Design, Modelling and Application of Microcontroller (MCU) on Ship's Steering Gear Motor System

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ABSTRACT

One of the most important equipment of a vessel is its steering gear. It is designed to turn the ship to right (Starboard side) or left (Port side) while sailing. All ships are required to have the main steering gear and an auxiliary steering gear as backup. The main steering gear only works when the ship is in motion, not in stationary state. This is because the system uses a rudder, directly mounted behind the ships propeller. The rudder is controlled by the steering gear. When the bridge gives a signal to turn left, the rudder is moved to the left as well (seeing from the back), causing water forces to turn the vessel in the wanted direction.
Steering gear systems have minimum requirements to achieve certain safety levels. In example they are required to maneuvers from 35 degrees port to 35 degrees starboard and visa-versa within 28 seconds, with the vessel sailing forwards at a steady maximum continuous rated shaft RPM. It also required to have an auxiliary system on the background in case the main system has failures.
In this paper the author proposes a simple low-priced microcontroller unit design for steering gear hydraulic oil 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
LCD	Liquid Crystal Display
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
UMS	Unattended Machinery Space

1.0 INTRODUCTION

On a ship there are many parameters that needs to be controlled or monitored including: temperatures, pressure, level, viscosity, flow control, position of vessel, speed, torque control, voltage, current, machinery status (on/ off), and equipment status (open/ closed). As the market is driving ship owners to become more efficient with reduced staff on board it called for an automatic control and monitoring system for the ship that enabled unattended operation of machinery spaces. Vessels capable of safe operation at any period of time qualify as UMS (Unattended Machinery Space) ships. A modern automation and control system is a fully integrated systems covering many aspects of the ship operation that includes the propulsion plant operation, power management operation on the auxiliary engines, auxiliary machinery operation, cargo on-and-off-loading operation, navigation and administration of maintenance and purchasing of spares. [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 home security system has been proposed in reference [3] to monitoring windows and doors at night and raise alarm automatically.

A similar paper [4] shows the project has GSM technology and anti-theft system using PIR motion detection. Whenever Motion is detected it sends the SMS on predefined mobile number. We have connected PIR Motion sensor with this project. GSM based home security system with SMS alert, it uses PIR Motion Sensor, GSM Modem and 16×2 LCD is used to display system status, It Sends SMS through GSM modem that is attached to Serial Rxd and T (engineer, 2017)xd Pins when motion is detected from PIR sensor, Set your mobile number inside the code in Send SMS subroutine.

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 both tank and a microcontroller will constantly observe the 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, buzzers and standby motor. LEDs which serve as display are installed on the panel boards. The overall control system is realized by using a smaller 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 for respective tank will stop automatically and the standby pump will keep running. The motor will be controlled by the MCU through a relay.

2.1 Component

The proposed controller system comprises of following main components.

(1) PIC16F877A, this Microcontroller come with only 40-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.

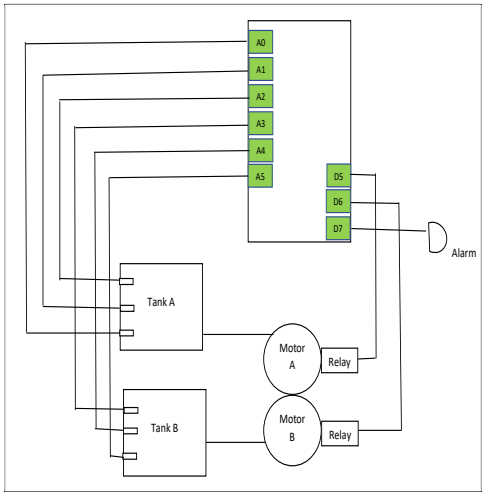

Figure 1: Simplified Schematic diagram

2.2 Operations

The operation of the controller is described below:

o at normal (N) level of both tanks, the respective tank motor will run continuously. Lcd will display normal condition.

o When liquid reaches Low (L) level in the tank A, LED L will be ON, the Alarm will be triggered, and standby motor B will run. Lcd will display Low condition.

o When liquid reaches Low Low (LL) level in the tank A, LED LL will be ON, the Alarm will be triggered, and motor A will stop (prevent the damage to the motor) while motor B keep running. Lcd will display Low Low condition.

o When liquid reaches Low (L) level in the tank B, LED L will be ON, the Alarm will be triggered, and standby motor A will run. Lcd will display Low condition.

o When liquid reaches Low Low (LL) level in the tank B, LED LL will be ON, the Alarm will be triggered, and motor B will stop (prevent the damage to the motor) while motor A keep running. Lcd will display Low Low condition.

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

Table 1: Truth Table

Input Ports						Output Ports						
S1	S2	S3	S4	S5	S6	N	L	LL	LCD	Alarm	Motor A	Motor B
1	0	0	0	0	0	Off	Off	On	On	On	Off	On
0	1	0	0	0	0	Off	On	Off	On	On	On	On
0	0	1	0	0	0	On	Off	Off	On	Off	On	Off
0	0	0	1	0	0	On	Off	Off	On	Off	Off	On
0	0	0	0	1	0	Off	On	Off	On	On	On	On
0	0	0	0	0	1	Off	Off	On	On	On	Off	On

2.3 Microcontrollers

PIC16F877A [5], 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 PIC16F877A microcontroller which is sufficient enough to act as the central control of the system.

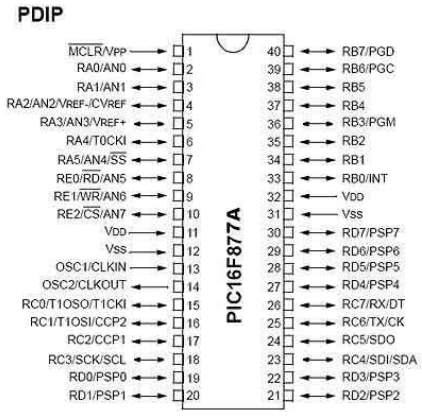

Figure 2: PIC16F877A Microcontroller Pin assignment (PDIP)

2.4 Software

The "C compiler for the PIC MCU," is utilized for composing [6], editing, compiling, and programming the codes for the microcontroller. This 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 PIC16F877A 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).

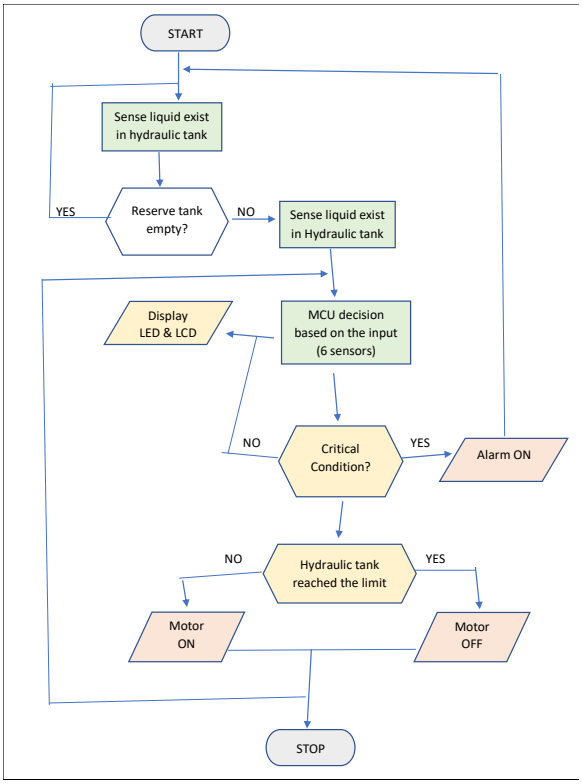

Figure 3: Flowchart of the system

[Open]

2.7 Circuit

The circuit have five 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.

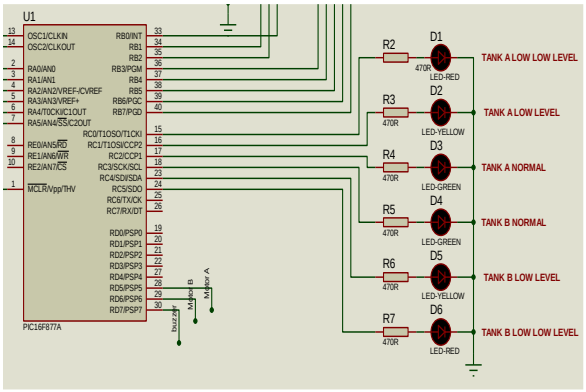

Figure 4: Input & Outputs

As in figure 4, all the 6 input sensors are connected using the Port A, and all the output of the system are connected using the Port C including the display units (LEDs).

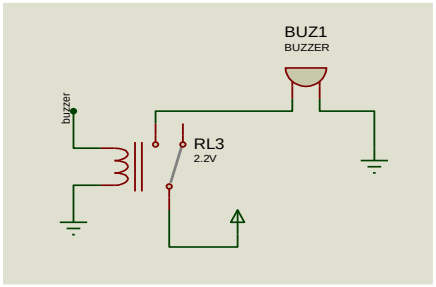

Figure 5: Alarm Circuit

Once the liquid in either tank reaches Low (L), 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.

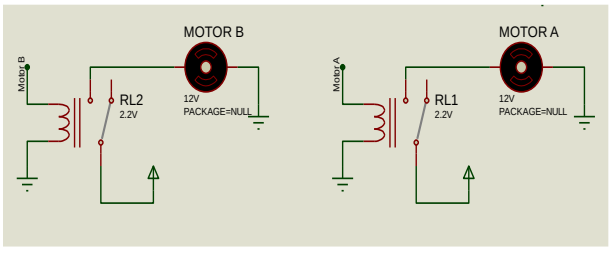

Figure 6 : Running Motor Circuit

The standby motor, will start automatically when the liquid in respective tank level yet to reach to sensor (S2,S5), and running will stop automatically when the liquid in respective tank level yet to reach to sensor (S1,S6) (Figure 6).

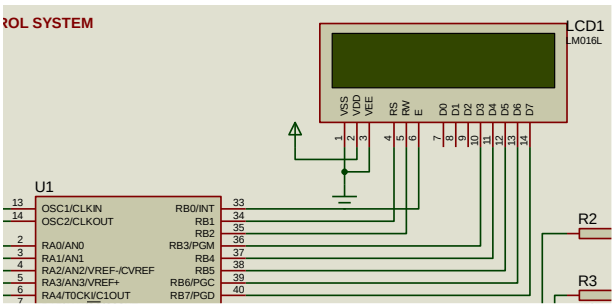

Figure 7: LCD Display Circuit

The lcd display will show the condition of all event in the circuit (Figure 7).

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 4 parts of circuits. The inputs from the sensors were connected to RA0 till RA5 pins (using Port A) of the microcontroller while the outputs of the system were connected through RB0 till RB7 for the LCD display units (figure 7), RC0 through RC5 for the LED display units, and RD7 is connected to the alarm (figure 5), and finally the (RD5, RD6) is used to connect to the Motor relay (figure 6). All the output pins are connected through (Port B, C and D) 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, then utilized LED and LCD 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 PIC16F877A – 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.

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