The Functions of Microcontrollers in Marine Fuel Oil Systems

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ABSTRACT

Minimum Labour (manning requirements according to IMO Resolution A.1047(27)) in an enormous vessel are becoming a new norm. Thus automated systems are introduced to assist marine engineering officers in operating these massive sea-going vessels . There are various types of storage tanks on these vessels; these are the fuel oil tanks used to store and process the fuel oil on board ships. The main tank supplies are generally drawn from other repository tanks (storage). There is still an absence of beginning preventative frameworks to screen the tank's level once it contacted the unstable group. This paper aims to depict a straightforward plan on a low-evaluated framework and use of the microcontrollers unit (MCU) framework. These plans were recreated utilizing the Proteus programming and afterward to execute and test the equipment models. The program has then accumulated in PIC C Compilers and was modified into the Microcontroller using a software engineer for PIC 8-bit microcontrollers. This paper will offer the improvements of the tank levels observing framework that will caution the team in charge through signs (visual & audibles) and trigger it to stop all the system's associated machinery from protecting them from damages. The model worked reasonably well by utilizing test system programming. The indispensable utilization of the framework is to reduce the workload of watchkeeping engineering officers, and with this system, unmanned machinery spaces can be implemented.

KEYWORDS: ***Fuel Oil Tanks, Microcontrollers (MCU), Level Controls, & Automations.***

NOMENCLATURE

IMO International Maritime Organization
UMS Unmanned Machinery Space
SOLAS Safety of Life at Sea (1974)
MCU Microcontrollers
PDLP Plastic Dual in Line Package
LCD Liquefied Crystal Display
LED Light Emitting Diodes
RISC Reduced Instruction Set Computing
USART Universal Asynchronous Receiver Transmitter
SPI Serial Peripheral Interface
I²C 2-wire Inter-Integrated Circuit
FO Fuel Oil
EEPROM Electrically Erasable Programmable read-only memory
CPU Central Processing Unit
SOLAS Safety Of Life at Sea (1974)
MCU Microcontrollers

1.0 INTRODUCTION

In recent years in the maritime merchant industry (referring to medium to big sized vessels), UMS is a method that is commonly practiced by most of the ship in service now. UMS is an unattended machinery space that can operate without humans' intervention unless that machinery/ equipment/ tanks/systems are abnormal [2]. Another point has been incorporated covering the operator's tasks; thus, introducing this system reduces the need to refill the tanks and monitor them always manually. It is an automated system, and with these kinds of arrangements, the vessel can be operated with a UMS engine room (according to SOLAS 1974 Chapter II-1, regulations 46 to regulation 53). This project is more focused on the marine fuel oil purification system. This system is a good sample because it could be applied in many other associated systems on the vessel and various industries.
On vessels, there are various factors to be estimated or noticed as often as possible. These incorporate the crucial factor, ship's position, temperatures, level, stream control, force control, consistency, speed, current, voltage, gear position (open/shut) and machines status (on/off), Weather, and sea conditions.

1.1 Similar System

This section refers to some other good researchers related to the tank controls operations on land-based applications. The system proposed a method of monitoring the water level and temperature monitoring system for some industrial arrangements. It could watch the entire system remotely and alert the operators when there are issues. Another Microcontroller based system embedded in the oven was suggested to monitor and control the temperature automatically. Another comparative paper shows the improvement of the water level observing framework with the automatic controls of machinery with a group transmitter's assistance that will start and stop the pumps and remote displays.

1.2 Current System

The usually automated systems available on ordinary vessels covering various vessel activity pieces join the plant activity, power organization procedure on the assisting motors, a collaborator on machine tasks, cargo on-and-off- movement, loading of items and provisions. Anyway, many of the tanks on the vessels are as yet being controlled and checked physically by utilizing simple switches. The tank controls are not entirely automatic and still require some manual controls on the tanks. The vast majority of the vessels use the cutoff by float switches to initiate or deactivate the siphons or engines. The figure below shows the marine heavy fuel oil system onboard an automated ship.

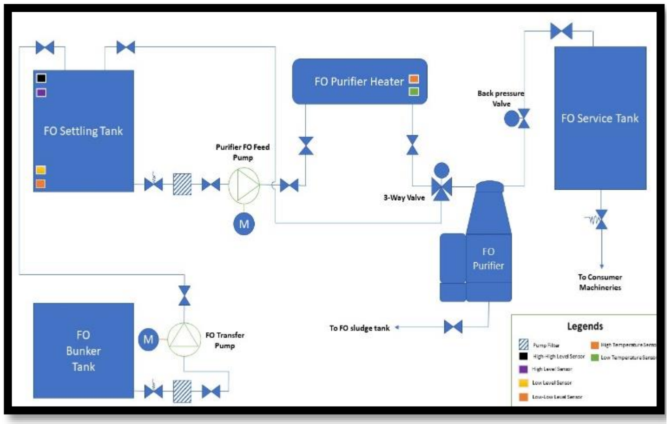

Figure 1: The Marine fuel oil purification system

1.3 Proposed System

A simple, reasonable, configurable, simple to be worked electronic control framework is proposed to convey a helpful to marine engineering officers and support staff for the engine room teams. This system also should be able to be integrated into current engine room monitoring systems.

2.0 METHODOLOGY

In this type of design, there are two different parts to complete the whole system. Firstly, there is a temperature sensor connected to the Purifier Heater outlet. The sensor will sense the fuel oil temperature at the heater's outlet before the fuel oil temperature enters the purifier inlet. It is to ensure the desired temperature required for optimum operation of the cleaner. The second part of this system is observing the fuel oil settling tank level. There were 4 level sensors attached to the settling tank. The level sensors are also is used as a switching device to complete the circuit and eventually allow the MCU to provide the next course of action. The MCU will then cause alerts through its ports and finally activate the external peripherals it is connecting to. Any combination of LEDs and buzzers may be such an alarm. Such LEDs could be mounted on the panel boards that serve as display purposes. This system could be realized by using lesser mechanisms, and the controllers also give great performances with dense size and low price MCU. When the Fuel Oil in the Settling tank is

Pump start level, FO transfer pump will be automatically be activated and started to top up settling tank from the FO Bunker Tank. However, when the transfer could not cope up and the low level is reached, it will automatically stop the Purifier Feed Pump Motor and Purifier Motor. When there is no more Fuel Oil from the bunker tank, the Low-low level sensor will automatically stop the FO transfer pump. However, when the tank reaches the average level, the sensor will automatically stop the FO transfer pump. The MCU will control the motor through a relay.

2.1 Component

The components of the system consist of

- This Microcontroller, PIC16F84A, comes with just 18 pins. The Plastic Dual in Line Package (PDLP) would serve as the system's brain.
- PIC 16F877A comes with two pin 40 & I/O pins 33. PDIP (Plastic Dual Inline Package) same acting same functions as the system's brain.
- LCD (LM016L) Interfacing of 16x2 LCD with our PIC16F877A
- The DS18B20 is a temperature sensor, and it supplies 9-bit to 12-bit readings
- 4N25 Optocoupler to be used to shield the Microcontroller from power suppliers.
- To transform light emitting diodes (LEDs) as a visual reaction.
- A buzzer that acts like a hearing aid.
- The sensors are located on the main tanks.
- Motor that will be triggered when necessary.
- Relay to trigger the motor and the buzzer

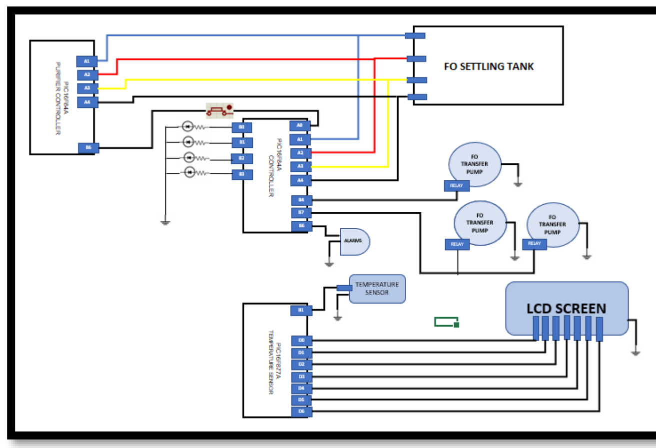

Figure 1 The schematic diagram of the system design.

2.2 Operations

The operation of the system controller is described as below:

- A switch controls the switching on of the Purifier Motor and Purifier Feed Pump motor.
- When the Settling tank at the average level, the LED Normal Level is switching on, Purifier Motor and Purifier feed pump motor will continue running.
- When the Settling tank reaches Pump Start Level, LED Pump Start Level will be switched on, Purifier Motor and Purifier feed pump motor will continue running, and FO Transfer pump will be started.
- When the settling tank reaches a Low Level, the LED Low level will be switching on. FO Transfer Pump will be started, while MCU will stop the Purifier Motor and Purifier Feed Pump motor (to prevent the cleaner from running empty).
- When the Settling tank reaches Low-low Level, LED Low-low Level will be switching on, an alarm will be triggered, and MCU will switching off FO Transfer Pump. (This is to protect FO Transfer Pump motor as sometimes our bunker tank is empty)

Table 1: Truth Table

PURIFIER A0	A1	A2	A3	A4	NL – B0	START – B1	LL – B2	LLL – B3	ALAMS	MOTOR – B4	PURI MOTOR – B7
1	0	0	0	0	0	0	0	0	0	0	0
1	1	0	0	0	1	0	0	0	0	0	1
1	0	1	0	0	0	1	0	0	0	1	1
1	0	0	1	0	0	0	1	0	0	0	1
1	0	0	0	1	0	0	0	1	1	0	0

2.3 Microcontrollers

PIC16F84A (Figure 2) is used for this system. As the brain of the device, this MCU can operate without the attachment of other sophisticated modules. PIC is a microcontroller family of reduced instruction set computing (RISC) manufactured by Microchip Technology resulting from the PIC1650, formerly developed by the Microelectronics Division of General Instrument. PIC is the integrated circuit used to establish external device control and lighten the load from the main system CPU. The main CPU acts as a brain, and the PIC is the same as our autonomic nervous system when compared to a human being. Therefore, an 8-bit PIC16F84A microcontroller is recommended, sufficient to act as the system's central control [3].

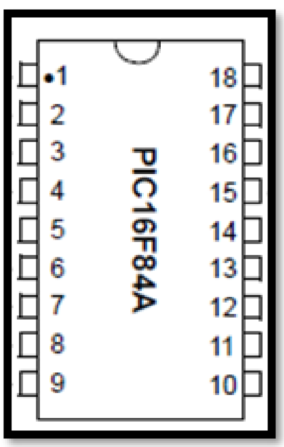

Figure 1: PIC16F84A Microcontroller Pin assignment (PDLP)

PIC16F877A (Figure 2.1) is used for this system PIC16F877A is a PIC Microcontroller and is usually used in Embedded Projects like Home Automation System, Bank Security System, etc. This strong (200 nanosecond instruction execution) yet simple-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller packs Microchip's robust PIC® architecture into a 40 package. It is upwards similar with the PIC16C5X, PIC12CXXX, and PIC16C7X devices. The PIC16F877A has 256 bytes of EEPROM data memory, self-programming, an ICD, 2 Comparators, eight channels of 10-bit Analog-to-Digital (A/D) converter, two capture/compare/PWM functions, the synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPI) or the 2-wire Inter-Integrated Circuit (I²C) bus & a Universal Asynchronous Receiver Transmitter (USART) [5].

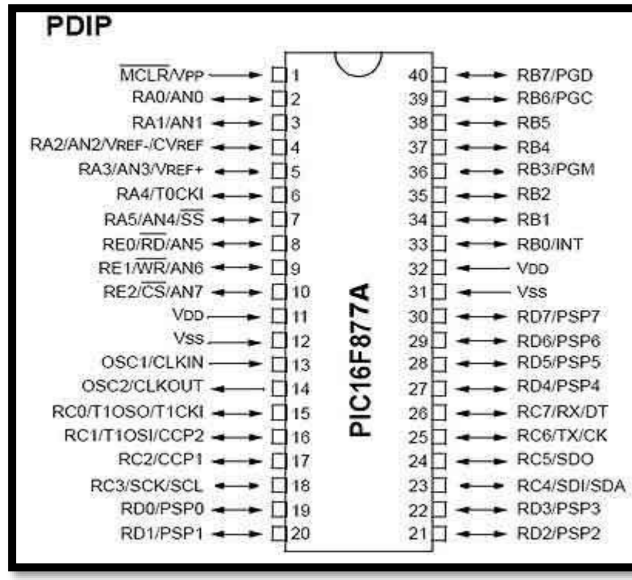

Figure 2.1: PIC16F877A Microcontroller Pin assignment (PDIP)

2.4 Software

The " C parser for the PIC MCU " is used to write, edit, compile, and programmer the microcontroller codes. This compiler helps the Microcontroller and the PicKit2 programmer be configured into high-level programming languages.
The programming algorithm can determine the parts' conditions by actuating the microcontrollers' input-output ports, taking into account the individual tasks. The whole device's fundamental ability is to enable an interim timing of micro-seconds, identify the inputs of the sensor, and trigger the outputs by triggering the alarm or motor.

2.5 Programming Description

The code used to govern the whole operation is encoded in the PIC16F84A & PIC 16F877A microcontroller's C language. All the codes were compiled using CCS compilers and checked.

2.6 System Flow

Sensors connected to the settling tank and bunker tank can then detect the current level of the tank and transmit the signal to the Microcontroller Device. This machine operates by detecting the level of fuel oil from the F.O settling tank. The MCU will then settle on the next course of action intelligently, either automatically activating the motor or triggering the alarm so that the person in charge of the vessel may take more action.

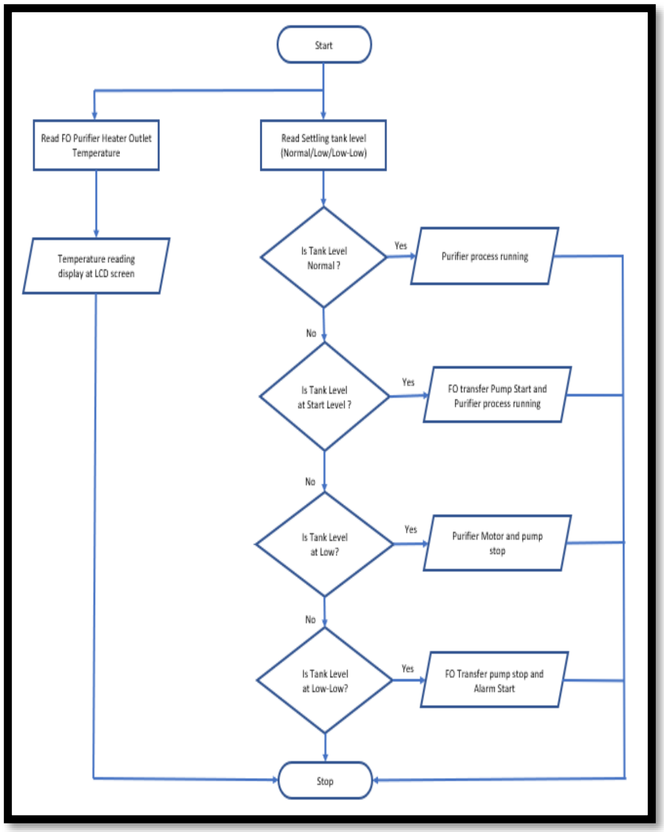

Figure 3: Flowchart of the System

2.7 Circuit

There are 4 main components of circuit: the power source component, the microcontroller portion, the input sections of the device, and the output parts. The MCU device is combined with all these components.

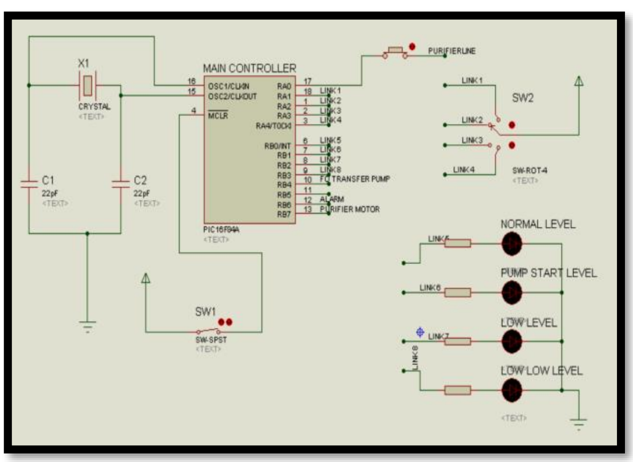

Figure 4: Input & Outputs for Main MCU Controller

As in figure 4, all the four input sensors at the tank and purifier MCU output are connected using Port A. All the system's work is secured using Port B, including the display units (LEDs).

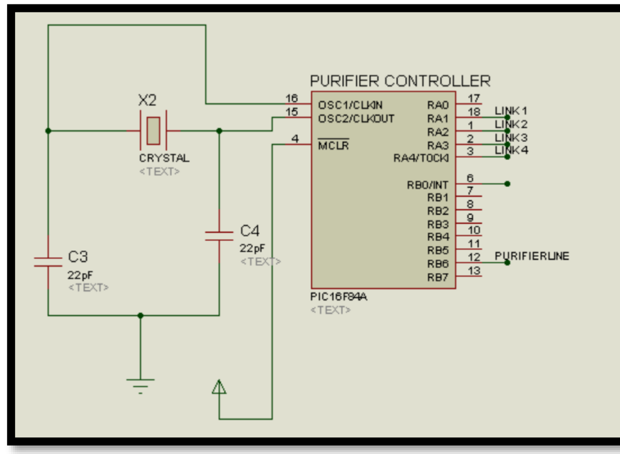

Figure 5: Purifier MCU Controller

As in figure 5, the tank's switching sensor is connected to Purifier MCU to act as a processor to analyst the safe operation of the Purifier motor and Purifier feed pump.

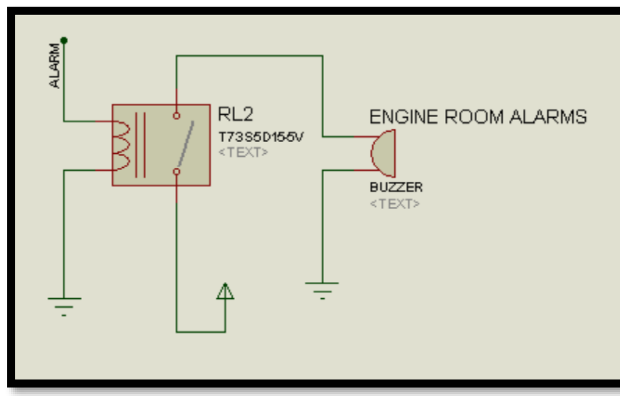

Figure 6: Alarm Circuit

As in figure 6, when the FO Settling tank level reaches the Low-low level (sensor B3), Main MCU will automatically trigger the engine Room alarm to alert the crew. A relay is used for the alarm buzzer, as shown above, figure.

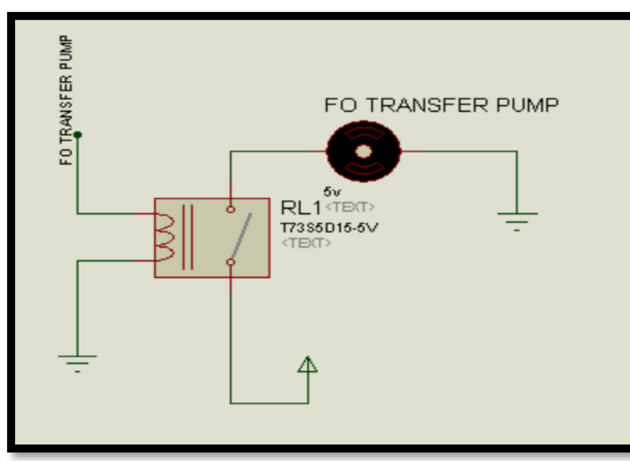

Figure 7: FO Transfer Pump Circuit (From Bunker to Settling tank)

The FO transfer pump will start automatically when the fuel in the settling tank level when sensors B1 detects (start pump level) and eventually stop automatically when the sensors in settling tanks reach the standard level at sensor B0. However, when the settling tank comes to the Low-low level at sensor B3, it will automatically stop the FO transfer pump [4].

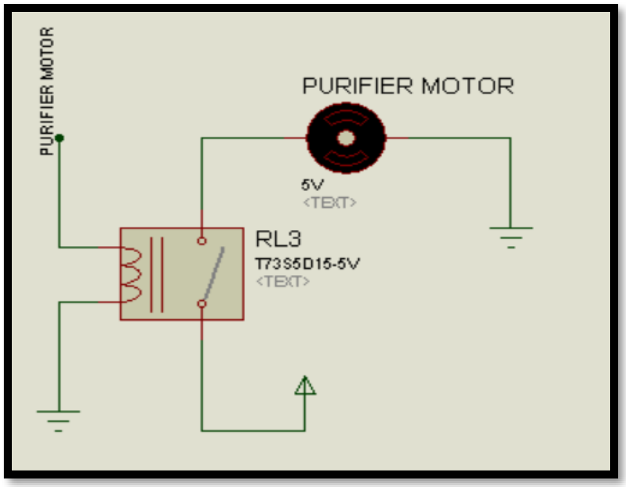

Figure 8: Purifier Motor Circuit

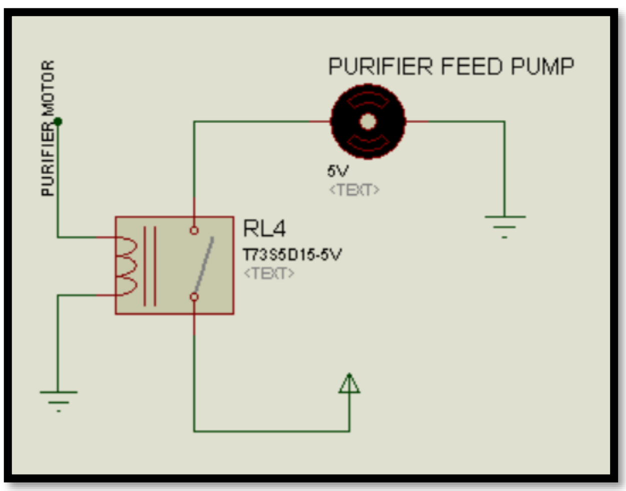

Figure 9: Purifier Feed Pump Motor Circuit

Figure 8 & figure 9 shows circuit for purifier motor, purifier feed pump, and connected with a relay. In normal condition, the purifier can be started at Normal Level B0 and Pump start level B1. However, when the Level Low Sensor B2 is triggered, it will automatically stop the purifier to ensure the purifier motor and feed pump motor would not be operated in empty condition [6].

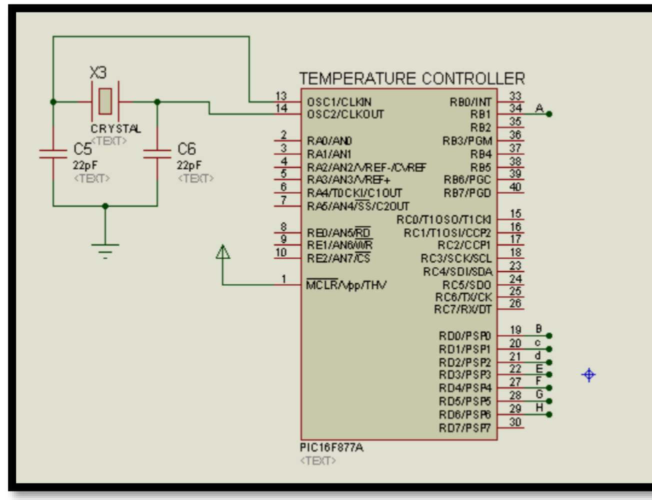

Figure 10: Input and output for Temperature Monitoring MCU

As in figure 10, the temperature sensor input is connected using Port B, and 7 output to the LCD display is connected through Port D.

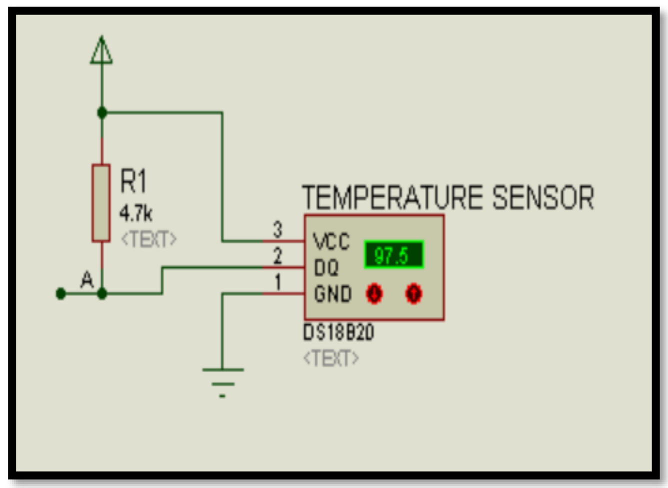

Figure 11: Temperature Sensor Circuit

As in figure 11, the temperature sensor analyzes the temperature at the purifier FO heater outlet and gives it to the Temperature Monitoring MCU for sending the signal to our display unit. The deviation for increasing and decreasing the FO Temperature is set to 0.5'Celcius.

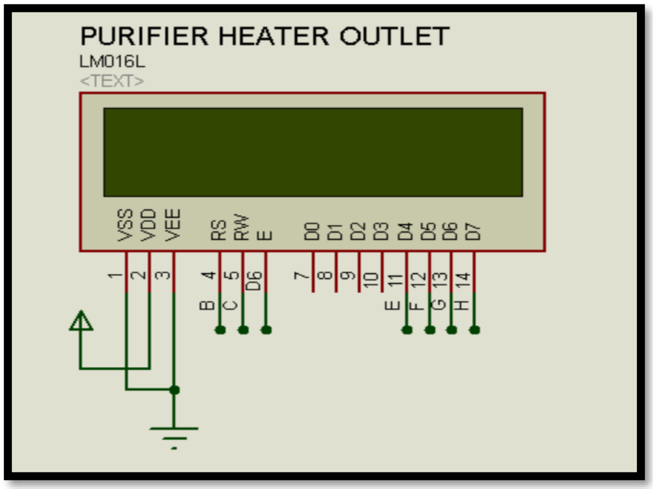

Figure 12: LCD Display Circuit.

Figure 12 is connected to the MCU of Temperature controller Port D. When the temperature sensor senses the temperature. It received data from the MCU unit, and it process with the temperature of the FO outlet's current value to show the Engine Crew for an easier way for us to monitor the temperature of the FO [7].

3.0 CIRCUIT DESIGN AND SIMULATION.

The circuit is generated in the software Proteus Version 7.6. According to the system, all components are chosen wisely from the software library to complete the course. All connection is connected accordingly after all require components is arranged. After that, the coding was made, and the programs for all MCU units is then compiled using the CCS C compiler. Hex file will be created after that, and the plans were uploaded into the PIC microcontroller using the PicKit2. Finally, the designed and improved system has been tested for a different kind of condition. There was a total of 3 microcontrollers used to complete this design.

3.1 Main MCU Controller (Figure 4)

The Main MCU is connected through 6 parts. The first part is input through pin RA0 from the purifier MCU. The second part of the output is connected to the sensor through Pin RA1 to RA4. The third part is connected to the LED Display through Pin RB0 to RB3. The fourth is output connected to the FO transfer pump through Pin RB4(figure 7). The fifth is the output alarm which is connected to pin RB6(figure 6). The final output is Purifier Motor which is connected through Pin RB7(figure 8 and 9).

3.2 Purifier MCU Controller (Figure 5)

For Purifier MCU, the input from the sensor is through Pin RA1 to RA4. And the output is connected to the Main MCU and connected through Pin RB6.

3.3 Temperature MCU Controller (Figure 9)

For temperature MCU, the input is by the temperature sensor (figure 11), connected through pin RB1. And the output is to the LCD display (figure 12), connected through Pin RD 0 to RD6.

4.0 RECOMMENDATIONS

In this project, the researchers stated the automated purification process for marine oil using the Micro-Controller Unit (MCU). The circuit was programmed to detect fuel oil settling tank level and send signals to the purifier and fuel oil transfer pump operation. This concept also applied safety mechanisms to the existing equipment to prevent massive machinery breakdowns. In conjunction, it is shown that a smart I/O style MCU is used as a part of an alarm device circuit and an LED for a signal. The MCU may be reprogrammed to handle onboard modifications to the standard rule. Each of these components is regulated and intelligently determined by the PIC16F84A-MCU, and further applications should be further prosecuted [8]. The temperature sensor device is also introduced into the purifier outlet, usually shown by the thermometer. The FO outlet temperature can be easily monitored, and the cleaner can operate in a good performance.

5.0 CONCLUSIONS

This project focuses on the safety of marine fuel oil purifiers and fuel oil pumps. The system's main objective is accomplished by means of a series of sensors mounted in the port to automatically detect the oil level in the fuel oil settling tank and pass the resulting data to the MCU for further operation of the fuel oil purifier and fuel oil transfer pump. The aiming system is to eradicate human intervention during the process of fuel oil purification. The built system would also include an audible warning to warn the crew if the system is not functioning. From the simulation data, the built circuit has shown that the PIC16F84A Micro-Controller Unit is capable of receiving and transfering signals to control the various machines onboard the vessel systems.

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