at the distilled water outlet pipes
(5) Motor that will be tripped when needed
(6) Relay which will be used to control the Motor and the Buzzer.
(7) LCD screen to indicate the alarm condition

Figure 1 shows the schematic diagram of the system design.

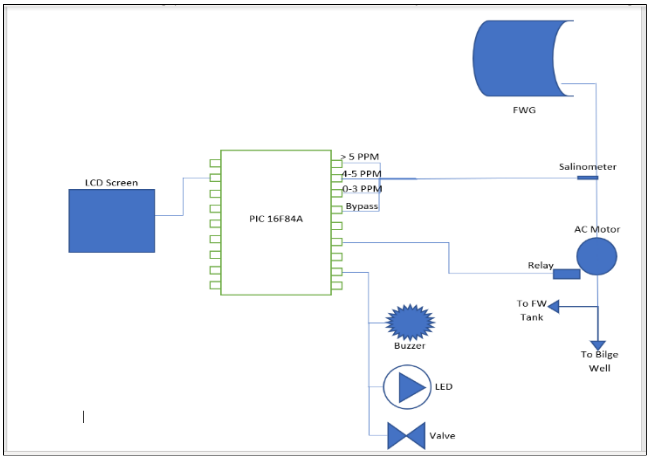

Figure 1:Simplified Schematic Diagram

2.2 Operation

The operation of the controller is described as below:

- When the salinometer detects the FW outlet to be at the range of 0-3 PPM, the three-way valve will direct the FW produced to FW tank. The LED FW TANK will light up and Distillate Pump will run as normal. The LCD screen will show Operation as 'FW TANK'.
- When the salinometer detects the FW outlet range to be between 4 to 5 PPM, the three-way valve will direct the FW produced to Bilge Well and the Bilge Well LED will light up together with the alarm buzzer will sound. The distillate pump will continue to run. The LCD screen will show Operation as 'Bilge Well'.
- When the salinometer detects the FW outlet above 5ppm, the three-way valve will continue to direct the FW produced to Bilge Well and the LED Bilge Well and STOP will light up together with the common buzzer will sound. The distillate pump will stop and trip. The LCD screen will show Operation as 'Pump Stop'.
- When the salinometer is bypass, the three-way valve will direct the FW produced to Bilge Well and the LED Bilge Well and BYPASS will light up together with the common buzzer will sound. The distillate pump will run, and the LCD screen will show Operation as 'BYPASS'.

Table 1 shows the simplified logic of the whole operations.

Table 1: Truth Table

Inputs				Outputs							
Bypass	0 - 3 PPM	4 - 5 PPM	> 5 PPM	LED FWT	LED BW	LED Bypass	LED Stop	VLV To FWT	VLV To BW	Motor	Buzzer
A1	A4	A3	A2	B4	B3	B1	B2	B4	B8	B5	B6
1	0	0	0	0	1	1	0	0	1	1	1
0	1	0	0	1	0	0	0	1	0	1	0
0	0	1	0	0	1	0	0	0	1	1	1
0	0	0	1	0	1	0	1	0	1	0	1

2.3 Microcontrollers

For this device, a PIC16F84A [3], Figure 2, was used. This MCU is the system's memory, and it can work without the need for additional complex modules. Microchip Technology's PIC family of reduced instruction set computing (RISC) microcontrollers is derived from the PIC1650, which was previously produced by General Instrument's Microelectronics Division. PIC stands for "programmable integrated circuit," and it is a form of integrated circuit that is commonly used to power external devices while reducing the burden on the system's main CPU. The main CPU acts as a brain, and the PIC acts as our autonomic nervous system when matched to a human being. As a result, it is proposed that an 8-bit PIC16F84A microcontroller be used as the system's central controller.

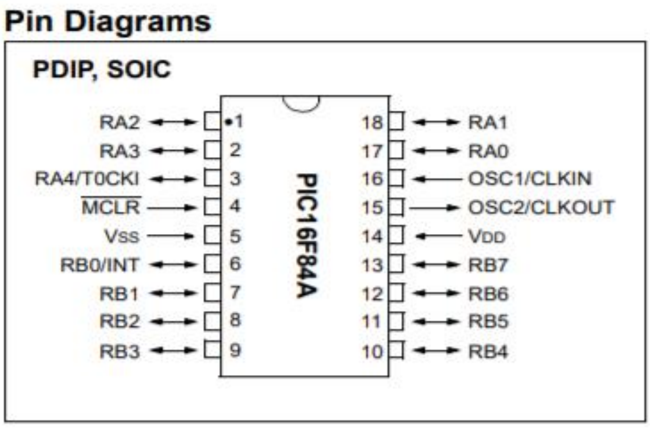

Figure 2:18 Pin PIC16F84A Microcontroller Chip

2.4 Software

For composing [4], altering, duplicating, and programming the microcontroller guidelines, the "C converter for the PIC MCU" is utilized. This compiler, related to the PicKit2 developer, permits the microcontroller to be tweaked in significant level programming dialects. The state of the parts will be dictated by the calculation of the codes, which will incite the microcontroller's info yield ports while thinking about the errands. The whole framework's essential ability is to empower a planned time, recognize sensor sources of info, and trigger the yields by authorizing the Alarm or the Motor. The author have also learn to use the coding by researching other work examples in the internet. With also some help from the lecturer and friends, the author able to modify the codes in software. Various try and error were done to improve the coding to be able to use in the microcontroller for the purpose intended for the design.

2.5 Programming Description

The software that controls the whole operation is written in the C language of the PIC16F84A microcontroller. CCS compilers were used to compile and validate all the codes. After several try and error based on the understanding of C compiler language the program code was able to achieve the intended function of the design.

2.6 System Flow

This system works by sensing the salinity of the FW outlet by a sensor which is known as salinometer. The reading of the salinometer is sent to MCU controller. The MCU controller then decides, by the series of coding embedded to it, on whether to send the FW outlet to the FW tanks, trigger the alarm and send the FW outlet to BW or trip the Distillate PP. The Flowchart was done according to common shipboard FWG System onboard most common ships sailing throughout the world. The system flow is better mentioned as per Figure 3.

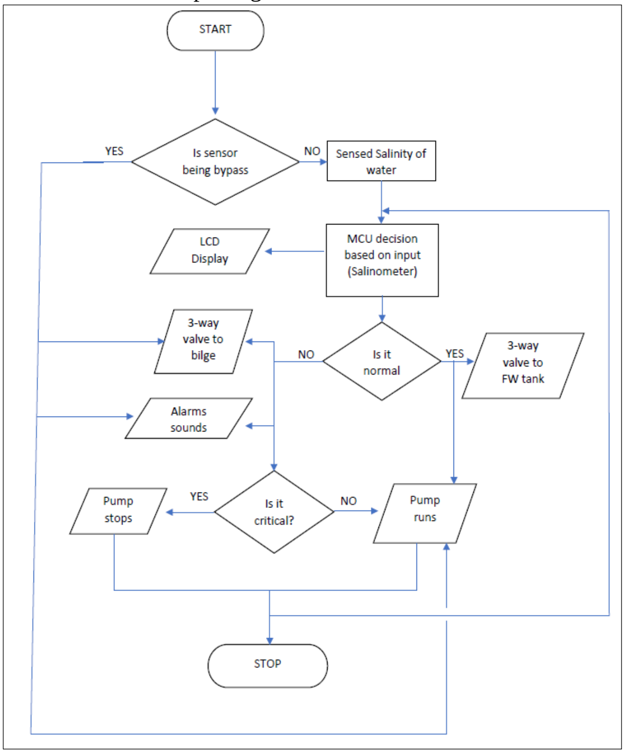

Figure 3: Flowchart of The System

2.7 Circuit

The circuit consists of 2 microcontrollers MCU U1 and MCU U2 segment which comprise the input and output parts. Microcontroller U1 comprises the whole circuit input and output segment. Microcontroller U2 comprises input signal for alarm signal for the circuit.

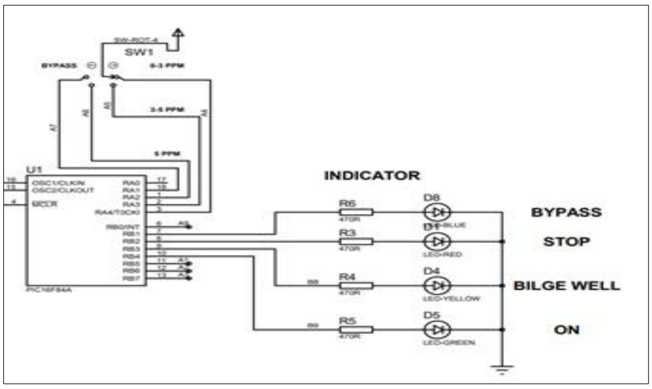

Figure 4: Inputs and Outputs

As per figure 4, Port A which is input for MCU U1 are connected from 4 output of salinometer, and all the output of MCU U1 are connected using the Port B including the display units (LEDs) and (LCD).

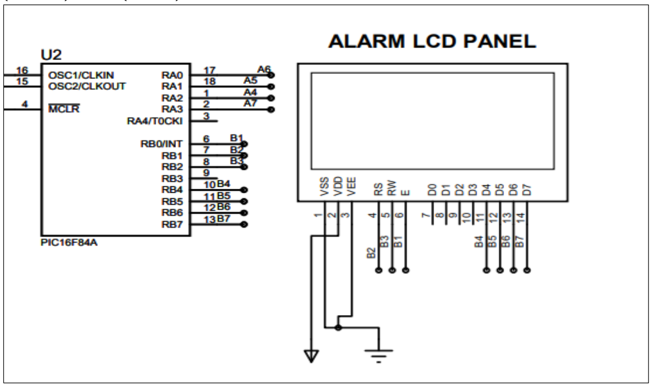

Figure 5: LCD Panel Circuit

As per figure 5, all the 4 outputs from MCU U1 are connected to the Port A which is input of MCU U2. All the outputs of the MCU U2 are connected using Port B to ALARM LCD Panel. LCD Panel display will synchronize with LED indicator which is output of MCU U1.

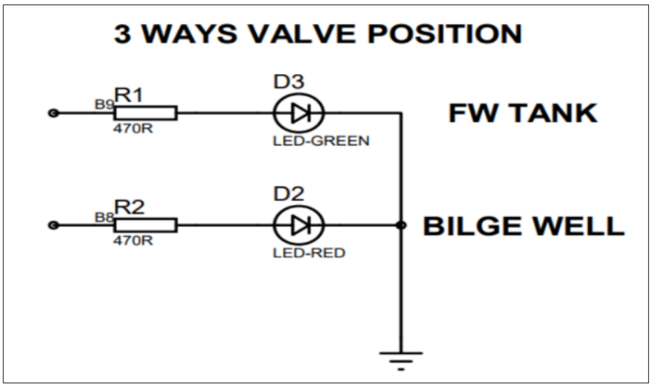

Figure 6: Three-Way Valve Position Indicator Circuit

As per figure 6, the input for 3 ways valve position is from output MCU U1. This shows the position of the valve based on salinity of the FW outlet either to FW tank or Bilge Well. If salinity below 3ppm, it will direct FW outlet to FW tank. If salinity above 3ppm, it will direct FW outlet to bilge well.

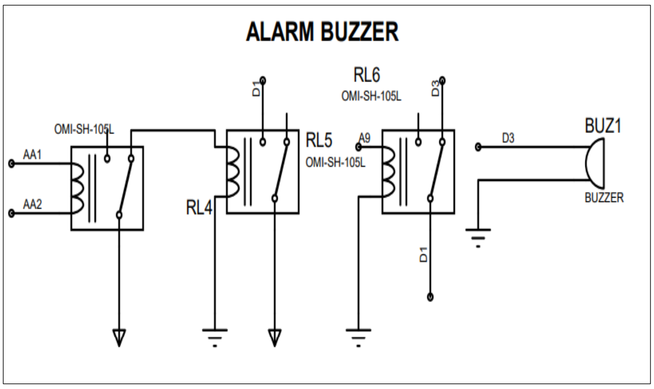

Figure 7: Alarm Acknowledgement Circuit

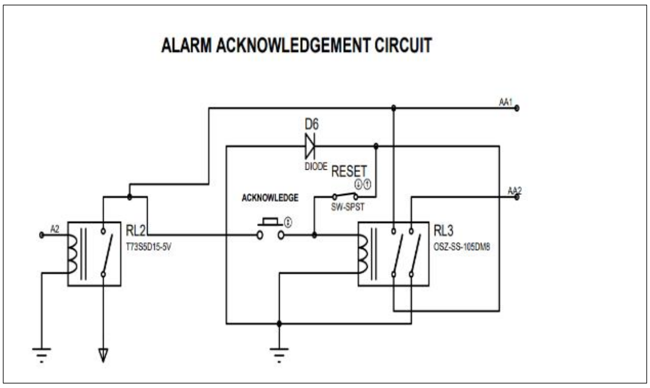

Figure 8: Alarm Buzzer Circuit

As per figure 7 and 8, the circuit enable the operator to inhibit the alarm remotely. The inputs for the buzzer to sound are from port B of MCU U1. Relay will energize to stop the buzzer continuous sound.

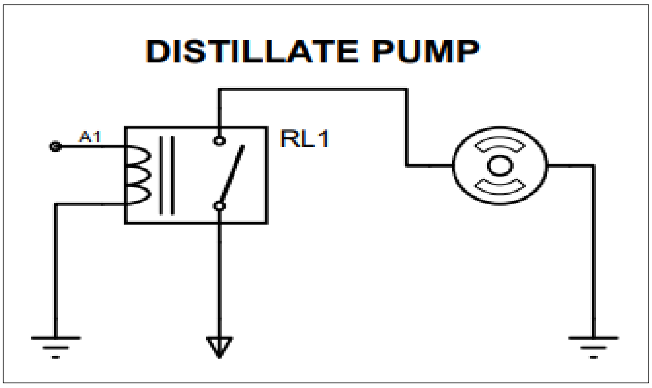

Figure 9: Distillate Pump Circuit

As per figure 9, motor of the distillate pump will run, or trip depends on output of MCU U1 terminal Port B. If the salinity of the FW outlet above 5ppm, the distillate pump will automatically stop. The distillate pump will run when salinity below the 5ppm.

3.0 CIRCUIT DESIGN AND SIMULATION.

The circuit was then replicated in Proteus v7.6 software. The critical circuit components were carefully selected from the software library, and the connections were made by lines in this software. Later, the software was compiled with the CCS C compiler. Using the PicKit2, the program's output, a hex file, is loaded into a PIC microcontroller. After that, the simulation is put to the test. The circuit used for simulation is given (figure 4). The connection to the microcontroller is separated into 5 parts of circuits. The inputs from the sensors were connected to RA1 till RA4 pins (using Port A) of the microcontroller U1 while the outputs of the system were connected RB1 through RB4 for the display units (LEDs) and LCD (figure 5), and RB5 is connected to the distillate pump relay (figure 8), and finally the RB6 is used to connect to the alarm (figure 7). All the output pins are connected through (Port B) of the microcontroller U1. In Microcontroller U2, the input of Port A is connected from the output Port B of microcontroller U1 (figure 5).

4.0 CONCLUSION AND RECOMMENDATION

In this project the author demonstrates the working principle of most shipboard FWG system. The author also make use of an MCU with a clever I/O form as a part of this circuit design for FW outlet salinity control and detection. By utilizing LED for signals and Buzzers for alarm, this circuit controls and checks the input and output of the measured value. The MCU can be modified even further for better safety features and added action to improve the safety and make the work easier for watchkeepers onboard. All this feature will be controlled by the PIC16F84A-MCU.

Therefore, the proposed system will ensure the safety of life and equipment on board as much as possible. According to the proposed system, it will minimize the risk of high salinity water into FW tanks onboard ships. This then also significantly makes the life of watchkeeping engineer onboard ship easier and the safeguarding the main equipment onboard better. Not only that, but it will also reduce the cost of repair of main equipment for such small matter which can be avoided easily.

This system could be further improved soon. For better improved projects, the design could be added with delays for alarms. As the measurement of salinity in the FW outlet could be varying in a quick phase, the delays added could help the user to avoid constant alarms. In upcoming designs, the circuit also can be added with automatic bypass system for initial starting of the FWG system.

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