Wireless Monitoring and Controlling Marine Navigation Parameters

Iman Morsi[1], Mohamed zaghloul [2] and Mostafa Elfiky[3]

Arab Academy for Science, Technology and Maritime Transport' Electronic and Communications' P.O.1029, Alex, Egypt

[1] drimanmorsi@yahoo.com, [2] dr_mszaghloul@yahoo.com, [3] Mostafa_elfiqy@yahoo.com.

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Abstract. This paper is a practical implementation of data acquisition system based on navigational devices. The data are extracted from different ship sensors on board. The objective of this paper is to build a navigation system based on sensors to simulate the original system. This system is implemented by collecting data from different sensors which are connected to microcontrollers PIC 16F628A & P16F886 then these data is transmitted wireless using Serial UART wireless module (200M Range-433 Mhz) to a computer station which enable continuous tracking for the all ship's sensor which indicate the situation in receiving site located at another place .The simulated system is built by using Lab View version (13). The ROM cost of the system around (220$).

1- INTRODUCTION

Navigation is process of reading and controlling the movements of ships from one point to another, this is executed by using and integrating electronic systems. Integrated systems take inputs from various ship sensors, electronically and automatically indicate these data on the position chart, and provide control signals required to maintain a vessel on a preset course. The navigator becomes a system manager, choosing system presets, interpreting system output, and monitoring vessel response [1].Many researchers realized different methods to deal with monitoring and controlling for different sensors such as using microcontroller system and displayed data via Visual basic screen [2]. Design a ship's alarm, for all parameter using microcontroller and display the situation via LCD 2*16 [3].Displaying information about ship position, speed and different inputs sensor is aided beside ECDIS (Electronic Chart Display Information System) via c++ Builder [4]. The proposed systems in this research have been developed and integrate in one electronic circuit. Using the powerful data acquisition program Lab View and microcontroller circuit’s have a positive impact on the operation. The proposed system is open architecture that enables the user to connect and host multiple sensors in addition to tat the data can be transmitted wireless via wireless module Serial UART for continuous tracking. The output signals is displayed on the electronic screen to enable full management and control for all navigational sensors, this is applicable for different types of platforms. The organization of the paper is as follow: section 2 present experimental works; section 3 presents Lab View software; section 4 present obtained results, and finally section 5 presents conclusions.

1I- EXPERIMENTAL WORK

The components of data acquisition systems include: sensors that convert physical parameters to electrical signals, signal conditioning circuitry to convert sensor signals into a form that can be converted to digital values and Analog to digital converters, which convert conditioned sensor signals to digital values [5]–[6] as shown in figure 1.

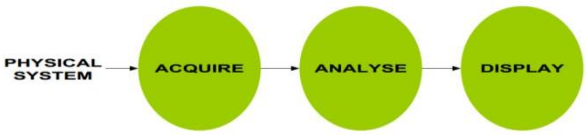

Fig .1. Data Acquisition system

A simulation circuit is designed to show marine navigational system model based on Global Positing System (GPS) that give Latitude, longitude. Echo sounder to measure distance under the ship, an analog and digital indicator. Inertial Navigational System (IMU) shows roll and pitch and the hydrographic sensor (humidity and temperature system. The system consists of two parts:

Part I: The physical parts, which consist of transmitter and receiver system .Transmitter system is a circuit board that consist of five microcontrollers that works as processors to receive and send information synchronous from four sensors using RF transmitter module to send data wireless to the receiver system.

Part II: Receiving the data from transmitter board Via RF receiver module and deliver it to the Lab View. The used software is programmed allows the user to indicate, analysis all data separately for each sensor in form of analogue, digital, curves and graphics format.

A. Transmitter Circuit

The transmitter circuit consists of

1- Sensors board which contains four marine sensors:

a- GY-80 10 DOF that contain inside it a gyroscope (L3G4200D), an accelerometer (ADXL345), a Magnetometer (HMC5883L) and a Barometer & Temperature sensor (BMP085) as shown in fig. 2(a).

b- DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor complex with a calibrated digital signal output as shown in fig. 2(b). By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology we ensures high reliability and excellent long-term stability [7]–[8]. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component. All sensors connect to a high-performance 8-bit microcontroller, offering excellent quality, fast response, and anti-interference ability.

c- US-100 compact ultrasonic sonar that can be used for measuring distance as shown in fig. 2(c). It depends on driving the US-100 trigger input to logic high so the US-100 will send short bursts of ultra sonic wave and then the outputs pulse as soon as a returning echo is detected .The microcontroller that attached to the US-100 will detect the distance by measuring the pulse width of the output pulse [9].

d- GPS (VK 16U16) module with a high sensitive GPS antenna as shown in fig. 2(d) is connected to microcontroller via UART / TTL. The module support GPS, GALILEO, and SBAS (WAAS, EGNOS, MSAS, and GAGAN) hybrid engine with .5 Hz update rate positioning.

(a) (b) (c) (d)

Fig .2. Types of sensor (a) GY-80 IMU sensor, (b) DT11 Temperature & Humidity sensor,(c) US-11 Ultrasonic sensor and (d) GPS sensor.

2- RF transmitter is based on Texas instrument CC1101 chip, which can work as from one to many and also can work directly with Micro-controller via Serial UART. The reading of each sensor is sent wireless through UART protocol using serial communication, 200 m distance range and 433 Mhz frequency as shown in figure 3.

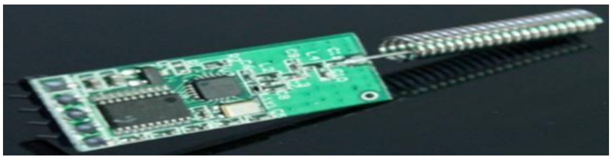

Fig .3. Wireless Module Serial transmitter UART (200M Range-433 Mhz)

3- Microcontrollers (PIC 16F628A and P16F886) is used to each four sensor individually, and one for main RF transmitter as shown in figure 4.

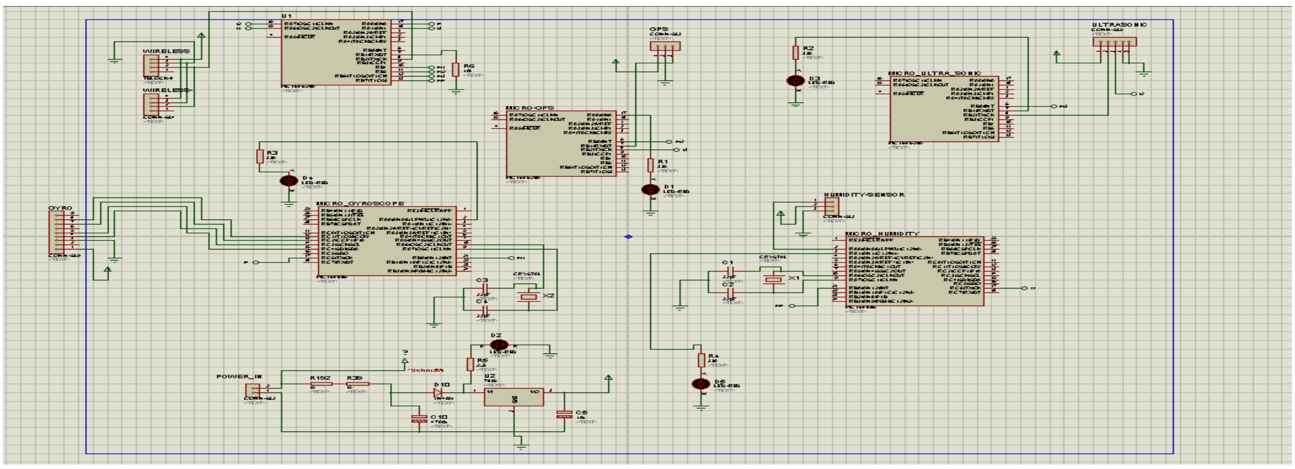

Fig .4. Transmitter circuit

4- Power supply input terminal to feed the circuit with power is designed as shown in figure 5.

The layout of the electronic circuit board is shown in figure 6 and the 3D visualization to present the board is shown in figs. 7 (a) and (b).

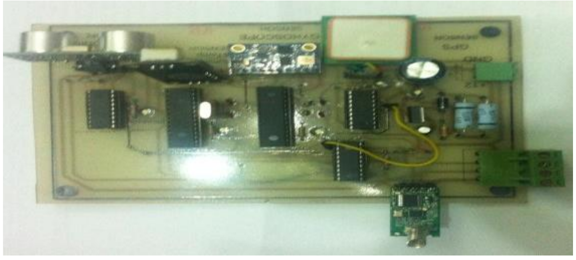

Fig .5. Complete circuit board (transmitter circuit)

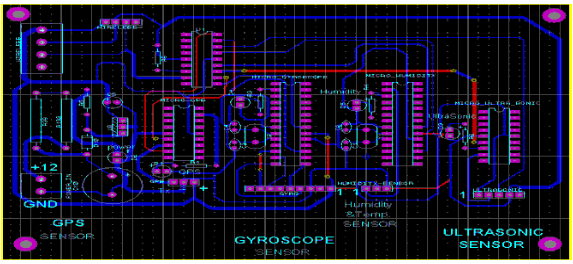

Fig .6. lay out of the electronic circuit board.

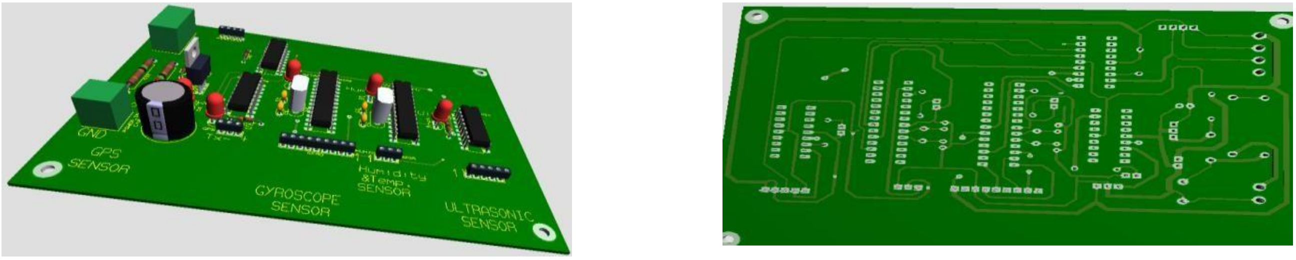

Fig.7. (a) 3d visualization (top) and (b) 3d visualization (bottom)

In the design the four sensors (Ultrasonic, humidity &Temp, IMU, GPS) are connected to a separate microcontroller (micro GPS, micro humidity, micro gyroscope, micro Ultrasonic) and the output is extracted and stored. There is also another microcontroller to act as a master Microcontroller (U1) to collect, mange and sending data via RF module consequently.

- Master microcontroller U1

In the design four pins are connected to the sensor's microcontrollers, these pins are used to select which one will be activated, then acquiring the activated sensor's data and transmit it to microcontroller U1, These data are collected from all sensors simultaneously. These pins are (m1, 2, 3, and 4) as shown in figure (7). In this design several microcontrollers are used to reduce complexity of the code due to programming and to get many pins as multiple transmitter & receivers (software) also to achieve high level of storage memory, moreover to avoid time delay due to transmission. Later the master microcontroller is attached to RF wireless module Serial UART (200M Range-433 Mhz) for data transmition.

- Ultrasonic Sensor

When enabling the microcontroller (micro Ultrasonic) via (m 1) which has two interfaces modes of the module that can be selected by jumper interface. The UART (serial port) mode is selected, when plug in the jumper cap and unplug the level one triggered mode then we choose sending via serial communication (9600 baud), the system can be issued in the eight 40KHZ ultrasonic pulse, and then detect the echo signal. The distance value is of two bytes, first byte is the distance from the high 8 (H Date), the second byte is low 8 (L Data) of the distance in millimeters.

- DT11 humidity & temperature sensor

By enabling the microcontroller (micro humidity) via (m1) and activate DT11 sensor is connected to the micro controller. Serial Interface (Single-Wire Two-Way), Single-bus data format is used for communication and synchronization between MCU and DHT11 sensor. Microcontroller is programmed to send a start signal and check the response first; the Data consists of decimal and integral parts. A complete data transmission is at 40 bit, and the sensor sends higher data bit first. Data format is 8bit integral RH data + 8bit decimal RH data + 8bit integral T data + 8bit decimal T data + 8bit check sum. If the data transmission is right, the check-sum should be the last 8bit of "8bit integral RH data + 8bit decimal RH data + 8bit integral T data + 8bit decimal T data".

- IMU sensor

By enabling the microcontroller (micro gyroscope) via (m1) and activate IMU sensor connected to the microcontroller via I2C communication. The micro controller is programmed to extract the output of each gyro and accelerometer in (X, Y, Z), using equations 1 and 2 to obtain Roll and Pitch values, then sending them via serial communication to the master micro controller U1 [10].

$$\tan \phi_{xyz} = \left(\frac{G_{px}}{G_{pz}}\right) \quad (1)$$

$$\tan \theta_{xyz} = \left(\frac{-G_{px}}{G_{py} \sin \phi + G_{pz} \cos \phi}\right) = \frac{-G_{px}}{\sqrt{G_{py}^{2} + G_{pz}^{2}}} \quad (2)$$

- GPS sensor

By enabling the microcontroller (micro_ GPS) via (m1) and activate GPS receiver module which attach to microcontroller via serial communication via Rx pin with baud rate (9600). From the data and by program the microcontroller. The master microcontroller U1 arranges the data that contain all serial sensor's information starting from Ultrasonic up to GPS, then send these data with time delay 1ms and additional check serial letters in the begging , middle and final of transmitted data for periodical check at the receiver.

B. Reciever System

The Receiver System consists of:

1- RF receiver connected to a serial computer or via serial-to-USB which enable wireless data reception from transmitter circuit board and connect to a computer station as shown in figure 8.

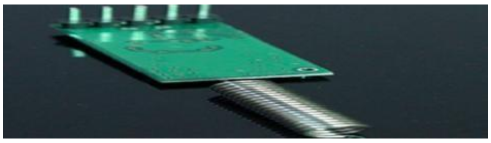

Fig .8. RF Receiver

III. LAB VIEW SYSTEM

Lab View is a system design platform and development environment for a visual programming language from National Instruments, the programming language, also referred to as G (not to be confused with G- code), is a dataflow programming language. [11], Execution is determined by the structure of a graphical block diagram (the LV-source code) on which the programmer connects different function-nodes as shown in figure 9. These wires propagate variables and any node can execute as soon as all its input data become available. Lab View also ties the creation of user interfaces (called Front panels) into the development cycle.

Lab View programs/subroutines are called virtual instruments (VIs). Each VI has three components: a block diagram, a front panel and a connector panel. By using Lab View software programmed data is accepted via VISA (Configure Serial Port) inside lab view and check the number of bytes sending and arranging them inside Index Array Function to separate them for final display and calculation

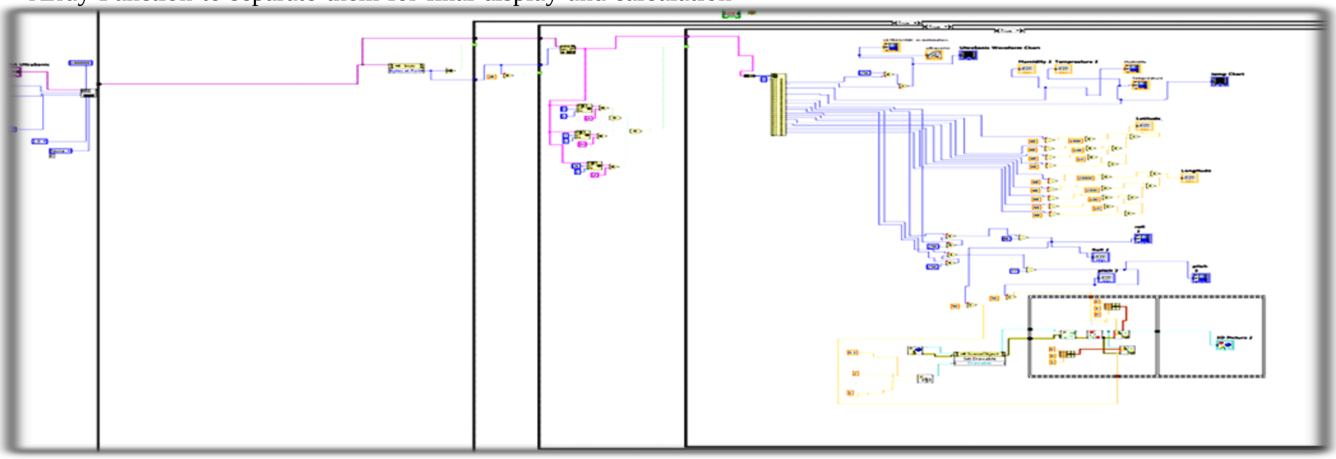

Fig .9.block Diagram of Lab View

IV. RESULTS AND ANALYSIS

- **The output of Ultrasonic sensor**

After connection and operation to the total designed system the measurements are done for different sensor parameters and the output of each sensor is measured and displayed. For Ultra sonic with digital and analog representation the value of distance is shown in figure 10. The relationship curve between distance and time is presented as shown in figure 11.

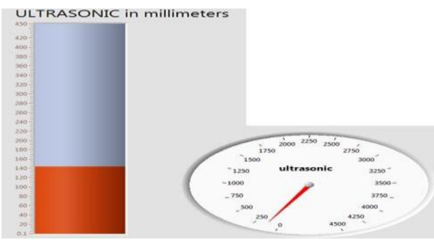

Fig .10. Real time Ultrasonic sensor representation

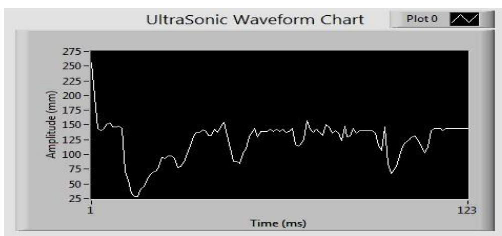

Fig .11. Relationship curve between distance and time

- **The output of DT11 humidity and temperature sensor**

The outputs from humidity & temperature sensor are displayed in both numeric and analogue form as shown in figure 12 .The relationship curve between temperature and time is presented as shown in figure 13.

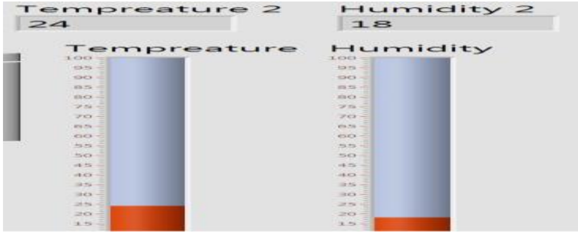

Fig .12. Real time Humidity & temp sensor

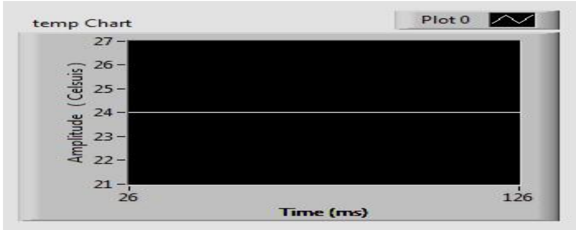

Fig .13. Relationship curve between temperature and time

- **The output of IMU sensor and GPS**

The output from IMU sensor for Roll and Pitch is displayed in analogue as shown in figure 14, and in 3D representation according to real time change as shown in figure15. Also The output from GPS Longitude and latitude according to GPS position coordinates are shown in figure 16.

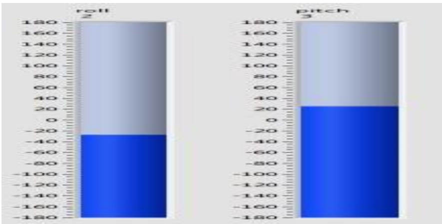

Fig .14. Real IMU sensor

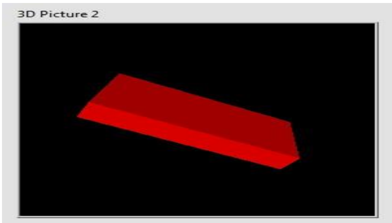

Fig .15. 3d Representation

Fig .16. real time GPS Module

V. CONCLUSION

We demonstrate that we are able to design data acquisition system for marine navigation sensor parameters. The designed system based on microcontrollers (PIC 16F628A & P16F886),RF transmitter receiver module, Lab View system and a group of different sensors GY-80 10 DOF gyroscope L3G4200D, an accelerometer ADXL345, a Magnetometer HMC5883L and a Barometer & Temperature sensor BMP085 & DHT11 & Humidity Sensor ,US-100 compact ultrasonic sonar, GPS VK 16U16 module . All experimental data are obtained and performed in a fully automated computer display. Analysis of each sensor data has been done. We were able to transmit the obtained data wireless using wireless module Serial UART (200M Range-433 Mhz) to the base station computer destination. By employing the previous designed system we simulate the real ship system and we can use this system for different purposes as example for land base training which will lead to saving the real and costly systems on board. This system cost is relatively cheap by comparison to other simulation systems of control navigation equipments.

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