Design, Modelling and Application of Microcontroller (MCU) on Marine Tanks

Ramesh Babu Amathalai,[a,*]

[a)] *Malaysian Maritime Academy, Melaka, Malaysia*

*Corresponding author: rameshb.amathalai@alam.edu.my

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ABSTRACT

Large commercial ships used for transportation of liquid cargo are provided with many tanks for storage of liquid cargo during voyage. The cargo loading and unloading process requires close monitoring of the liquid level in these tanks to prevent overflow or spillage. In most ships the liquid level sensing of these tanks is still performed either manually or with the help very rudimentary analog devices which apart from being less accurate are also unreliable giving false readings and often cause of accidents from cargo spill.

In this paper the author proposes a simple low-priced microcontroller unit design for tank liquid level monitoring and control. The proposed design has been simulated using the Proteus software and then later implemented and prototype tested in the hardware models. 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 and prototype testing.

KEY WORDS: *PIC microcontroller, Tank Controls, MCU*

NOMENCLATURE

CPU	*Central Processing Unit*
F	*Full Level*
L	*Low Level*
LED	*Light Emitting Diode*
LL	*Low – Low Level*
MCU	*Microcontrollers*
N	*Normal Level*
PDLP	*Plastic Dual In line Package*
PIC	*Peripheral Interface Controller*
RISC	*Reduced Instruction Set Computing*
UMS	*Unattended Machinery Space*

1.0 INTRODUCTION

Unattended Machinery Space, or UMS is a new concept of operating ships machinery and auxiliary services through the application of digital software driven automation and monitoring system. The implementation of UMS in ship operation brings in many changes in the seagoing engineer's conventional watch keeping duty and requires him to acquire additional knowledge and skill in operations management and ship safety. The UMS also brings onboard many sophisticated hardware and software with potential to perform additional functions, such as machinery condition monitoring, modernized maintenance management and data logging. Numerous parameters like pressure, position of vessel, temperatures, level, flow control, torque control, viscosity, speed, current, voltage, equipment position (open / closed) and machines status (on / off) which are recorded manually in conventional ships are now easily monitored and auto logged in UMS system [1].

1.1 Developments of microcontroller based systems

This section describes research work of some authors conducted for the control and monitoring of process parameters of a few land based plants using microcontrollers. The schematics arrangement of control and monitoring the water level and temperature of some industrial process has been discussed in reference [2]. The system monitors all parameters remotely and thereby the user could save their scarce time as well as operating cost. In another similar design using a microcontroller based system embedded on oven has been proposed in reference [3] to monitor and automatically control the temperature of an oven automatically.

A similar paper [4] shows the improvement of water level observing framework with an incorporation of GSM module to caution the individual in-control through Short Message Service (SMS). The water level is observed and its information sent through SMS to the proposed expert mobile telephone after achieving the basic level.

Another similar paper presents the development of water level monitoring system with an integration of GSM module to alert the person-in-charge through Short Message Service (SMS). The water level is monitored and its data sent through SMS to the intended technician mobile's phone upon reaching the critical level [5].

1.2 Current System

Existing Automation and Controls systems which regulate various functions of the vessel operation such as the power plant operation, power administration of the auxiliary engines, cargo loading and unloading voyage route monitoring, are of analog design with little or no flexibility to make adjustments for any changes in ship's operation. Because of this restriction, most of the tanks on the vessels are still being controlled and monitored manually by using analogue switches. The majority of tanks level control are still not fully automated and being monitored manually through limit or float switches to activate or deactivate the pumps or motors on board. In this paper author proposes a simple, low cost, configurable, easy to operate microcontroller for use onboard merchant ships to control and monitor liquid level in tanks .

2.0 METHODOLOGY

In this design, level sensors are attached to the main tank and a microcontroller will constantly observe the main tank liquid levels. Sensors act as 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 external peripherals that it is attached to. This warning could be some combinations of LEDs and buzzers. LEDs which serve as display are installed on the panel boards. The overall control system is realized by using less number of components and it gives great performance with dense sized and low price MCU. If the liquid level in the main tank gets lower the motor will automatically activate and pumps the liquid from the reservoir tank. The motor will be controlled by the MCU through a relay [5].

2.1 Component

The proposed controller system comprises of following main components.

(1) PIC16F84A, this Microcontroller come with only 18-pins. 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,
(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 shows the schematic diagram of the system design.

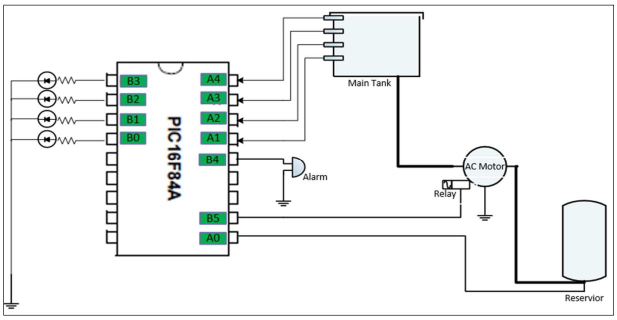

Figure 1: Simplified Schematic diagram

2.2 Operations

The operation of the controller is described below:

- When liquid reaches Full (F) level in the main tank, all LED F, N, L and LL will be ON, the Alarm will be triggered, and Alarm to be at halt.
- When the level is at Normal (N) position, LED N, L & LL will be light up, the Alarm and the Motor will be OFF.
- When the liquid level is sensed by the sensor at the Low level (L) position, only LED L and LL will be ON, the motor will be ON until the level of the main tank reaches Normal (N) position.
- When the liquid level reaches Low Level (LL), only LED LL will be ON, the Alarm will be triggered and the Motor will keep on pumping.
- When the liquid level is low in the reserve tank, the MCU will turn OFF pumping motor. This is to prevent the damage to the motor.

Table 1, shows the simplified logic of the whole operations.

Table 1: Truth Table

Input Ports					Output Ports					
Res Tank A0	S1 A1	S2 A2	S3 A3	S4 A4	LL B0	L B1	N B2	F B3	Alarm B4	Motor B5
1	0	0	0	0	ON	OFF	OFF	OFF	ON	ON
1	1	0	0	0	ON	OFF	OFF	OFF	ON	ON
1	1	1	0	0	ON	ON	OFF	OFF	OFF	ON
1	1	1	1	0	ON	ON	ON	OFF	OFF	OFF
1	1	1	1	1	ON	ON	ON	ON	ON	OFF

2.3 Microcontrollers

PIC16F84A [6], Figure 2, has been used for this system. This MCU is the brain of the system and 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 is 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.

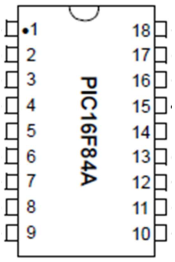

Figure 2 : PIC16F84A Microcontroller Pin assignment (PDLP)

2.4 Software

The "C compiler for the PIC MCU," is utilized for composing [7], 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 regulate the entire process is embedded in PIC16F84A microcontroller’s C language. All the codes have been compiled and tested using CCS compilers.

2.6 System Flow

This system works in sensing the level of liquid from the main tank, sensors which are attached to the tank will then sense the current level of the tank, and send the signal to the Microcontroller Unit. The MCU then will intelligently decide on the next course of action, either activating the Motor automatically or triggering the Alarm to allow the person in charge on the vessel to take further action (Figure 3).

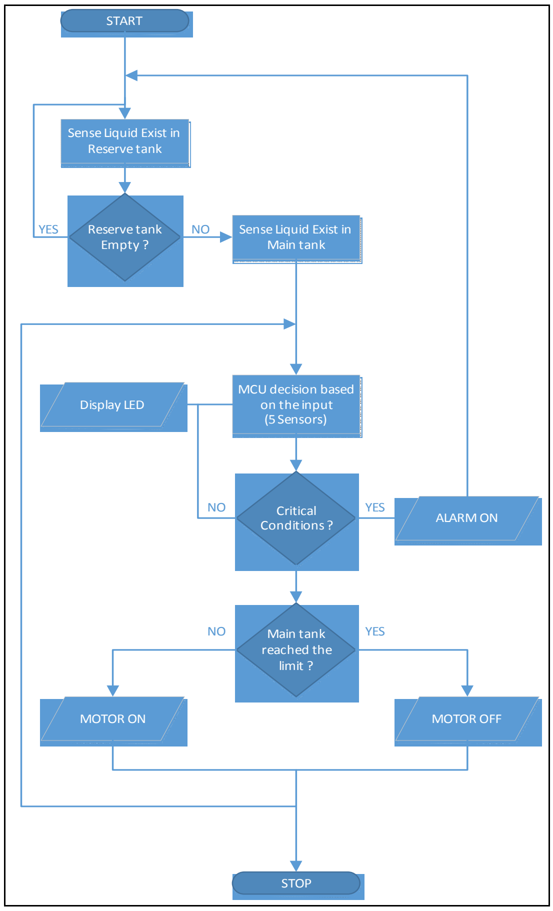

Figure 3: Flowchart of the system

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.

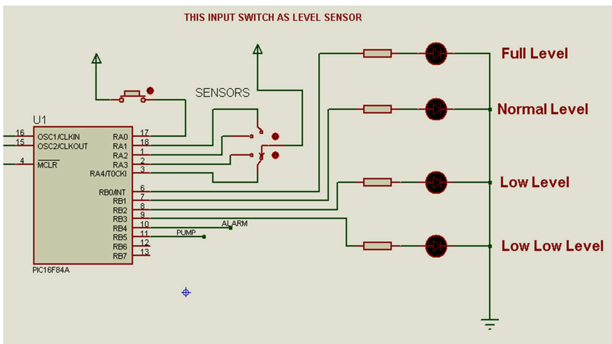

Figure 4 : Input & Outputs

As in figure 4, all the 5 input sensors are connected using the Port A, and all the output of the system are connected using the Port B including the display units (LEDs).

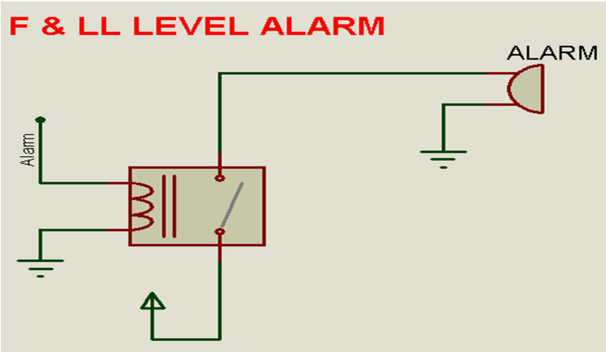

Figure 5 : Alarm Circuit

Once the liquid in main tank reaches Full (F), or it is at the Low – low Level (LL), 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.

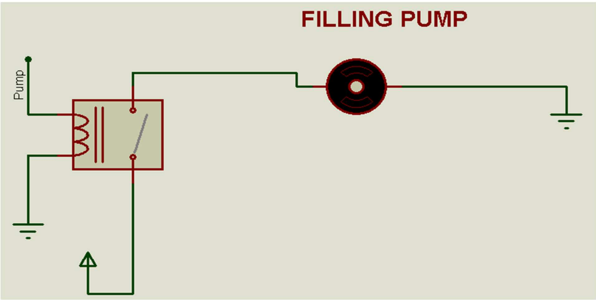

Figure 6 : Filling Pump Circuit

The filling pump or Motor, will start automatically when the liquid in main tank level yet to reach to sensor (S4), and eventually stopped automatically when the sensors in main tanks reaches to the desired level (Figure 6).

3.0 CIRCUIT DESIGN AND 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 (figure 4). The connection to the microcontroller is separated into 3 parts of circuits. The inputs from the sensors were connected to RA0 till RA4 pins (using Port A) of the microcontroller while the outputs of the system were connected RB0 through RB3 for the display units (LEDs), and RB4 is connected to the alarm (figure 5), and finally the RB5 is used to connect to the AC Motor relay (figure 6). All the output pins are connected through (Port B) of the controller.

4.0 CONCLUSIONS & RECOMMENDATIONS

In this paper, the author presents the operation of customary liquid level controller. Besides, it is demonstrated to utilize a savvy I/O sort MCU as the part to a circuit for liquid level detection and controls. This circuit checked and controlled the liquid level of a tanks, 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.
Thus, this proposed system will ensure the occupational safety on board by minimizing the needs for the crew to frequently moving to view the status of each tanks by themselves and the protection of the equipment or machines as well.
This system could further be improved in near future. Upcoming system could be focused on enhancing the visual aids, by integrating Liquid Crystal Display (LCD) to the system, allowing the crew to know exactly the level of the liquid in the tanks and even allowing the crews to be alerted wirelessly through a wireless module connected to the MCU, and more similar application cases could be further explored.

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