Design, Modelling and Application of Microcontroller (MCU) on Board Auto Bilge Pumping System

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ABSTRACT

In marine industry all large ship must be installed with proper bilge pumping arrangement regard with SOLAS and MARPOL regulation The bilge system's purpose is to pump from and drain any watertight compartment inside the ship. The capacity or size of the pumps in the system is determined by the ship's size, type, and operation. amounts of fluid that have leaked or condensed into a dry space are removed using the bilge method. The machinery spaces, freight holds, cofferdams, voids, warehouses, tunnels, and pump rooms are all served by the system. While each space has its own piping, the pump is most likely shared or separately installed. The bilge main is set up to drain every watertight compartment except the ballast, oil, and water tanks, and discharge the contents overboard. The number of pumps and their capability are determined by the vessel's size, type, and operation. Both bilge suctions must have appropriate strainers, which in the machineries space will be mud boxes at floorplate level for easy access.

The author of this paper proposes a simple low-cost microcontroller device design for bilge well auto start and stop pumping when the bilge well level reaches a certain level. The proposed design was first simulated in Proteus software before being implemented and prototype tested in hardware models. The software was written in PIC Compilers and then programmed into the microcontroller with a PIC 8-bit microcontroller programmer. During simulation and prototype testing, the proposed microcontroller performed admirably.

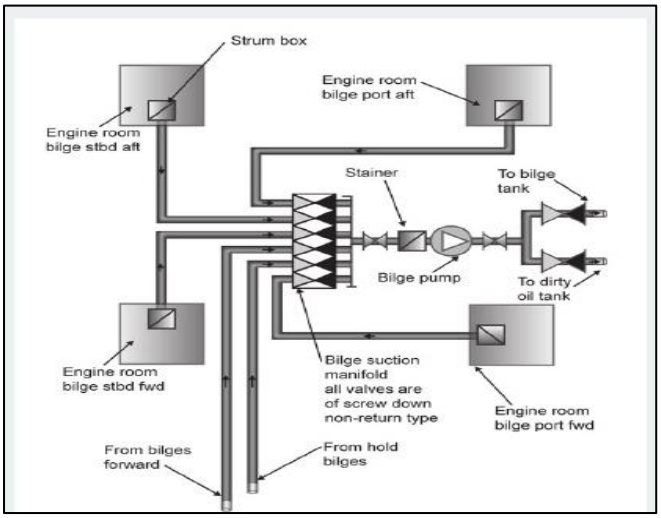

Figure 1: Bilge Pumping Arrangement On Board Vessel

KEY WORDS: *PIC microcontroller, bilge well, MCU*

NOMENCLATURE

CPU Central Processing Unit
LED Light Emitting Diode
MCU Microcontrollers control unit
PDLP Plastic Dual in line Package
PIC Peripheral Interface Controller
UMS Unattended Machinery Space
LCD Liquid Crystal Display
CCS COMPILER Custom Computer Service

1.0 INTRODUCTION

Unattended Machinery Room, or UMS, is a modern way of running a ship's machinery and auxiliary services using digital software-driven automation and monitoring. The use of UMS in ship operations brings in a range of benefits to the ship staff. There have been a lot of change in the traditional watch of a seagoing engineer. The UMS also includes a variety of advanced hardware and software that can perform additional tasks, such as machinery. Condition control, maintenance management that is more modern, and logging of data. Various parameters such as pressure, vessel position, temperatures, level, flow control, torque control, viscosity, speed, current, voltage, and equipment position (open / closed) are all taken into consideration. Computer status (on / off) is manually reported in Traditional ships can now be easily tracked, and auto mode is available. [5] This system for this project is to designed to make ease to ship staff regarding the prevention of flooding inside the engine room. Running the bilge pump while the sensor detects high levels of bilge water in the bilge well and pumps it to the bilge tank until the level returns to normal. When there is no suction in the system, the sensor for the pump will sense warning of bilge pump long run and will stop the motor.

1.1 Developments of microcontroller based systems

This section describes research work of the teams and some author conducted for the monitoring of process and operation of bilge pumping arrangement and some similar system using on land and marine industry using microcontrollers. The schematics
arrangement of control and monitoring the water level. The system monitors bilge level remotely and automatically will transfer the bilge to other tank in auto operation. And additional of the safety device added to give more efficient to the system. [2]

1.2 Similar System

This section refers to some researchers work that is related to the tank level in others system. The system that similar with this project system is sewage treatment plant which are method of monitoring the level of sewage in the treatment plant to discharge overboard after be treat properly. It could monitor the entire system remotely. At the end of process to treat the sewage, when the level on chlorination tank showing high level automatically will start the pump to discharge sewage overboard or to holding tank. The chlorinator is fitted in the last chamber to treat the final stage water for discharging overboard. The chlorinator can be of tablet dosing type or chemical injection type. Inside the tablet-based chlorinator, clean water comes directly in contacts with the chlorine tablets, making a chlorine solution. The chlorinator comprises cylinders for filling the chlorinator with tablets. In chemical pump type, a measured set quantity of NaOCl is injected to sterilization/ chlorination tank using the diaphragm type reciprocating pump. Usually, three float switches, namely – high level, low level, and high alarm level switch are fitted on the chlorination/sterilization

chamber. This chamber is also fitted with level switches to control the start-stop of the discharge pump. [4]

1.3 Current System

Current control system in now days when the ship is used the old system, bilge pumping arrangement is manually used. All related with the bilge pumping system including valve opening, pump start and stop will be manually operated. Now days new ship design with engine room in UMS operation, all pumping arrangement will change to auto pumping arrangement.

The tank controls are not fully automated and still requires some manual controls on the tanks. Most of the vessels used the limit or float switches to activate or deactivate the pumps or motors on board.

1.4 Proposed System

A modern, safe, effective, configurable, efficient and easy to be operated electronic control system is proposed to change the old system to give more beneficial assistant and backing for the ship crews in modern building of the ship. When a ship in UMS mode it makes bilge pumping arrangement easier by the ship staff to handle.

2.0 METHODOLOGY

In this design, level sensors are attached to the bilge well tank and a microcontroller will constantly observe the bilge well tank levels. Sensors act as switches to complete the circuits, and the MCU will then decide next action will happen. Alarm 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 buzzer and LCD display. 3 MCU consist of main MCU, LED MCU and LCD MCU used in this project. 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 bilge level in the bilge well indicate high level, the motor will automatically activate and pumps the bilge to bilge holding tank. The motor will be controlled by the MCU through a relay. If the motor of pump running in long run condition, alarm will have triggered and stop the motor. Pump will put on manual mode and need to rectify the problem before it can operate by manual mode. Also in the system is included the LCD display for showing and indicated the alarm trigger on high level, normal level and pump long run.

2.1 Component

The components of the system consist of 3 units of (1) PIC16F84A MCU microcontroller. This Microcontroller come with only 18-pins. The Plastic Dual in line Package (PDLP) that would perform as the brain of the system, (2) light emitting diodes (LEDs) to turn as visual response, (3) Buzzer which function as the hearing response aids, and (4) switch act as Sensors that is installed to the main bilge well, (5) Motor that will be activated to run the pump, (6)2 type of Relay LM016L and RTD14024F which will be used to control the Motor, Buzzer and indication of running and stop motor. Figure 1 illustrates the schematic diagram of the system design.

2.2 Operations

The operation concept is described below:

- When bilge reaches High Level in the bilge well, LED yellow for High Level Alarm will respond and blinking and the buzzer will have sounded and on LCD will displayed the (BILGE WELL HIGH LEVEL) and will start the bilge pump motor
- When the level is at Normal Level position, LED Normal level will be blinking and will stop the bilge pump motor and on LCD will display the (BILGE WELL NORMAL LEVEL).
- When long run motor is happening, LED will be blinking and buzzer will trigger and bilge pump motor will stop running
- On LCD will display the (WARNING, LONG RUN MOTOR ALARM)
- System can put on manual mode and can run the motor bilge pump by local start. Indication will be showing the LED is lighting on when pump is running and ON auto start.
- There have selector to select pump in auto or manual mode.
- There also has indication consist of LED pump in run or stop operation.

Table 1, shows the logic of the operations.

TABLE 1:TRUTH TABLE

INPUT							OUTPUT									
MAIN			ALARM MCU				MAIN				ALARM MCU					
AUTO A0	MANUAL A1	LOCAL START B1	LONG RUN A0	HIGH LEVEL A1	AUTO START B0	NORMAL A3	LED AUTO A2	LED MANUAL A3	PUMP B0	LOCAL SWITCH RELAY B2	LONG RUN ALARM B0	HIGH LEVEL ALARM B1	LED RUN B2	LED STOP B3	MOTOR LED STOP/RUN B6	BUZZER B7
0	1	0	1	0	0	0	OFF	ON	OFF	OFF	*ON	OFF	OFF	OFF	STOP	ON
0	1	1	1	0	0	0	OFF	ON	ON	ON	*ON	OFF	ON	OFF	RUN	ON
0	1	0	0	1	0	0	OFF	ON	OFF	OFF	OFF	ON	ON	OFF	STOP	ON
0	1	1	0	1	0	0	OFF	ON	ON	ON	OFF	OFF	ON	OFF	RUN	ON
0	1	0	0	0	1	0	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	STOP	OFF
0	1	1	0	0	1	0	OFF	ON	ON	ON	OFF	OFF	ON	OFF	RUN	OFF
0	1	0	0	0	0	1	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	STOP	OFF
0	1	1	0	0	0	1	OFF	ON	ON	ON	OFF	OFF	ON	OFF	RUN	OFF
1	0	0	1	0	0	0	ON	OFF	OFF	OFF	*ON	OFF	OFF	OFF	STOP	ON
1	0	1	1	0	0	0	ON	OFF	OFF	ON	*ON	OFF	OFF	OFF	STOP	ON
1	0	0	0	1	0	0	ON	OFF	ON	OFF	OFF	ON	ON	OFF	RUN	ON
1	0	1	0	1	0	0	ON	OFF	ON	ON	OFF	ON	ON	OFF	RUN	ON
1	0	0	0	0	1	0	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	RUN	OFF
1	0	1	0	0	1	0	ON	OFF	ON	ON	OFF	OFF	ON	OFF	RUN	OFF
1	0	0	0	0	0	1	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	STOP	OFF
1	0	1	0	0	0	1	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	STOP	OFF

*Delayed for 12 seconds

2.3 Microcontroller

Microchip makes a series of microcontrollers known as PIC. PIC stands for Peripheral Interface Microcontroller, and it was developi ng by General Instruments Microcontrollers in 1993.There are many type of microcontroller and almost of the are cheaper, functional and simple. In comparison to other microcontrollers, such as the Arduino Uno, which are more expensive and come with development boards. However, if you don't want to spend a lot of money on your project, a single chip pic micro would be ideal. PIC16F84A microcontroller is a very famous pic microcontroller and also known as beginner microcontroller. This microcontroller considered for new learner to learn about PIC microcontroller and programming. Its contains 35 assembly language and the cost less than 2 USD per unit. All instructions are takes one cycle to complete except branch instructions. Size of instruction is 8-bit. Operating frequency maximum is 20MHz. But it can be operated on lower frequency also to save power. The size of data in this microcontroller is 8 bits. To programme the system less time need. It has 1024 words of program memory. If you are working on simple applications then 1024 words of program memory is enough, and this is where PIC16F84A is frequently used. [3]

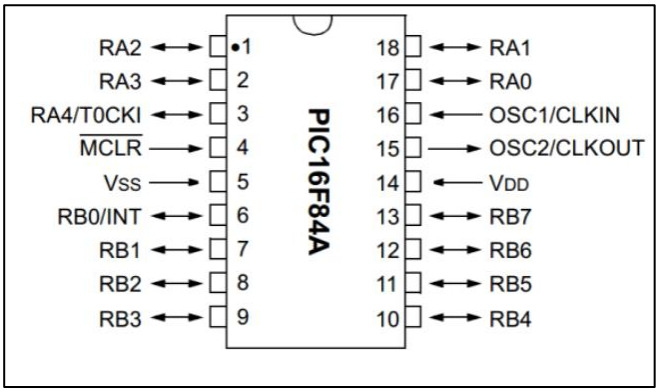

Figure 2: PIC16F84A Microcontroller Pin assignment (PDLP)

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 pins 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 will have activated the Alarm and 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 auto mode to sensing the level of bilge well, sensors which are attached to the tank will then sense the high level of the tank, and send the signal to the Microcontroller Unit. The MCU then will intelligently decide on the next course of action, will display the alarm on LCD and buzzer will sounded and give a signal to motor to auto start to pumping the bilge until normal level. If level still high and no suction on pump motor and its running in long run condition it also will triggered the alarm on buzzer and will display on LCD and automatically will stop the pump. Figure 3.

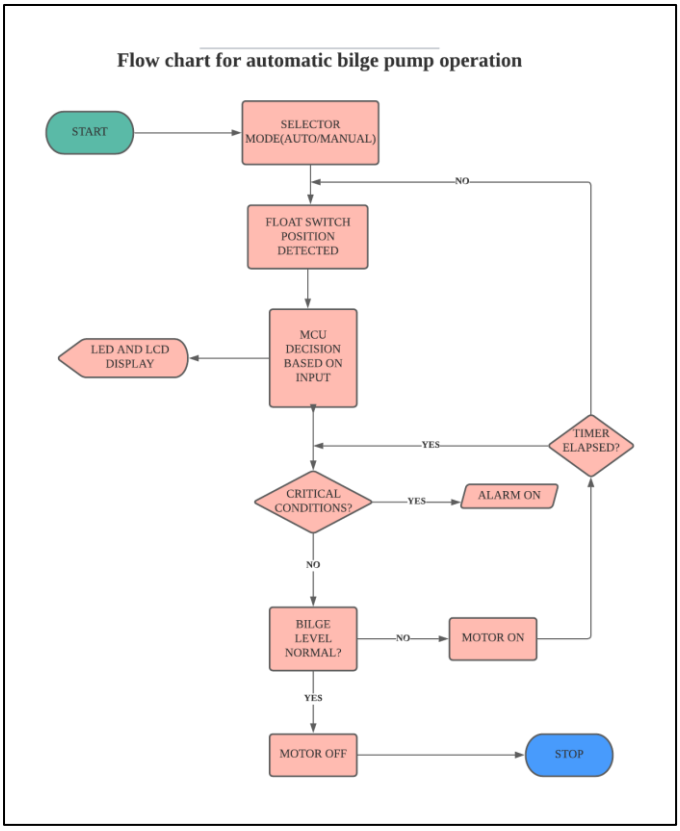

Figure 3: Flowchart of the system

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 3 MCU units. Figure 4

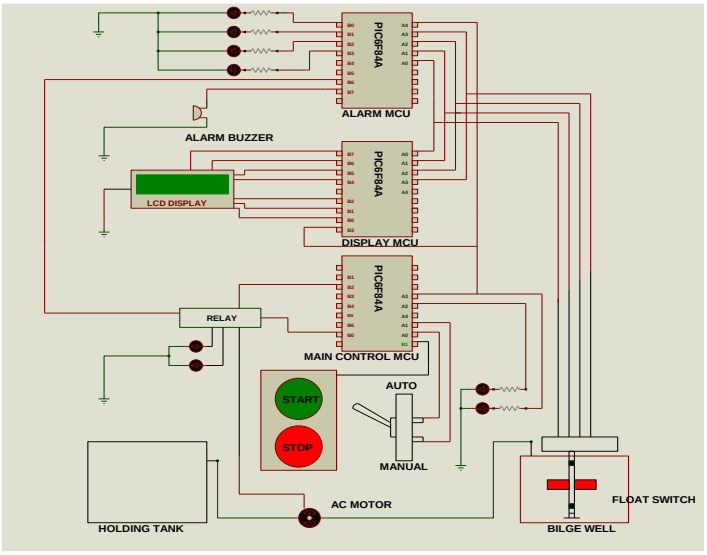

Figure 4: Simplified schematic diagram

The circuit have 3 units of microcontroller, consist of main control MCU, LCD display MCU and LED alarm MCU. The other element is consisting of input electrical part and output electrical part. It's also included the power source and grounding units. All the input is connected using Port A and output using the Port B. In main control MCU it will control the selector on auto and manual mode, start and stop button and running and stop condition indicator of motor. (Figure 5).

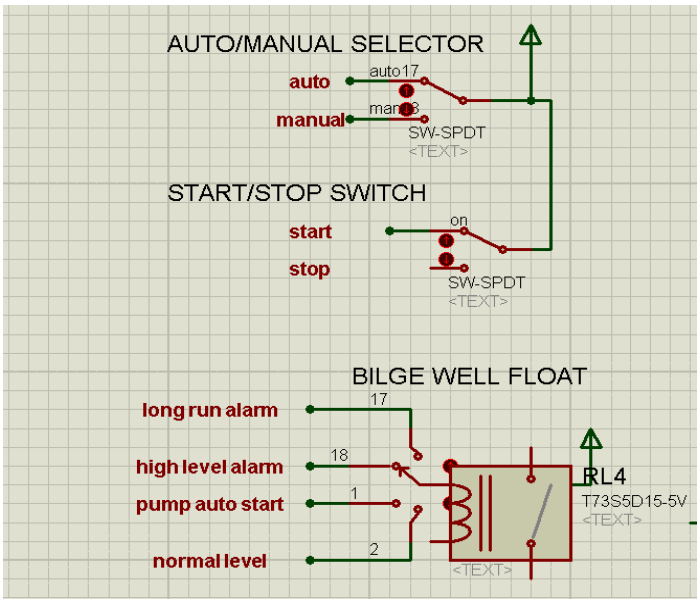

Figure 5: Auto and manual mode / start and stop button

When alarm high level indicated, main MCU will get the input and the output will trigger by MCU and automatically will run the motor. Figure 5

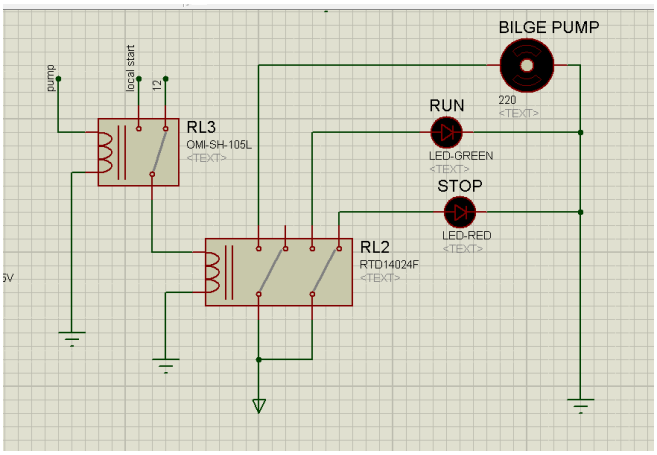

Figure 6: Main control MCU to run the motor and LED to indicated the running and stop condition of the motor

In alarm MCU consist of input float switch sensor will sense the high level or normal level bilge well and will trigger to MCU output to indicated the LED to blinking at the same time the buzzer alarm will sounded. There have four LED consist of high level alarm, long run motor, start and stop indication of motor. For the long run motor sense to MCU, automatically the motor will stop and its act as interlock for safety device. Figure 7.

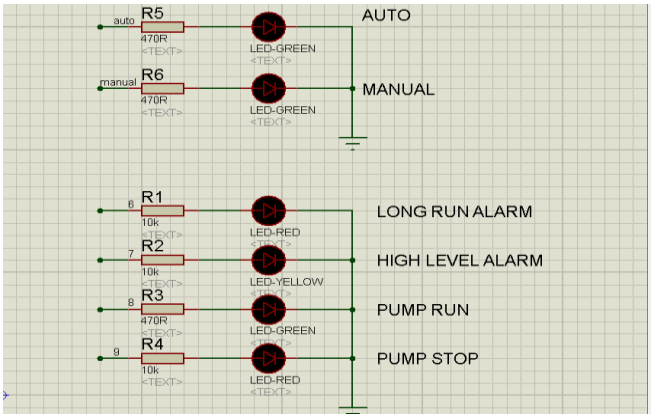

Figure 7: Output for MCU alarm

The display MCU consist of input for sensing the level of bilge well and output consist of LCD display for alarm high level, warning long run motor, bilge pump run and stop operation. Figure 8

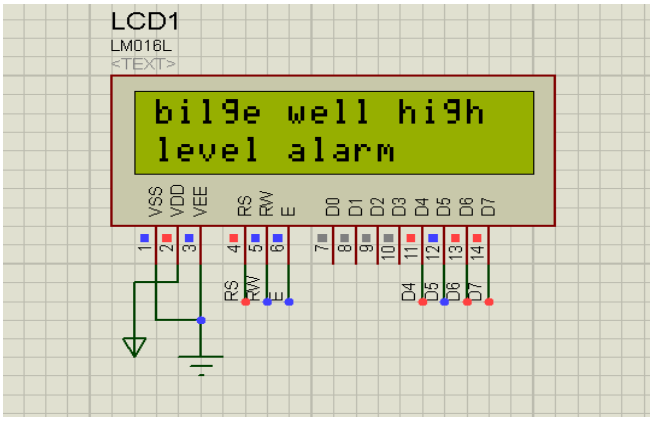

Figure 8: LCD display MCU

3.0 CIRCUIT DESIGN 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 in Figure. 4. There are used 3 MCU to complete this circuit. The 3 MCU is main MCU, alarm MCU and LCD display MCU. For main MCU, for input there used pin RA0 to RA3 and the output there used pin RB0 to RB2. There are consist of auto and manual selector and auto and manual start. For output consist of indication of LED on auto selector, manual selector auto starts and manual start. For the alarm MCU for input there used pin RA0 until RA4. For the output there used RB0 until RB3 and included the pin RB6 and RB7. For the input consist of four pin there are sense of high bilge level, warning for long run motor and start and stop of motor. For output consist of alarm buzzer, warning long run motor, high bilge level and start stop of motor. For LCD display MCU unit the input used pin RA0 until RA3. For the output there used the pin RBO until RB7 to LCD display unit except for RB3 output to manual mode. For the input it senses of high level alarm, long run motor, start and stop of the motor. And for output to indicated and display all the process transfer into LCD display. For RB3 output to send the signal for manual mode so the motor can run in manual mode.

4.0 RECOMMENDATIONS

In this paper, the team presented the operation of bilge pumping arrangement in auto and manual mode. On this project it is demonstrate the microcontroller used as the part of the complete circuit for detected the level of bilge well and utilized the LED for signal and to activate the buzzer sounded. For the additional of this project is LCD display unit are added to more system efficiency and improve awareness for the watch keeper. One of the big part of this project is the motor for the bilge pump. When a signal for input showing high level alarm and warning long run for motor it will cause the motor to start and stop. So every one of these component is controlled and intelligently decide by the PIC18F84A microcontroller. For this circuit it makes more simple and not so complicated and it suitable used on board modern vessel which follow the requirement needed and updated regulation.

5.0 CONCLUSIONS

Thus, this system will ensure the occupational safety on board and meet requirement by MARPOL regulation by minimizing the time for the crew to frequently work during UMS operation to monitoring the bilge level, flooding to happened and to monitored and act as safety device for the motor to run in long period. More effectively additional to LCD display too easy for ship crew to see any operation and alarm indicated in LCD monitored.

This system could further be improved in future. Should be must have the alarm for high level alarm on bilge holding tank and automatically will stop the motor, otherwise bilge holding tank will Rise until full and flooding will happen. For make sure during UMS no alarm coming, before engine room put on UMS, ship staff must alert and to make sure the bilge always in low level and manually pumping the bilge is carried out. If alarm for bilge high level still coming that showing have leakage of water to bilge need to rectify before engine room to put on UMS.

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