Wireless Monitoring and Controlling Marine Navigation Parameters

Iman Morsi,Mohammed Saad Zaghloul and Mostafa Elfiky

This paper is a practical implementation of data acquisition system based on navigational devices. The data are extracted from different sensor's ship 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 .Transmission data wireless based on Wireless Module Serial UART (200M Range-433 Mhz) to a computer station which enable continuous tracking for the ship's situation from any place without restrictions .The simulated system built by using Lab View version (13) the total cost of the system (220$).

Keywords: IMO, Microcontroller, sensors, DAQ, Lab View

I. INTRODUCTION

Navigation is process of reading and controlling the movements of ships from one point to another, and it is all about directing a system. Electronic systems and integrated bridge concepts are driving navigation system planning. Integrated systems take inputs from various ship sensors, electronically and automatically indicate 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]. These previous systems have been developed in this paper and integrate in one electronic circuit. The powerful data acquisition program Lab View and microcontroller circuit's ,that have a positive impact on the operations is applied . The system enables the user to connect and host multiple sensors with lower cost than using other individual hardware system in addition to send the data wireless via Wireless Module Serial UART for continuous tracking. The output of all signals is displayed on the electronic screen to enable full management and control for all navigational sensors, either ships or barges military or civilian. The organization of the paper is as follow: section 2 present Experimental work ; section 3 present Lab View software; section 4 present Results, and finally section 5 present Conclusions..

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II. 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.

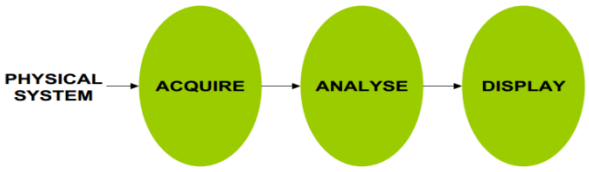


Fig .1. Data Acquisition system

A simulation circuit is designed to show marine navigational system model based on Global Positing System that give Latitude, longitude. Echo sounder to measure distance on 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. By using RF transmitter module we 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 to allow the user to indicate, analysis of all the data separately for each sensor in analogue, digital, curves and graphics format.

A. Transmitter Circuit

The transmitter circuit consists of

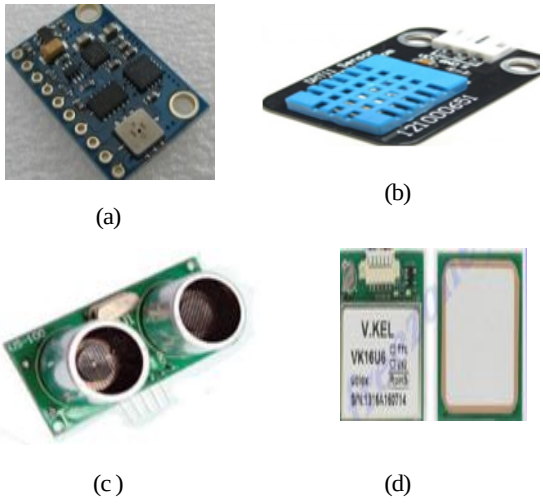
1- Sensors board which contains four marine sensors:

a-GY-80 10 DOF that contain inside it a gyroscope (L3G4200D), an accelerometer (ADXL345),a Magnetometer (HMC5883L) and a Barometer and 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, it 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 which will send a 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, 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 which is based on Texas instrument CC1101 chip, which can work as one to many and also can work directly with Micro-controller via Serial UART. The reading of each sensor is sent wirelessly through UART protocol using serial communication, 200 m distance range and 433 Mhz frequency as shown in figure 3.

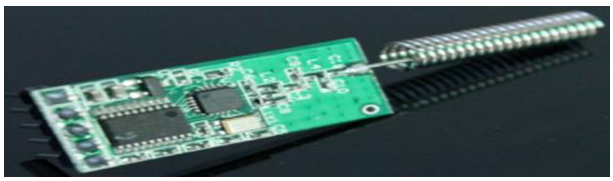


Fig .3. Wireless Module Serial transmitter UART (200M Range-433 Mhz)

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

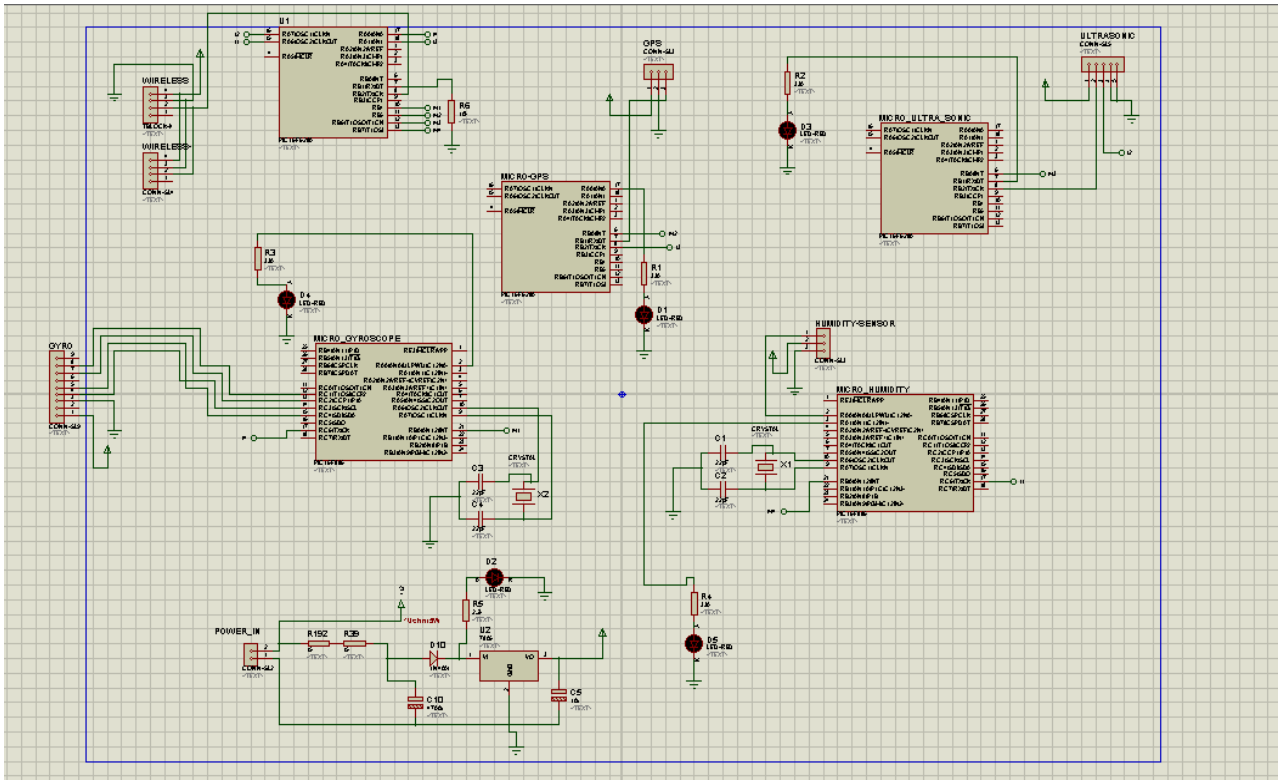


Fig .4. Transmitter circuit

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

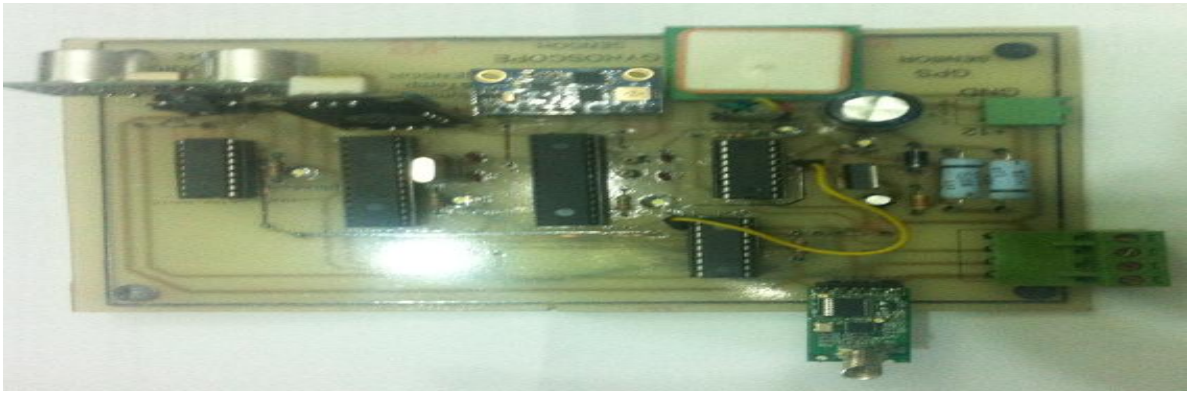


Fig .5. Complete circuit board (transmitter circuit)

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

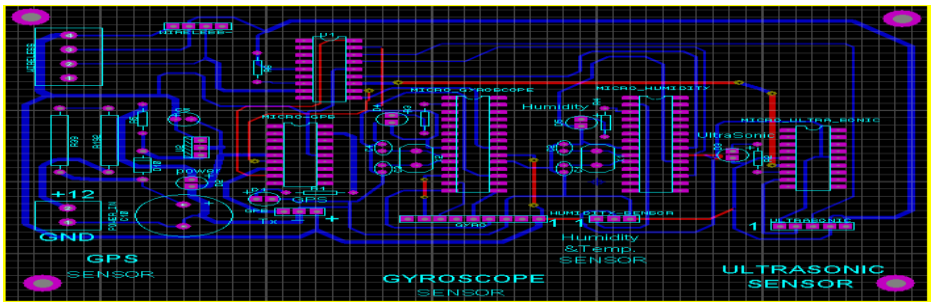
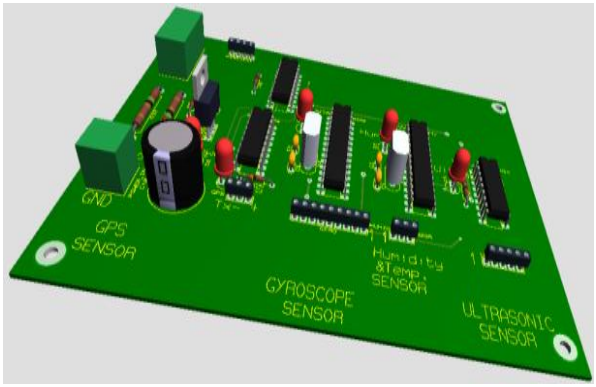
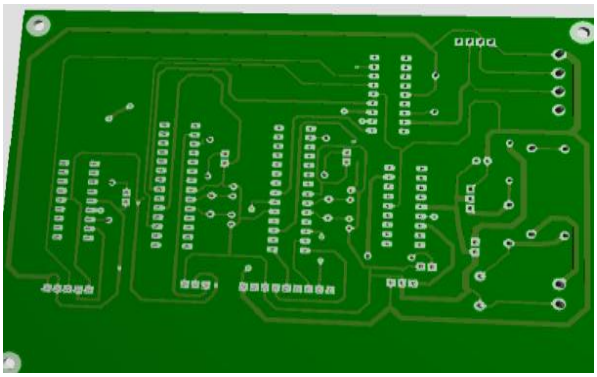


Fig .6. lay out of the electronic circuit board.



(a)



(b)

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

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 simulated. 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 to select which one will activate. Then acquiring it's own sensor's data and transmit it to microcontroller U1, The data is collected from all sensors simultaneously. These pins are (m1, 2, 3, and 4) as shown in figure (7). Several microcontrollers are used to reduce complexity of the code due to programming to get many pins as multiple transmitter & receivers (software) and to achieve high level of storage memory, also to avoid delay in time due to transmission. Then the master microcontroller is attached to RF Module Wireless Module Serial UART (200M Range-433 Mhz) as a transmitter.

- Ultrasonic Sensor

By enabling the microcontroller (micro_ Ultrasonic) via (m 1). There are two interfaces modes of the module. The mode can be selected by jumper interface. The UART (serial port) mode is selected, when plug in the jumper cap and unplug the level-triggered mode. Then choose sending via serial communication (Serial trigger ranging timing) only the Trig / TX pin input 0X55 (9600 baud), the system can be issued in the eight 40KHZ ultrasonic pulse, and then detect the echo signal. The distance value of the output of a total of two bytes, first byte is the distance from the high 8 (HDate), the second byte is low 8 (LData) of the distance in millimeters. Distance value (HData * 256 + LData) mm.

- DT11 humidity and temperature sensor

By enabling the microcontroller (micro_ humidity) via (m1) and activate DT11 sensor which 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 40 bit, and the sensor sends higher data bit first. Data format: 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 which is 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), and by using equations to obtain Roll and Pitch values , sending them via serial communication to the master micro controller U1 [10].

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

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

- 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 NMEA 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- Receiver system

The Receiver System consists of:

1- RF Receiver which can connect to a serial computer or via serial-to-usb which can able to receive data wireless from transmitter circuit board and connect to a computer station as shown in figure 8.

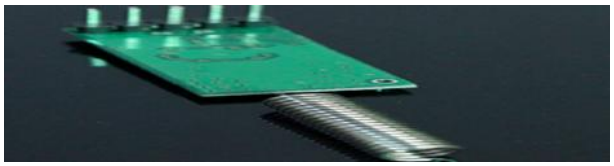


Fig .8. RF Receiver

Lab View is a system-design platform and development environment for a visual programming language from National Instruments The programming language used in LabView, 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 by drawing wires 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.

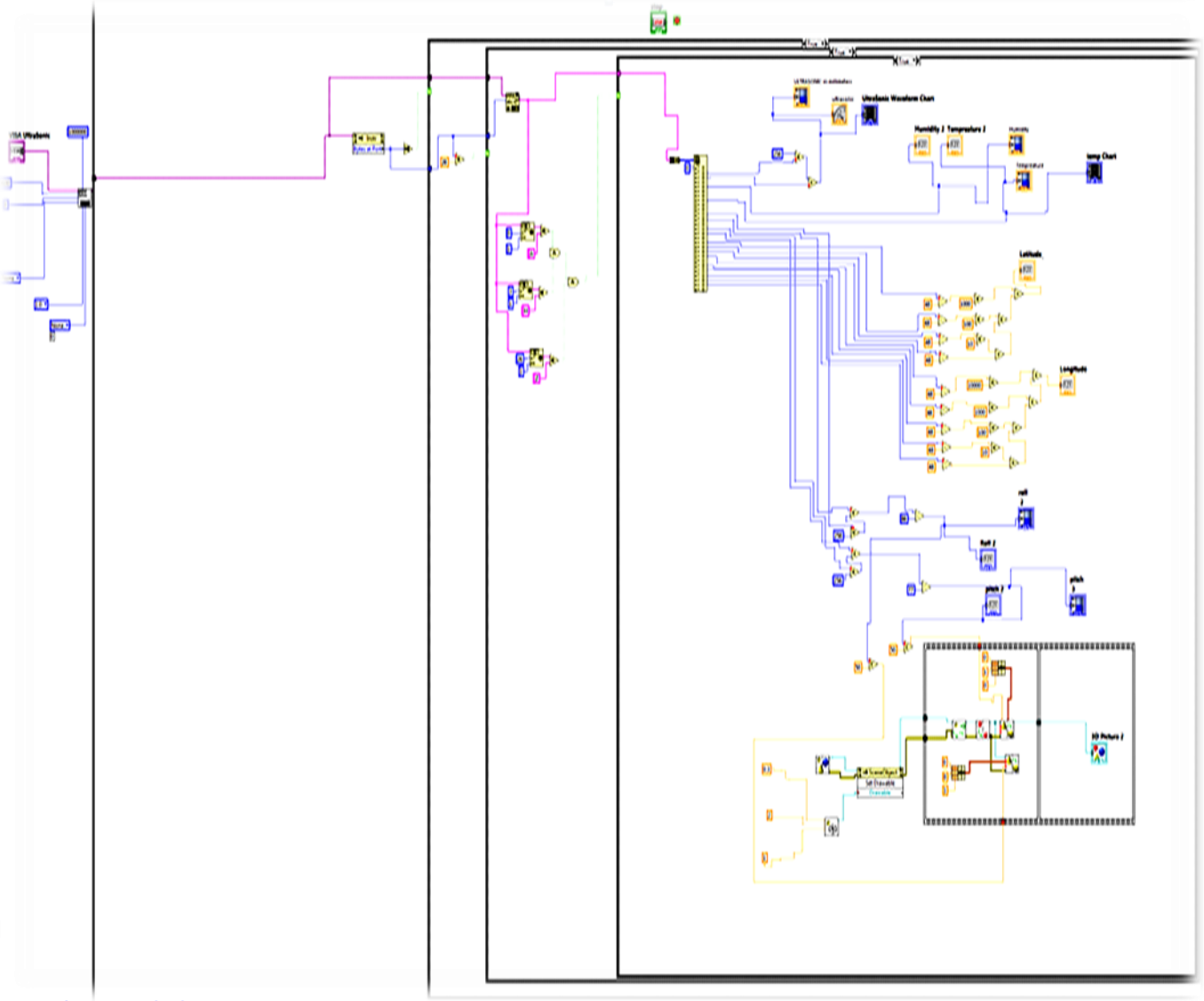


Fig .9.block Diagram of Lab View

III. LAB VIEW SYSTEM

By using Lab View software which programme to accept data 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.

IV. RESULTS AND ANALYSIS

• The output of Ultrasonic sensor

The measurements are done for different sensor and parameters .The output of each sensor from Ultra sonic with digital and analog representation of it's value with distance as shown in figure 10. The relationship curve between distance and time is presented as shown in figure 11.

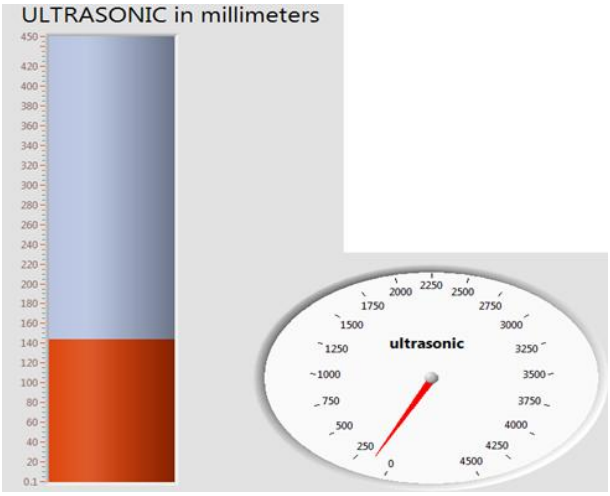


Fig .10. Real time Ultrasonic sensor representation

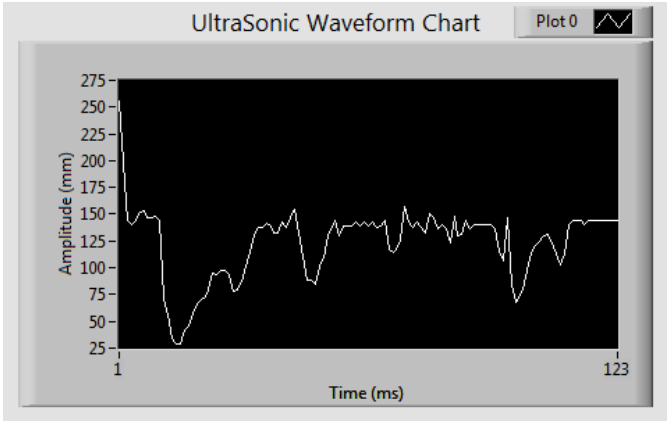


Fig .11. Relationship curve between distance and time

• The output of DT11 humidity and temperature sensor

From humidity and temperature sensor the two parameters 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.

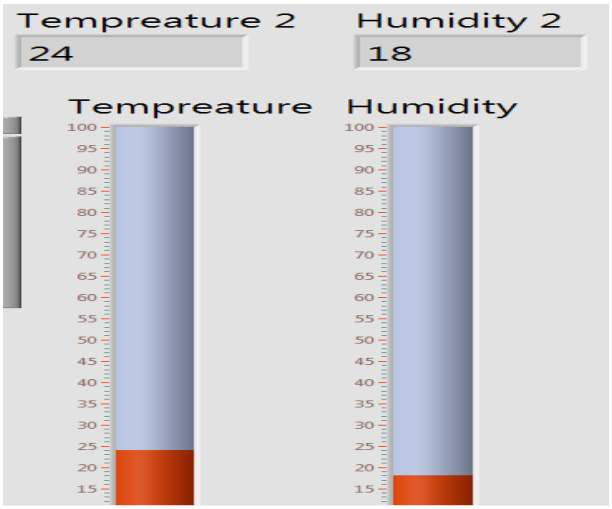


Fig .12. real time Humidity & temp sensor

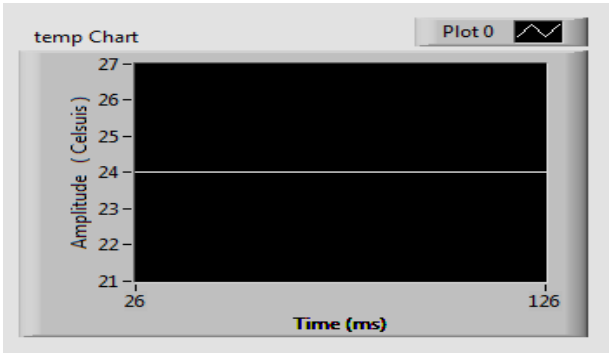


Fig .13. Relation curve between temperature and time

• The output of IMU sensor

From IMU sensor values of Roll and Pitch displayed in analogue as shown in figure 14 ,and in 3d representation of change of roll and pitch parameter simutansoluy according to real time change as shown in figure15

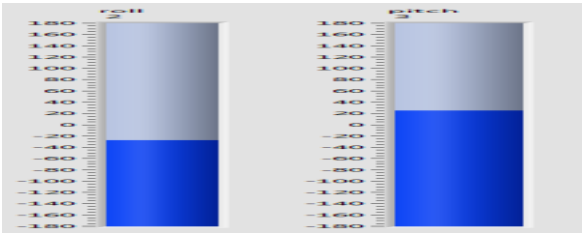


Fig .14. real IMU sensor

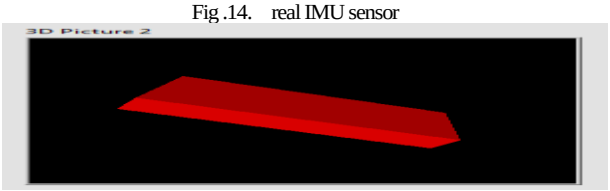


Fig .15. 3D representation of change of roll and pitch parameter

• The output of GPS sensor

From GPS have Longitude and latitude according to GPS position coordinates as shown in figure 16.

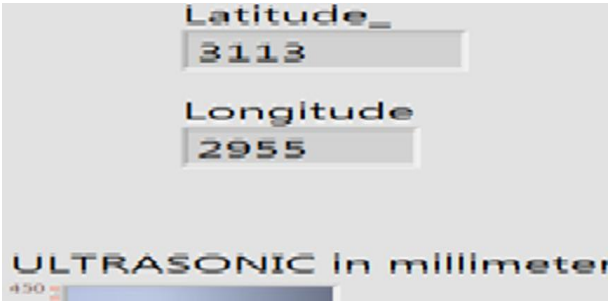


Fig .16. real time GPS Module representation

V. CONCLUSION

The data acquisition system is built for marine navigation parameters. The designed system based on microcontrollers (Pic 16F628A & P16F886),RF module transreciever , Lab View system and a group of sensors (GY-80 10 DOF (gyroscope (L3G4200D), an accelerometer (ADXL345), a Magnetometer (HMC5883L) and a Barometer & Temperature sensor (BMP085)) DHT11 Temperature & Humidity Sensor ,US-100 compact ultrasonic sonar, GPS (VK 16U16) module have been designed . All experimental data are performed in a fully automated computer display and analysis of each sensor has been done. The obtain data has been transmitted wireless using Wireless Module Serial UART (200M Range-433 Mhz) to the base station computer destination. The system cost is relatively cheap by comparison with other systems of control navigation .The relative cost is (220$)

REFERENCES

[1] Corina Popescu, Anastasia Varsami, " The use of ecdis in modern navigation", Year. XI, Vol.13.

[2] M. S. Zaghloul. "Modern CAD Technique to Design Gyrocompass for UAVs and Robot, Ships, Aircrafts Navigation Systems", International Journal of Computer Science and Application Vol. 3, Issue. 1, Feb. 2014

[3] M. S. Zaghloul. "Design of Open Architecture Ship Alarm, Monitoring and Control System". International Journal of Research in Engineering & Technology Vol. 2, Issue. 1, Jan. 2014

[4] M. S. Zaghloul. "Design of Open Architecture Electronic Chart Display and Information System (ECDIS) ", International Journal of Research in Engineering & Technology Vol. 2, Issue. 1, Jan. 2014

[5] Sarita Kumari. "Wireless Biometric Data Acquisition System", International Journal of Power System Operation and Energy Management (IJPSOEM) Vol.1, Issue.1, 2011.

[6] Abhilash C S, Muralidhar N. "Data Acquisition From Capacitance Sensor AD7746 To Central Monitoring System Using I2C Protocol". International Journal of Advanced Research in Computer and Communication Engineering Vol. 3, Issue. 1, Jan. 2014

[7] DHT11 Humidity & Temperature Sensor, D-Robotics UK, July. 2010.

[8] Md.Khaled Hossain, S.M.Ariful Haque, Sumit Bhattacharyya. "GSM based Wireless Sensor Network to Measure Global Warming, Humidity and CO2". International Journal of Computer Applications (0975 – 8887) Volume 76 – No.14, Aug. 2013.

[9] US-100 compact ultrasonic sonar, e-Gizmo Mechatronix Central, 2011.

[10] Mark Pedley." Tilt Sensing Using a Three-Axis Accelerometer". Freescale Semiconductor, 2013

[11] Mr.Sathish Kumar.M." Labview Based Wireless Sensor for Monitoring the Building". M IJMEIT Vol. 2, Issue. 4, Apr. 2014