Indigenously Designed Addressable Bilge Alarm System for Naval Vessels

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Abstract: *The primary purpose of an Addressable Bilge Alarm Panel is to provide an early warning of the bilge level of a vessel so that the personal, equipment and valuable resources can be protected and action is taken to remove bilges as soon as possible, all according to a predetermined plan. This study presents aspects of the bilge alarm system onboard Sri Lanka Naval Ship (SLNS) Sagara, by analyzing the existing system based on automation and advanced microcontroller programming using Raspberry Pi3, and ATMEGA 328P microcontrollers. The designed system is an addressable type bilge alarm system that communicates in serial RS 485. The novelty of the designed system are the own data protocol used in RS 485 communication, voice command of specific bilge location and the self designed advanced graphical user interfaces (GUI). In the simulation process, the bilge alarms may be raised automatically by a bilge sensor or manually by a person operating a test button. This response indicates the exact location of the ship on the given blueprint of the touch panel and provides an automatic warning alarm of the bilge location through the ship fitted General Alarming system. The study covers the designing process, implementation, microcontroller and Touch Panel programming, simulation process, testing and commissioning process. The designed system was installed onboard and tested for several months under different sea conditions by experienced Senior Electrical Engineers and Marine Engineers of SLN, then the system was commissioned on 03rd February 2022.*

Keywords: *Bilge alarm, communication protocol, GUI*

1. Introduction

A ship either being a merchant or war, the bilge alarm system plays an enormous role to protect the ship by confirming its stability and reducing the risk of marine causalities. It helps to identify any leakages of water, oil or any types of liquid in underwater compartments whether from onboard fitted machinery or ingress water from the sea. To identify the bilges compartment of the ships, reserved with risk markings are fitted with floater or level activated sensors. These sensors are activated with the bilges crossed to their permissible limit and give sensing data to the designed integrated systemThe Officer Of the Watch (OOW) on the Bridge, officer in the Machinery Control Station (Engine Room) and Damage Control Headquarters (DCHQ) of the ship will immediately identify and activate the preventive actions such as bilge pumps operation, emergency repair party initiatives, etc.

The overview of the GUI is displayed in figure 1. Specific bilge locations are plotted on the blueprint of the specific ship such that any bilge status is clearly visible in an emergency. Meantime, an audible alarm specifying the relevant bilge location is activated through the ship's broadcast system so that ship's crew gets aware of the bilge location remotely.

Figure 2. Bilge Alarm GUI

2. Literature Review

International regulations have been imposed to confirm the water tight integrity of a ship. Standards for bilge alarms and de-flooding have been introduced through such regulations as Safety of Life at Sea (SOLAS), UK Statutory Instruments etc. Procedures have been mentioned to implement in a flooding situation.

As per UK Statutory Instruments (Regulations, 2021) have been imposed in 2021 for cargo ship bilge alarms. It is stated that a bilge alarm may be risen within 30 seconds upon detection of a high bilge state by a sensor.

Regulations related to the pumping of flooded compartments have been listed under SOLAS by the International Maritime Organization (IMO) (SOLAS, 1997) . All parameters related to bilge main, pumps etc have been elaborated in the regulation.

Studies have been conducted by different parties to calculate the risk factors according to the flooding level and risk severity of a ship (Liu, et al., 2021). Many researchers have applied fuzzy reasoning to logically express the risk analysis of flooding.

3. Implementation

The study was carried out to introduce a novel design with an indigenous server client communication protocol with advanced monitoring and alarm facilities. The overall functional diagram is described in figure 2.

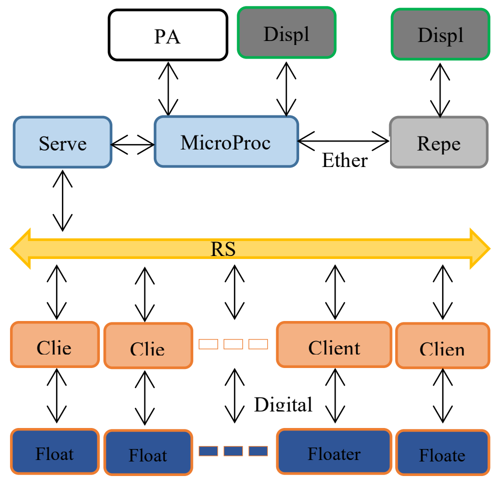

Figure 2. Functional Block Diagram

A. The Server

server is designed to be the heart of the overall functioning of the system. Main processing, communication establishment and execution of audio files will be handled by the server. The layout of the server is elaborated in figure 3. A printed circuit board (PCB) shown in figure 4 has been self designed to cater to the server functions.

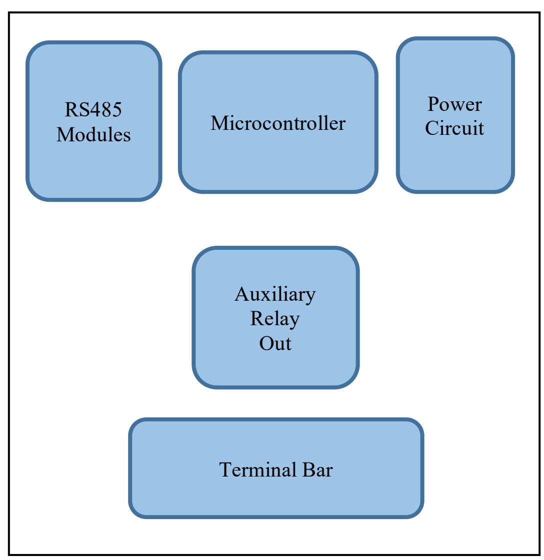

Figure 3. Server Layout

Figure 4. Server PCB

B. Client (Slave Device)

There are 06 Nos. of clients in the designed system which is feasible to be extended up to 31 Nos. Individual floater switches are integrated into the relevant client to indicate bilge high/ low state. Following bilge locations of the ship have been installed with the clients.

i. After Steering Post

ii. Engine Room

iii. Auxiliary Engine Room

iv. Harbor Diesel Alternator Room

v. After Baggage Room

vi. Forward Baggage Room

Each client will be responsible for communicating with the server to send the real time bilge status of each floater. A self designed PCB shown in figure 5 has been used for the client's purpose.

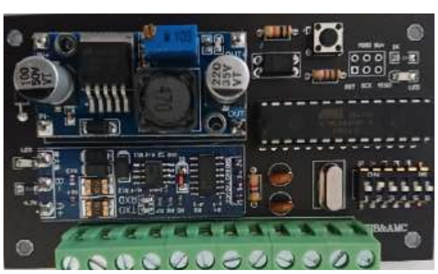

Figure 5. Client PCB

C. The Communication Protocol

An indigenous communication protocol has been introduced using RS 485 serial communication. Each client has been assigned both physical and software addresses as their ID. The physical address is to be set with the aid of dip switches shown in figure 5. The software address has been set in the program. Both addresses will be matched by the server for data transfer during serial communication.

A data array has been formed by the client in the following form shown in figure 6.

Figure 6. Client Data Format

The server will send a request to each client with the client ID. The corresponding client will respond to the server with the real time bilge status. In every loop, each client will be called by the server. Then, the above data stack will be appended by the server as in figure 7. Any malfunction of a client will be notified on the GUI as a communication error.

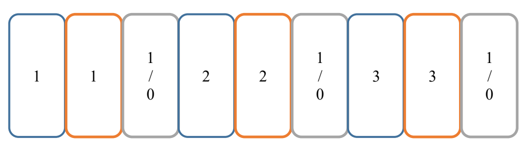

Figure 7. Appended Data Array

Thus appended data array corresponding to the number of clients will be transferred serially to the Raspberry Pi microprocessor shown in figure 3.

D. Graphical User Interface

The GUI has been designed for the server and repeater panels to demonstrate the bilge locations as shown in figure 1. In order to indicate the specific location, the appended data array has been split again by the microprocessor and mapped on the GUI as a low/high alarm state.

E. Main Monitoring Panel

The main monitoring panel shown in figure 8 consists of the server, Raspberry Pi microprocessor and touch screen display (configured in Raspbian operating system) with GUI and has been installed either in the machinery control room or the DCHQ. Further, GUI is created based on JavaScript programming language and an executable file is generated for easy access through the touch screen panel to simulate the bilge indications.

Figure 8. Main Monitoring Panel

F. RepeaterPanel

A repeater panel shown in figure 9 has been introduced and installed on the bridge of the ship for remote monitoring of the bilge status. A similar GUI has been modeled into the repeater panel. The latter communicates with the main monitoring panel through Ethernet communication. The system has been designed as user friendly such that a healthy connection between the two panels is indicated on each monitoring panel.

Figure 9. Repeater Panel

4. Performances

Specific fixed address for each client and allocated for every bilge compartment. The facility has been provided to the end user to manually test each client by pressing a test button arranged in each client device. Simultaneously, the bilge alarm warning on the GUIs of the main monitoring display and the repeater panel was checked along with the vocal alarm of the specific location through the ship's broadcast system. The following additional indications have been provided on the GUIs for user friendly fault identification.

i. Slave (Client) Communication Error (On main monitoring display)
ii. Repeater Connecting (On main monitoring display)
iii. Repeater Connected (On main monitoring display)
iv. Master Connecting (On repeater display)
v. Master Connected (On repeater display)

The system was thus tested for performance and fault tolerance, then commissioned on 03rd February 2022 onboard Sri Lanka Navy Ship Sagara.

5. Conclusion and Future Work

A study has been conducted to introduce an indigenously designed and developed addressable bilge alarm system for Sri Lanka Naval vessels. Self designed monitoring and advanced communication methods have been introduced to monitor the risk of bilges inside vulnerable compartments in a ship. Self designed PCBs, communication protocol based on RS 485, GUIs and vocal alarms have been put forward as the novel outputs of the design.The addressable bilge alarm system has been tested and proven to the suitability in a marine environment.

The design can be extendable up to 31 Nos. of Clients (Slave devices). Further, this study can be continued with fuzzy reasoning to calculate the risk likelihood and risk severity of flooding for a given compartment. Risk likelihood may be based on the location, draft of the compartment, type of machinery available in the compartment etc.

References

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