Health Monitoring of Ships using Power Line Communication

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***Abstract*— To maintain the reliability and operational continuity of a ship, even in the adverse conditions, it is necessary to continuously monitor a wide range of parameters. In this process of monitoring, another herculean task is to regularly transmit the information to the control center and then initiate a suitable action if in the case of an emergency. In this paper, an experimental setup is developed to integrate the multiple sensors in the monitoring units with the control center using power line communication. Compared to other communication technologies, PLC has the advantage of avoiding extra communication cables and thus reducing the weight of the ship.**

***Keywords*— Accelerometer, Gas sensor, Humidity sensor, water log sensor.**

I.INTRODUCTION

Once the ship sets sailing, it is anticipated that it will operate with the highest reliability and withstand against any minor turbulence. The very reason for this expectation is the difficulty in undertaking major repair works while at sea. To maintain the survivability and reliability of a ship, the various parameters affecting the ship operation are to be constantly monitored. But the ship's enormous structure will also bring in the difficulty in undertaking monitoring activities.

The ship decks are divided into compartments whilst accommodating large machinery like boilers and generators. The compartment layout is usually complex and congested to cater to the various needs of the ship. The deck and platforms of a ship can be depicted from the Figure 1. Due to the very nature of the heavy machinery and also the operational conditions of the ship, there may be gas leakage, water logging or fire mishaps. Another worrisome parameter is the excessive movement of the ship due to turbulence created in waters.

For a safe and reliable operation, it is necessary to continuously monitor such parameters at various strategic locations of the ship. The information from the monitoring units should be transmitted to the control center for further necessary action. The received information can be logged for future reference and simultaneously preventive measures can be notified to the crew members if in the case of any abnormality in the ship condition.

For a bigger size ship, like a cruise or merchant vessel, the distance between the control center and the monitoring unit may be of larger distance. Hence the medium in which the information is to be transmitted is also important. Since the ship is entirely made of a metal, wireless transmission is not possible and any wired communication system like Ethernet or DSL cables may only add weight to the ship [1]. In addition to this, any additional wiring will only increase the maintenance of the ship and also compromise the ship space. The control units can be decentralized keeping in view the ship's size or can be placed in an optimal location. Whatever the case may be, the control center should be able to alert the maintenance personnel for quick action.

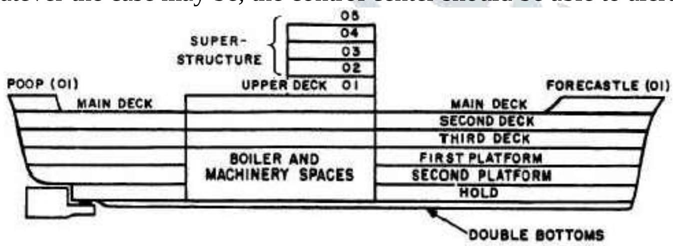

Fig. 1. Illustration of ship decks and platform

Communication over power lines will make use of the existing infrastructure and hence will have very minimal installation costs. Since all the compartments of the ship are electrified, there will be no need for any additional cabling. The sensors can be connected to the existing electrical networks and the data can be transmitted to the control center. In the recent past, Power line communication (PLC) technology has attracted the industry and academia to the higher bandwidth it is offering. Based on the application, the PLC technology can be implemented in the narrow band or broadband i.e at kHz frequency band or MHz frequency band.

In this paper, an experimental setup is developed to monitor the multiple parameters and transmit the information to the control center via power lines. The parameters monitored in this paper to estimate the ship condition are water logging, fire, gas leakage, humidity and ship turbulence. The control unit will continuously receive the data and will alarm if any abnormality is detected in the parameters.

The subsequent sections of this paper are organized as follows. The section II will give a brief description of power line communication and its applicability for monitoring the various parameters. Section III discusses the functional layout of the developed system. Section IV discuss about the components used in developing the experimental setup. In the final section, the operational outcome of the setup is discussed.

II. POWER LINE COMMUNICATION

PLC makes use of the existing electrical network to transfer data from one node to another. Due to the omnipresence of electrical lines, PLC provides an economical alternative for transmitting the information. Though PLC offers numerous advantages to the user, it should be noted that the power lines were actually not intended to transfer data. The medium may be hostile to communication. Hence, prior to the implementation of this technology, the medium needs to be thoroughly understood. The power line channel characteristics across the world will be different and the same applies to the different topologies. To be more precise, the different types of ships will have different electrical wiring pattern and inconsistent load specifications [2].

In the recent past, research is being carried out in different parts of the world to understand the power line characteristics. The industrial networks and vehicular power line channels, like car, ship and aircraft are also under investigation to analyze the channel behavior. It should be noted that, ship power systems present highly spurious signals [3]. The analyzed behavior is modeled using various channel modeling techniques for further development of a reliable and efficient PLC system [4].

Significant research has been carried out in narrowband power line communication i.e 1- 500 kHz and the PLC modems are also commercially available. These modems usually operate at resonant frequency of approximately 150 kHz of and are incorporated with FSK or any other equivalent modulation technique. These modems of the baud rate of 1096 and are generally used for monitoring and controlling the electrical machinery, street lighting control, automatic meter reading etc.

Similar research is also being carried out on the broadband power line communication i.e, data transmission in the frequency range of 2-300 MHz. The signal response and the noise generated from the loads are of the different pattern as compared to narrowband frequency range. Hence the analysis to be carried out in these higher frequencies is also different. Since the research in this frequency range is still in its preliminary stage, the modems are not easily available on the commercial basis [5][6].

One complexity in designing the PLC modem is isolating the mod/demodulator and other ICs from the high voltage supply. Since the data is to be transmitted through the power lines, the circuitry should be physically isolated and simultaneously perform the needful actions. To achieve this, a coupling interface is to be developed as per the required frequency of operation and the voltage level of the power line medium [7].

The coupling interface can be of a ferrite core to insert or extract the data to/from the power lines or a combination of capacitor and transformer connected in series. It is usually preferred for the simplicity in operation and ease of availability and is as shown in Figure. 2. The capacitor filters out the power frequency which is usually 50/60 Hz and permits the signals in the required frequency range. The transformer will be of ferrite core provides the required galvanic isolation.

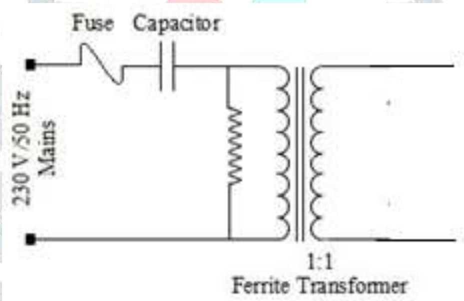

Fig. 2. Coupling Circuit

In the interest of this paper, the PLC modem is expected to operate on the ship power line channels. Assuming the ship distribution voltage is 415/230V supply with 50 Hz frequency, a coupling interface is designed. Since the application in this paper is to transmit the data monitored by different sensors, a narrowband communication modem is used.

III. SYSTEM ARCHITECTURE

The experimental setup consists of two major circuits. The first one is the monitoring unit and the second one is the control unit. The data between the monitoring unit and control unit is transmitted in semi-duplex mode through the existing electrical wiring. The connection to these two circuits is given from the regular power sockets.

A. Monitoring Unit

The monitoring unit has multiple sensors and will be controlled by the microcontroller as shown in Figure 3. The Gas sensor, humidity sensor, temperature sensor, water logging sensor and accelerometer are connected to the microcontroller. Keeping in view the large length of the ship, two accelerometers are connected to the microcontroller.

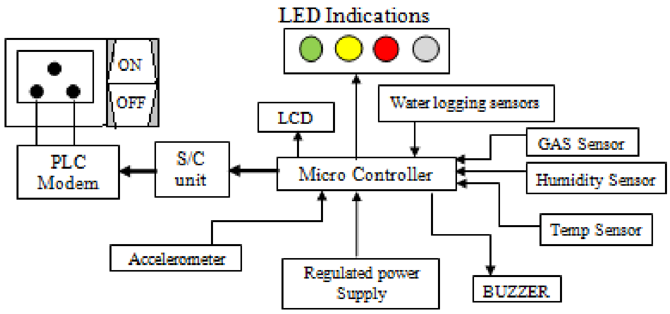

Fig. 3. Monitoring Unit

Each sensor will be set with a predetermined value to detect any abnormalities. If any of the sensors are triggered, the information will be updated by the microcontroller. The microcontroller will display the data on the LCD screen and also activate the buzzer placed in the monitoring unit. The microcontroller is powered all the time through a regulated power supply to monitor the sensor activity. Apart from executing the local tasks, the data will also be transmitted to the control center through the power line medium. The PLC modem is placed between the output of the microcontroller and the power socket.

B. Control unit

The control unit receives the information from the monitoring unit through the power line medium. The received information will be processed by the microcontroller and the status of each sensor is displayed on the LCD screen. The buzzer in the control unit is also activated as shown in Figure 4. The beep timings of the buzzer are set differently for each sensor output, thus indicating the type of abnormality. The microcontroller is also programmed to further action to the monitoring unit. The action will usually be the disconnection of the circuit and consequently safeguard the ship.

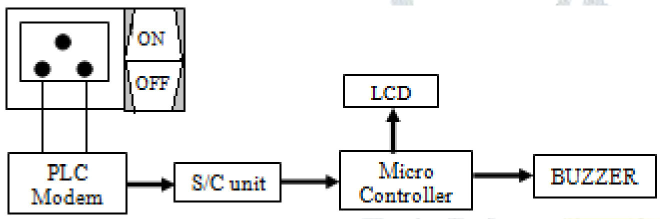

Fig. 4. Control Unit

IV. HARDWARE IMPLEMENTATION

In this paper, the monitoring and control modules developed to monitor the multiple parameters of the ship and transmission of the data for further processing to the control center through the power line medium is shown in Figure 5. Both the modules are connected into the power sockets and the information is passed through it. The microcontroller is powered from a regulated DC power supply. The 230V input supply is stepped down to 12 V. However, based on the supply voltage the transformer output may vary from 12-18 V. The voltage regulator will maintain the voltage at 12 V AC and the full wave bridge rectifier will convert the voltage into 12 V DC [7].

Fig. 5. Hardware implementation

The components involved in developing these modules are the microcontroller, PLC modems, accelerometer, gas/ smoke sensor, water logging sensor, humidity sensor, regulated power supply, LCD display, buzzer and few other accessories. The major components used in these modules are discussed below.

A. Microcontroller

The microcontroller used in these modules is PIC16F877A. It is a fully featured processor with internal RAM, EEROM FLASH memory and peripherals. It is operated at a speed of 10MHz and as the feasibility to easily update the program. It has up to 28 I/O points and 8 channel 10-bit A/D converter. The 16f877A is the commonly used PIC microcontrollers with 40 pin and many internal peripherals. One of the main advantages is that only each pin is only shared between two or three functions so it's easier to decide what the pin function

B. PLC modem

Power line modem is useful to send and receive serial data over existing AC mains power lines of the building. It has high immunity to electrical noise persistence in the power line and built-in error checking so it never gives out corrupt data. The modem is in form of a ready to use circuit module, which is capable of providing 9600 baud rate low rate bi-directional data communication. Due to its small size, it can be integrated into and become part of the user's power line data communication system.

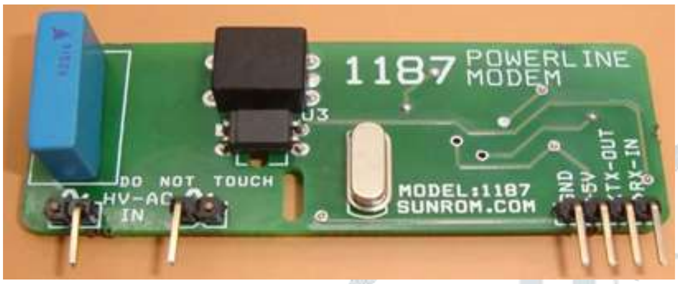

Fig. 6. PLC modem

The PLC modem used in this work is of sunroom technologies and can be used for Home automation, automatic meter reading, process control, sign and information display, fire and security alarm system, remote sensor reading, data/file transfer, fire & security alarm system, power distribution management.

C. Gas Sensor

The Gas sensor used in this system is the MQ2 type Gas sensor as shown in Figure 3. The sensitivity and the response time of this sensor are widely appreciated and can be adjusted by a potentiometer. This is the commonly used sensor to detect the gas leakage in home and industries. It is best suited for detecting the leakage of LPG gas, alcohol, propane gas, smoke etc.

D. Temperature and Humidity Sensor

The sensor used for temperature and humidity analysis is RHT03. It is a combinational sensor of both temperature and humidity. It is cost effective and does not require additional components. It is well-calibrated device and is commonly used.

E. Water log Sensor

The purpose of a float switch is to open or close a circuit as the level of liquid rises or falls. These float switches are usually closed indicating that the water level is low. The circuit is operated with a magnetic reed switch which contains two contacts sealed in a glass tube. When these two contacts come close, they get attracted and allow the current through pass and complete the circuit. The waterlogging sensor used in this paper is YF-S201 water logging sensor.

Fig. 7. Water logging sensor

F. Accelerometer

Accelerometers are electromechanical devices that sense either static or dynamic forces of acceleration. Static forces include gravity, while dynamic forces can include vibrations and movement. Accelerometers can measure acceleration on one, two, or three axes. 3-axis units are becoming more common as the cost of development for them decreases. Accelerometers are useful for sensing vibrations in systems or for orientation applications. The accelerometer used in this module is a ADXL362 triple axis accelerometer.

V. Results & Discussion

The sensors will activate if the readings exceed the threshold limits and the information will be processed by the microcontroller. The microcontroller at the monitoring unit and at the control unit will alarm the buzzer and display on the LCD screen. The LCD displays at both the modules will display the messages corresponding to thebgas leak, water logging or fire hazards. The displays shown in the LCDs can be seen in Figure. 8.

Fig. 8. Temperature sensor output

In fact, the status of the sensors can also be monitored continuously at the control center. The LCD display at the control center will give the information of the sensor status as shown in Figure 9.

Fig. 9. Waterlog sensor status

The developed setup is an ideal prototype to illustrate the applicability of power line communication with multiple sensors. Though the usage of PLC technology onboard ship is in its preliminary stage, it certainly has numerous advantages [8][9][10]. PLC technology supports multi-node of master and slave systems. A single control center in the ship bridge or multiple control centers at strategic locations can be placed.

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