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Implementation of Safety and Security System for House Boats using PIC Microcontroller

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***Abstract*— The paper illustrates the implementation of a complete Smart safety system for house boats using PIC Microcontroller, ZigBee Pro and LabVIEW. The system incorporates relevant sensors and actuators for the measurement and monitoring of critical parameters that adversely affect the safety of house boats as well as security of tourists. A PC based control station, whose Graphical User Interface is designed using Lab VIEW, is used to monitor remotely the respective house boat. Also the location of the house boat is made available in the remote station as well as in the house boat by GPS navigational system.**

Keywords— House boats, PIC, ZigBee, LabVIEW, GPS

I. INTRODUCTION

'God's Own Country', Kerala, has immense scope in tourism, especially ecotourism. One of the innovative and appealing aspects of ecotourism in Kerala is its house boats. The industry was thriving at a profitable level, but of late, frequent accidents that happened in house boats poised a serious challenge to this sector of tourism. Accidents, major and minor, occur in house boat due to inadequate safety measures incorporated in house boats. Also the associated malpractices contributed a major share to the causes of accidents.

Nowadays, along with fast development in electronics as well as wireless communication technology, the foresaid problem can be solved to a large extend. Moreover the sensor development technology for measuring various parameters that cause accidents in house boat, has reached at its peak. The main causes of accidents in house boats are due to overload, fire, alcohol drunken driver as well as passengers, obstacles, over speed, inclination, out dated house boats, short circuits, engine coolant level etc.

An automatic system designed using PIC Micro controller with relevant sensors and actuators can meet the requirements of an effective and efficient monitoring system for house boats. Global Position System (GPS) based fleet tracking unit is used to identify the location of a houseboat and transmit the spatial or geographic information to a remote control station over the wireless communication network. The GPS system will also help the effective navigation of the houseboat. A remote station is developed for monitoring and controlling various relevant parameters which cause the problems towards the safety of house boats as well as security of the tourists. If any abnormal conditions occur, the automatic system produces warning along with audible and visual alarms and send the details to the control station through the ZigBee communication network. From the Human Machine Interface (HMI) device, of which GUI is designed using LabVIEW, arranged in the control room, the houseboat can be guided. Moreover any alerts from the weather forecasting center can be communicated to respective house boats.

TABLE (1) Parameters and Corresponding Actions

Sl.No.	Parameter	Expected Actions
1	Fire	Indication, Alarm, Transmission ,Control@
2	Overload	Indication, Alarm, Transmission, Control#
3	Alcohol (Driver)	Indication, Alarm, Transmission, Control*
4	Alcohol(Passenger)	Indication, Alarm, Transmission, Control^
5	Free board gap	Indication, Alarm, Transmission
6	Obstacles	Indication, Alarm, Transmission
7	Speed	Indication, Alarm, Transmission
8	Inclination	Indication, Alarm, Transmission
9	Gas leakage	Indication, Alarm, Transmission

@ Automatic cut of main supply, emergency standby supply in line, Auto start of fire extinguisher (actions depends on the intensity of fire)
#Engine cannot be started.
* Engine cannot be started
^Entry of tourists to the upper deck is blocked.

A. Related Work

A waypoint tracking guidance controller [1] for an autonomous house boat, based on fuzzy controller has been developed with digital compass and a differentially connected GPS receiver for getting the navigation data. The general concept of automatic berthing system [2] for ships was developed through GPS based system which provides the data for position, velocity, altitudes, angular velocity and time. A control system model [3] for the analysis was discussed for a fully autonomous sail boat navigational system. The proposed system allows an expert system to develop good routs and exploring environmental conditions such as winds, tides and currents. An auto pilot system [4] was designed and developed for guiding the trajectory of a small boat as it perform berthing. A commanding system [5] based on client and server structure was designed, for working boats'

operation. It combines the application of GPS and GIS technology.

A system [6] was proposed for obstacle detection of an intelligent vehicle based on Lab VIEW and laser measurement principle. The obstacles are remotely measured by Laser Measurement System (LMS 291) and the measurement data are collected and processed in LabVIEW environment by serial port RS-232 through VISA. A methodology [7] was proposed to construct a wire-less fire alarm system based on ZigBee. In this paper a comparative study of various wireless technologies like Wi-Fi, ZigBee and Bluetooth was also given. The system based on ZigBee overcomes the limitations of the cable alarm system and avoids high power consumption of the wireless communications technology. Compared with existing wireless sensor network, it has some advantages such as low cost, high network capacity, long life etc. A GPRS based positioning system [8] was presented with an accurate localization has been implemented using PIC18F4550 Microchip. The combination of the GPS and GPRS provides continuous and real time tracking. The system also provides information regarding the vehicle status such as speed, mileage, and driver performance.

II. HARDWAREDESIGN

Figure (1) shows the block diagram of Safety and Security System for House Boats.

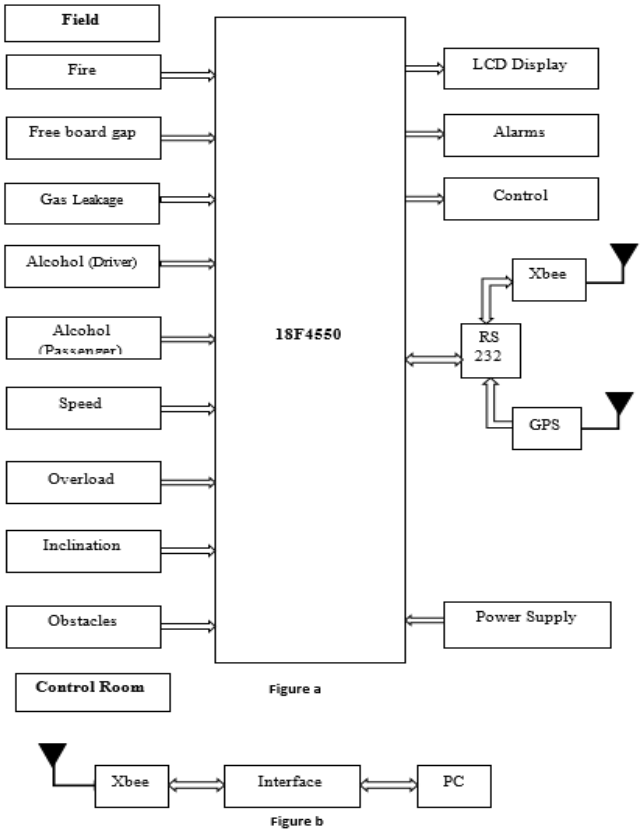

Fig: (1) Block Diagram of Safety and Security System for House Boats

While designing the hardware, selection of relevant and proper sensors and actuators is the most important step. Also the selection criteria for controller (PIC) and communication protocol (Xbee Pro) are again critically important. Moreover due importance has to be given to ensure the availability of data for all relevant parameters, at the input pins of PIC, after proper signal conditioning.

During programming of the PIC, the interfacing and initialization of various peripheral modules such as LCD module, Xbee Pro, GPS module, relay module, Alarm circuit etc.is carried out. Also the effective communication of PIC with above mentioned peripherals, is ensured. The programming of the PIC is achieved using MikroC.

GUI of the PC in the remote control room is designed using LabVIEW and the proper interfacing of XBee with the PC is ensured. Finally evaluated the system by varying various input data and corresponding output data such as display, record and control are verified. Also checked the position of the house boat with GPS navigational system. The system has two areas of operation, one in the field (house boat) and other in the control room.

A. The Field

Fig 1(a) shows the block diagram of the system in the field. As per the Table (1), the critical parameters that adversely affect the safety of house boat are overload, obstacles, fire, alcohol consumed driver as well as passengers, inclination, level etc. These parameters are measured by proper transducers and the measured data are given to the PIC after proper signal conditioning. These data are compared with the set points by the PIC and the derived control signals are applied to the respective output units such as display unit, alarm unit, actuator or transmitter. A brief description of various components such as controller, sensors & output devices are given below.

1. PIC 18F4550

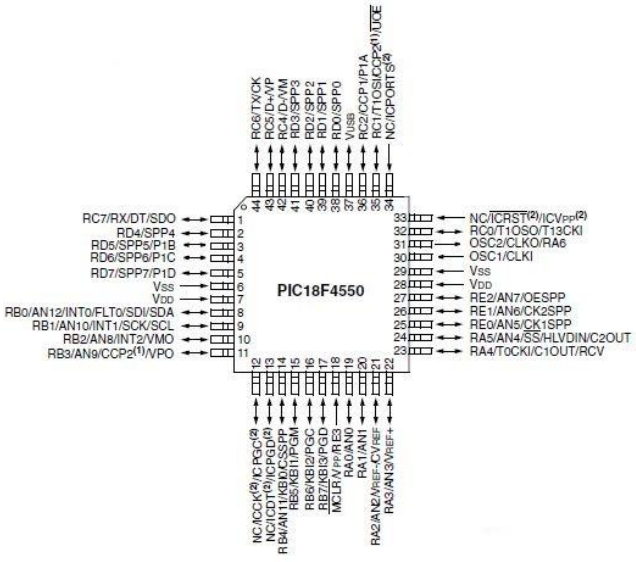

Fig: (2) Pin-out Diagram for PIC 18F4550

The PIC devices offers the advantages of all PIC18 microcontrollers – namely, high computational performance at an economical price – with the addition of high endurance, Enhanced Flash program memory. In addition to these features, the PIC18F family introduces design enhancements that make these microcontrollers a logical choice for many high-performance, power sensitive applications.

The PIC device 18F4550 incorporate a range of features that can significantly reduce power consumption during operation & called the nano watt technology. The Enhanced Flash cells for both program and data memory. Provides the Data retention without refresh up to greater than 40 years. These devices can write to their own program memory spaces under internal software control. By using a boot loader routine, located in the protected Boot Block at the top of program memory, it becomes possible to create an application that can update itself in the field. The PIC 18F family introduces an optional extension to the instruction set, which adds 8 new instructions and an Indexed Literal Offset Addressing mode. This extension, enabled as a device configuration option, has been specifically designed to optimize re-entrant application code originally developed in high-level languages such as C.

Other features include auto-shutdown for disabling PWM outputs on interrupt or other select conditions and auto-restart to reactivate outputs once the condition has cleared. It also provides Enhanced Addressable USART, 10-Bit A/D Converter, Dedicated ICD/ICSP Port.

2. *Fire –Temperature sensor (LM 35), Smoke sensor (MQ135)*

Fire can either be sensed by sensing the resultant temperature or by sensing the smoke or even by both. Temperature is sensed by LM35 precision integrated-circuit temperature sensor, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. It behaves linearly with the corresponding temperature variations.

a. Smoke Sensor

Fig: (3.1) Smoke Sensor Device

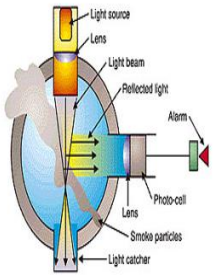

Fig: (3.2) Working Diagram

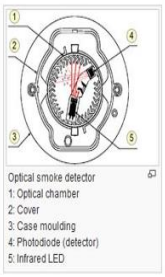

Fig: (3.3) Component Diagram

A smoke detector is a device that senses smoke, typically as an indicator of fire. Most smoke detectors work either by optical detection (photoelectric) or by physical process (ionization), while others use both detection methods to increase sensitivity to smoke. Sensitive alarms can be used to detect, and thus deter, smoking in areas where it is banned.

A photoelectric smoke detector (also known as an optical smoke detector) contains a light source (typically an incandescent light bulb or light-emitting diode), a lens, and a photoelectric receiver (typically a photodiode) as shown in fig 1.2 . A wall-mounted unit emits a beam of infrared or ultraviolet light which is either received and processed by a separate device or reflected back to the receiver by a reflector.

Although photoelectric alarms are highly effective at detecting smoldering fires and do provide adequate protection from flaming fires, fire safety experts and the National Fire Protection Agency recommend installing what are called combination alarms, which are alarms that either detect both heat and smoke, or use both the ionization and photoelectric processes

b. Temperature Sensor - LM35

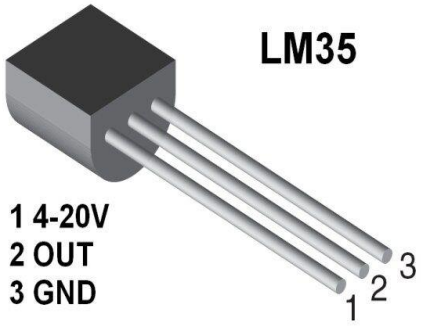

Fig: (4) Precision Centigrade Temperature Sensors

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°cover a full −55 to +150°C temperature range.

The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 μA from its supply, it has very low self-heating, less than 0.1°C in still air.

The LM35 can be applied easily in the same way as other integrated-circuit temperature sensors. It can be glued or cemented to a surface and its temperature will be within about 0.01°C of the surface temperature. This presumes that the ambient air temperature is almost the same as the surface temperature; if the air temperature were much higher or lower than the surface temperature, the actual temperature of the LM35 die would be at an intermediate temperature between the surface temperature and the air temperature. To minimize this problem, be sure that the wiring to the LM35, as it leaves the device, is held at the same temperature as the surface of interest. The easiest way to do this is to cover up these wires with a bead of epoxy which will insure that the leads and wires are all at the same temperature as the surface, and that the LM35 die's temperature will not be affected by the air temperature.

These devices are sometimes soldered to a small light-weight heat fin, to decrease the thermal time constant and speed up the response in slowly-moving air. On the other hand, a small thermal mass may be added to the sensor, to give the steadiest reading despite small deviations in the air temperature.

3. Overload-Strain gauge with load cell

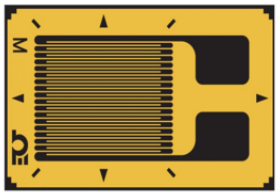

Fig: (5.1) Strain Gauge

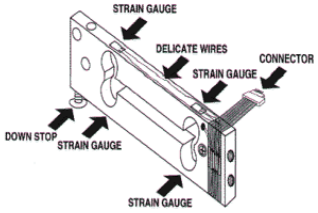

Fig: (5.2) Strain Gauge with load cell.

When a force is exerted on an object, the length of the object will change. The ratio of the change in length to the original length is called strain. A strain gauge is a small section of very fine wire that changes electrical resistance when its dimensions are changed by weight or subjected to a strain. This can be used to measure the weight of persons entering the houseboat. Here we are placing a platform at the entrance of house boat. This platform is built with a strain gauge to measure the weights of persons entering into the houseboat. It will add the weight of each person when entering the boat and subtracts when they leave the houseboat. An IR based counting mechanism is integrated along with this system to count the entering and leaving of persons. The output from this system represents the mean weight of the persons entered into the houseboat. If the value exceeds a particular limit then the controller will produce a buzzer alert and the ignition control to the engine is closed by using a relay control element.

4. *Obstacle-Laser Based Method*

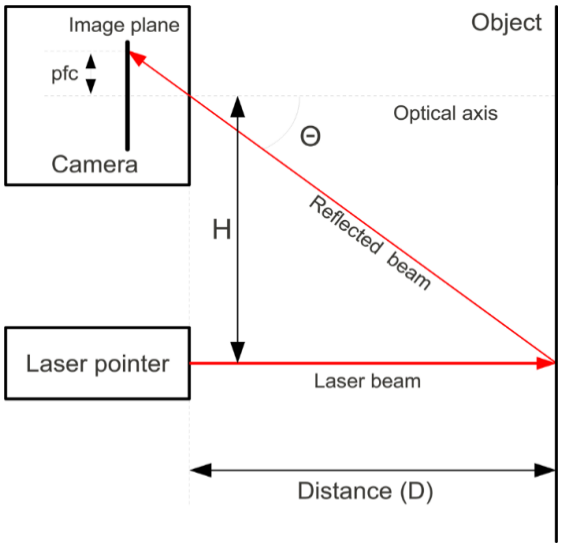

Fig: (6) LASER Based Obstacle Detector

A time-of-flight laser sensor operates by emitting a concentrated laser energy pulse. The pulse travels away from the sensor, strikes a surface, and returns. A clock measures the time elapsed between the beginning of the pulse and the leading edge of the return pulse from the receiver. For under water obstacles, Sonar can be used where the ordinary Laser is not effective.

5. *Gas (LPG) -MQ135*

Fig: (7) MQ 135

A gas detector is a device that detects the presence of gases in an area, often as part of a safety system. This type of equipment is used to detect a gas leak and interface with a control system so a process can be automatically shut down. A gas detector can sound an alarm to operators in the area where the leak is occurring, giving them the opportunity to leave. This type of device is important because there are many gases that can be harmful to organic life, such as humans or animals. The MQ series of gas sensors use a small heater inside with an electro-chemical sensor. They are sensitive for a range of gases and are used indoors at room temperature. MQ-135 performs a good detection to smoke and other harmful gas, especially sensitive to ammonia, sulfide and benzene steam. The conductivity of the gas sensor raises along with the concentration of the polluting gas increases. They are used in air quality control equipment's & safety devices for buildings/offices, are suitable for detecting of NH3,NOx, alcohol, Benzene, smoke,CO2 ,etc.

6. *Alcohol - MQ3*

Fig: (8) MQ-3 Alcohol Detector

When the alcohol molecules in the air meet the heated electrode, the ethanol burns into acetic acid and more current is produced. Sensitive material of MQ-3 gas sensor is SnO2, which with lower conductivity in clean air. When the target alcohol gas exist, the sensor's conductivity is higher along with the gas concentration rising.

7. Free-board gap (Level)-Float & Potentiometer

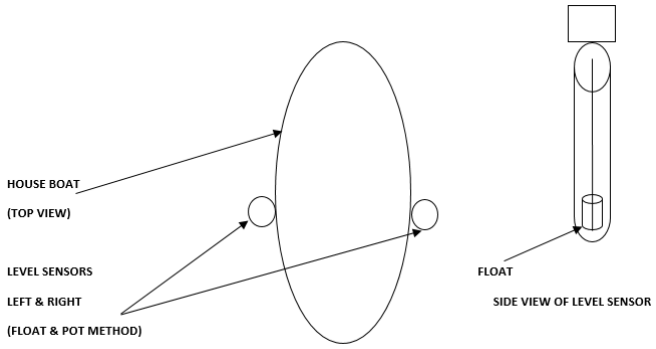

Fig: (9) Float & Pot Method

Free board gap is the level difference between the body surface and water surface. This is measured by an arrangement of Float and potentiometer assembly, simply called pot & float method which is set up on either side of the house boat as shown in figure (9) when the level changes, the float, attached to the moving contact of the potentiometer, moves and the output voltage changes. Taking the average of the voltages of the potentiometers on either side of the boat, the free board gap is obtained. Usually on site calibrations are done for measuring the free board gap as the body surface and water surface ratio of each boats vary as variations in its size, design features and even the water flow.

8. Inclination- Float & Potentiometer

The arrangement for measuring the free board gap can also be used for measuring the inclination of house boat. Taking the difference between the voltages of the potentiometers on either side of the boat, the free inclination of the boat is obtained.

9. Speed – Positive Displacement Flow Meter

The engine speed can be measured by Tachogenerator. However the actual speed of the boat is not the same as the engine speed since it is mostly depends on the nature of water such as its density, direction of water flow, other small obstacles etc. Hence actual speed can be measured by any positive displacement type flow meter.

10. Short Circuit Protection- Relay Module

Short circuit resulted from fire is avoided by energizing the relay with the signal from the fire sensor.

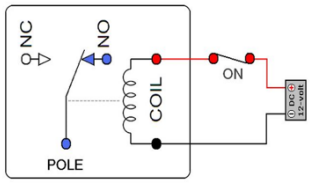

Fig: (10.1) Relay When Energized

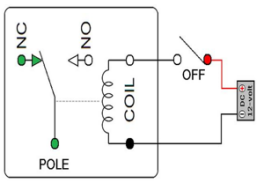

Fig: (10.2) Relay When De-Energized

A relay is an electrically operated switch... Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. A relay can handle the high power required to directly control an electric motor or other loads is called a contactor. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays". A simple electromagnetic relay consists of a coil of wire wrapped around a soft iron core, an iron yoke which provides a low reluctance path for magnetic flux, a movable iron armature, and one or more sets of contacts. The armature is hinged to the yoke and mechanically linked to one or more sets of moving contacts. It is held in place by a spring so that when the relay is de-energized there is an air gap in the magnetic circuit. In this condition, one of the two sets of contacts in the relay pictured is closed, and the other set is open. Other relays may have more or fewer sets of contacts depending on their function.

11. Alcohol (Passenger) – Solenoid

Entry of drunken tourists to the upper deck is blocked by solenoid operated door or lever.

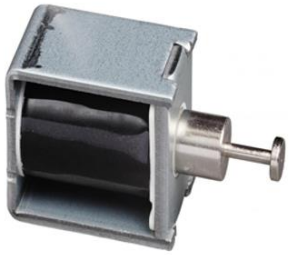

Fig: (11.1) Solenoid

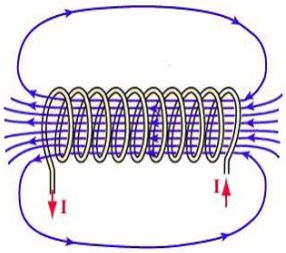

Fig: (11.2) Working Principle.

A solenoid is a device that converts energy into linear motion. It's basically a coil wound into a tightly packed helix. When power from a battery or electric generator flows around the electromagnet, the metal pin or cylinder is magnetically drawn inside the housing. When the electric current stops, the pin is released and the compression spring sends it forward with significant force.

12. Fire - Solenoid Valve

On detection of fire, fire extinguisher is automatically operated by the help of Solenoid Valve.

Fig: (12.1) Solenoid valve

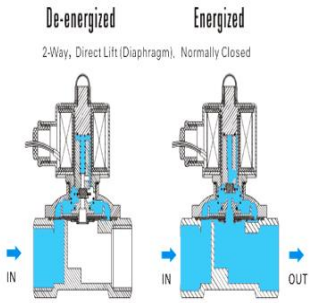

Fig: (12.2) Working Principle.

A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid: in the case of a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is

switched between the two outlet ports. Multiple solenoid valves can be placed together on a manifold. They are the most frequently used control elements in fluidics. Their tasks are to shut off, release, dose, distribute or mix fluids. They are found in many application areas. Solenoids offer fast and safe switching, high reliability, long service life, good medium compatibility of the materials used, low control power and compact design.

13. Warnings (visual)- LCD 20x4 Display

Fig: (13) LCD Display

LCD display modules are usually used to provide a visual indication as messages. This device are basically an output device which produce output from a controller. Only 5 volts is needed to energize this module.

14. Warnings (Audio)- Piezo Buzzer

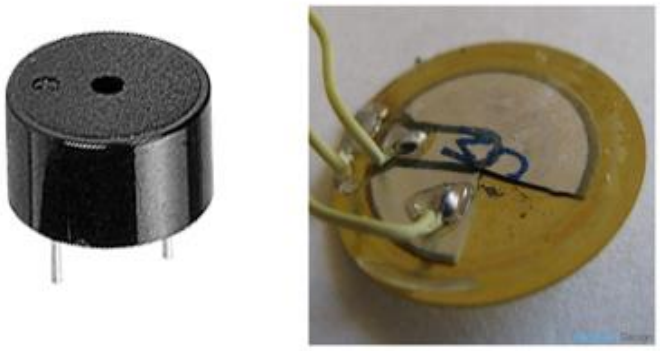

Fig: (14) Piezo Buzzer

Piezo buzzer is an electronic device commonly used to produce sound. Light weight, simple construction and low price make it usable in various applications like car/truck reversing indicator, computers, call bells etc. It is the phenomena of generating electricity when mechanical pressure is applied to certain materials and the vice versa is also true. Piezoceramic is class of manmade material, which poses piezo electric effect and is widely used to make disc, the heart of piezo buzzer. When subjected to an alternating electric field they stretch or compress, in accordance with the frequency of the signal thereby producing sound.

15. GPS – GR 87

Fig: (15.1) GPS Module

Fig: (15.2) GPS Antenna

The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. The system provides critical capabilities to military, civil, and commercial users around the world. The United States government created the system, maintains it, and makes it freely accessible to anyone with a GPS receiver.

The GR-87 series consists of SiRF star III chipsets technology, LNA and proprietary software. The system function block is described as follows.

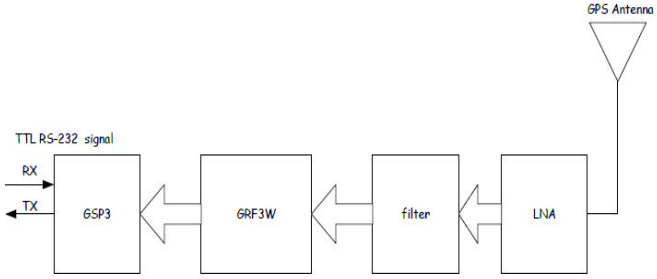

Fig (15.3) Functional Block Diagram of GPS.

The GR-87 design utilizes the latest surface mount technology (BGA) and high level circuit integration to achieve superior performance while minimizing space and power requirements. This hardware capability combined with software intelligence makes the board easy to be integrated and used in all kinds of navigation applications or products. The application system may communicate with the engine board set via two RS232 compatible bi-directional communication channels with CMOS/CMOS 3V voltage level.

16. XBee Transceiver

Fig: (16.1) XBee Pro

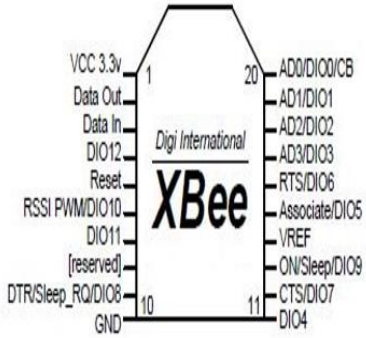

Fig: (16.2) Pin out

XBee is a microcontroller made by digi which uses the Zigbee protocol. The XBee uses 3.3V and has a smaller pin spacing than most breadboards/proto boards. Because of this, it is often useful to purchase a kit to interface the XBee with a breadboard. ZigBee and IEEE 802.15.4 are standards-based protocols that provide the network infrastructure required for wireless sensor network applications. 802.15.4 defines the physical and MAC layers, and ZigBee defines the network and application layers. For sensor network applications, key design requirements revolve around long battery life, low cost, small footprint, and mesh networking to support communication between large numbers of devices in an interoperable and multi-application environment.

B. *Programming Flowchart for PIC*

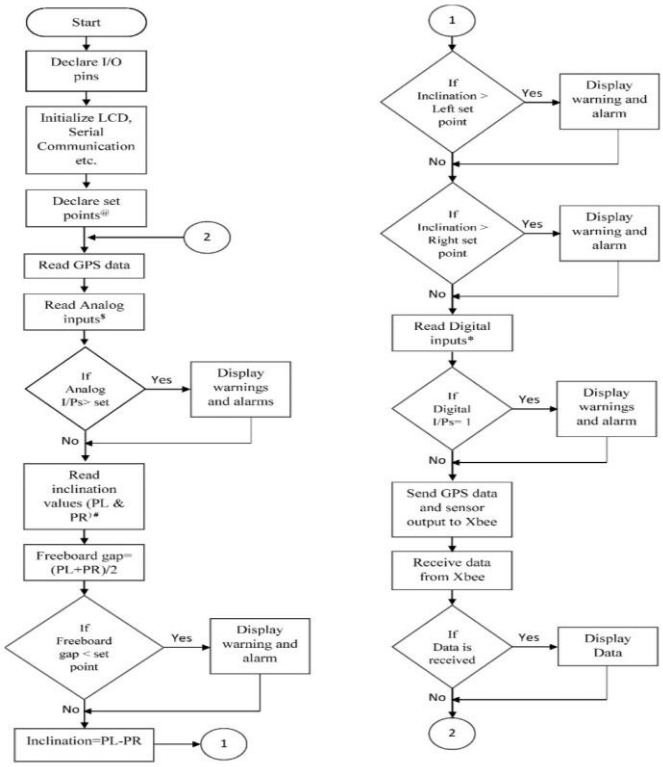

Fig: (17) Programming Flowchart for PIC

@ Temperature, overload, speed, inclination, freeboard gap, Alcohol
$ Temperature, overload, speed, Alcohol
 # Left and right potentiometer readings
** Gas leakage, smoke, Obstacle*

C. *Hardware Components*

Figure (18) show the hardware components and its assembly.

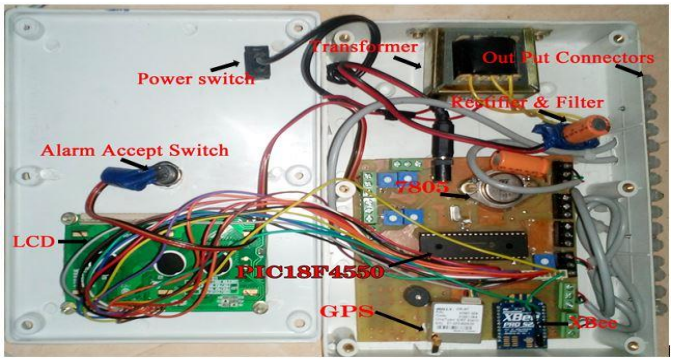

Fig: (18) Hardware Assembly

D. *Control Room*

The transmitted data from the house boat are available in the PC, installed in control room, by RS 232 serial communication and Xbee transceiver. The front end of the PC is designed using LabVIEW simulation software. Also any alerts from weather forecasting station can be send to respective houseboat. The front panel of the GUI designed using LabVIEW in the remote control room is shown in the figure (19) below. Also the corresponding block diagram is shown in figure (20).

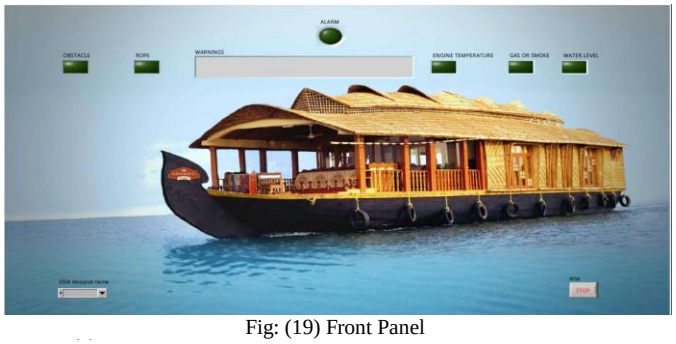

Fig: (19) Front Panel

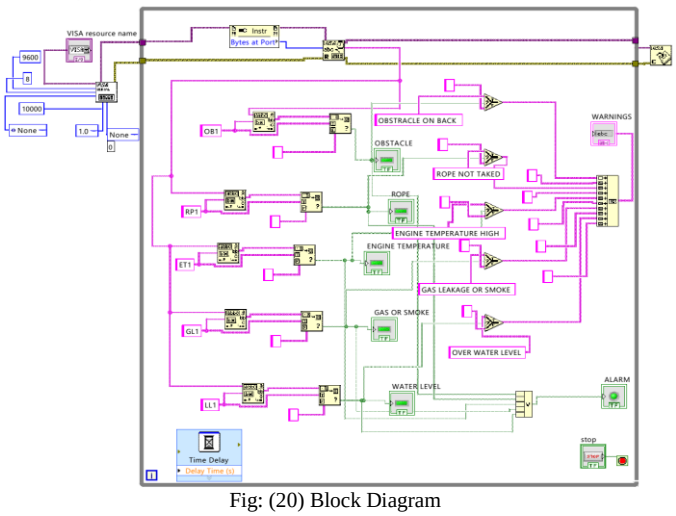

Fig: (20) Block Diagram

III. CASE STUDY

The real time implementation of the system in a working houseboat is carried out. The performance of the developed system is evaluated in two abnormal conditions namely engine temperature & internal water level. Figure (21) shows the LabVIEW front panel of the abnormal condition, engine temperature.

Fig: (21) Abnormal Condition - Engine Temperature

Figure (22) shows the LabVIEW front panel of the abnormal condition, internal water level.

Fig: (22) Abnormal Condition – Internal Water Level

IV. CONCLUSION

An automatic control system for the safety and security of houseboats is designed and implemented which includes computer and wireless communication network. The system is evaluated by installing in a working house boat and provides excellent performance. By the application of this system the house boat tourism will get a new face. Also by incorporating proper networking, all information regarding safety measures, rate/day, capacity etc. of respective houseboat can be made available to the targeted tourist and hence malpractices prevailing in this field can be reduced drastically. Moreover any alerts from the weather forecasting center can be communicated to respective house boats. Thus tourists, who are more concerned about safety and quality of systems, will be attracted more to this field of tourism and thereby increase the revenue to the Government and this in turn beneficial to the society at large.

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