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A Low Cost Navigation System for Aviation

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ABSTRACT: Over the past fifteen years the advancement of technology for Global Positioning Systems (GPS) has opened many new doors and has been the evolution of it. GPS is a satellite-based navigation system made up of a network of 24 satellites orbiting the earth at all times by encircling it twice a day in a very precise orbit. GPS receiver provides accurate speed and position on land, air or sea efficiently. When GPS-signals are unavailable, such as in tunnels, inside buildings, or when electronic interference is present, a wireless IMU system is required. Inertial measurement unit (IMU) i s an electronic device that measures and reports body specific force, angular rate and sometimes the magnetic field around the body using the combination of accelerometers, gyroscopes and magnetometers. IMU in GPS system is integrated and widely used in many highly accurate systems for surveying and mapping in airborne, land and marine environments. A GPS/IMU system generally consists of a GPS receiver, an Inertial Measurement Unit (IMU), a microcontroller board and RF transceivers along with associated software for system control, computation and user interface. The idea here is to build a system which helps to navigate, track and display the movements of the aero plane in any environment. Our design provides an overview in the process of designing such a System that can determine the user's position. The main feature of this is its ease of use along with the compact size and display of results using LCD and PC via Labview software.

KEYWORDS: GPS, IMU, Arduino Mega, LCD, RF Transceiver.

I. INTRODUCTION

Originally designed for military and intelligence applications, the global positioning system (GPS) - is a network of satellites that orbit the earth at fixed points above the planet and beam down signals to anyone on earth with a GPS receiver. These signals carry a time code and geographical data point that allows the user to pinpoint their exact position, speed and time anywhere on the planet. Transit was the first satellite system launched by the USA and tested by the US Navy. Just five satellites orbiting the earth allowed ships to fix their position on the seas once every hour. Transit was succeeded by the Timation satellite, which demonstrated that highly accurate atomic clocks could be operated in space. GPS developed quickly for military purposes thereafter with a total of 11 "Block" satellites being launched. The US launched their 24th Navstar satellite into orbit, which completed the modern GPS constellation of satellites - a network of 24 - familiar now as the GPS. Today's GPS network has around 30 active satellites in the GPS constellation.GPS is a tool that is used to measure distance and to help pinpoint location any place in the world.GPS satellitescontinuously broadcast satellite position and timing data via radio signals on two frequencies (L1 and L2). The radio signals travel at the speed of light (186,000 miles per second) and take approximately 6/100ths of a second to reach the earth. A system with GPS receiver can read the geographical co- ordinates of a place with the help of at least three GPS satellites for tracking and navigation,when GPS signals are not available we use IMU systems with GPS. An Inertial measurement unit is an electronic device that measures and reports a body's specific force, angular rate, and sometimes the magnetic field surrounding the body, using a combination of accelerometers and gyroscopes, sometimes also magnetometers. IMU are typically used to maneuver aircraft, including satellites andLanders. A GPS/IMU system generally consists of a GPS receiver, an Inertial Measurement Unit (IMU), a microcontroller board and RF transceivers along with associated software for system control, computation and user interface. The idea here is to build a system which helps to navigate, track and displaythe movements of the aero plane in any environment. This idea can be used in navigating airplanes or as a system in a UAV. An Unmanned aerial vehicle (UAV) is a type of aircraft which has no

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Vol. 3, Issue 4 , April 2016

onboard crew or passengers. UAVs include both autonomous drones and remotely piloted vehicles (RPVs). A UAV is capable of controlled, sustained level flight and is powered by a jet, reciprocating, or electric engine.

II. OBJECTIVE

Global Positioning System(GPS) can provide some navigation information for users such as time, latitude, longitude, and altitude, etc. Therefore the idea here is to build an GPS tracking and navigating system for aero planes that tracks the location of it. Since there are 24 satellites that are orbiting the Earth at different locations and make a complete orbit around it in about 12 hours at least three satellites will capture the information of the aero plane and update the information. They correspond with receivers that are scattered around the world. They are always transmitting information through digital radio signals. These signals tells the transmitters where they are and the exact time. They are so precise that they transmit time to the billionth of a second in accuracy. IMU systems are used when GPS signals are not available to provide accurate measurements when the system travels in tunnels, buildings etc. Hence a GPS/IMU system is chosen to provide necessary parameters at every instant in any environment along with Roll, Yaw and Pitch that help us in finding the rotational angle and also the altitude of the airplane. The main feature of this Navigation System is its ease of use along with the compact size and visual display of results.

III.LITERATURE SURVEY

The purpose of good Avionics system with low cost design is crucial to establish a platform that integrates all avionic systems and sensors together, and thus enabling them to meet the aircraft requirements. To understand the idea of avionics and its related systems a thorough literature survey is required. The following are the technical papers that the authors have revised for fulfilling the requirements.

[1] I. A. Getting, proposed "the Global Positioning System," *IEEE Spectrum*, vol.30, inDecember 1993.

This paper states about the Global Positioning System (GPS) that was developed by Department of defense earlier to provide estimation of position, velocity and time to the U.S military. And the second objective was to benefit the civilians For the purpose of national security the use of GPS by the civilians was limited to set of band signals itself. Nevertheless, the applications of GPS for the civil purpose have grown at increasing rate.Many applications by the designers of the GPS are thrilling and on the way. GPS has been used in transportation, aviation, surveillance, mapping, buildings, navigation, agriculture, science, tracking systems, and in many other fields. Thecommunity for civil user are finding ways to degrade the signals and encrypt them for the security reasons.

[2] Author Sonal N Parmar suggested "Designing and Implementing GPS based Navigation System" for Location based Services.

This proposal shows the designing of Global Positioning System that is used for navigation, tracking and positioning of objects and places in a simple and efficient way. The idea here is to locate the basic services as well as emergency services.The design is an hand held terminal with a GPS installed in it using the microcontroller board and a GPS receiver. This handy device being portable and light weight does not require any connection with the pc for tracking anything.The main objective of thishandy GPS tracker is to provide an ease of handling and provide visual displays using the LCD and PC. Following to the design an interface to the computer can also be done to provide an option to download the location and also online tracking.

[3] Authors Right M, Stallings D, and Dun D proposed "The Effectiveness of Global Positioning System Electronic Navigation" in April 2003, IEEE Southeastconin2003.

The project is implemented as Advanced anti accidental solution by analyzing, tracking and detection in prior using GPS in the ships. This idea helps in reducing the ship accidents or in taking precautionary measures against the accidents by identifying the problems such as change in the temperature, fire or the ship alignment vibration in the ship and final location about ship where ship is available in the sea. The purpose of creating this project is to track and also locate the status of the ship and the temperature which will let us avoid ship accidents. The status of the ship in this project is recognized using the sensors. In this project whatever status available on the ship; get read with the help of related sensors. The pre-analysis includes the status of the sensors that means if fire occurs in the ship then this information is directly transmitted and received along with their status and compared with the status of vibration in ship

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International Journal of Advanced Research in Science, Engineering and Technology

Vol. 3, Issue 4 , April 2016

and misalignment of the ship. All relevant information along with tracking of ship are sensed by the sensors. These sensors are mounted on the device which is located on the ship. The sensors used here are temperature sensor, vibration sensors, and fire sensor along with GPS Module and antenna.

[4] Stephen TeangSoo Thong, Chua Tien Han and Tharek Abdul Rahman suggested an approach for "Intelligent Fleet Management System with Concurrent GPS & GSM Real-Time Positioning Technology", IEEE, Wireless Communication Centre (WCC), university of Technology Malaysia (UTM), in 2007.

Fleet management system is a rapidly growing industry that helps institutions to manage vehicle fleet through smart allocation of resources. In this project, an fleet management system is discussed which intelligently incorporates the power of concurrent Global Positioning System (GPS) and Global System for Mobile Communications (GSM) real-time positioning, front-end intelligent and web-based management software as proposed.0 In contrast to this which depends solely on GPS positioning, the proposed system provides high positioning accuracy and is capable to track the target at areas where GPS signals are weak or unavailable. The terminal is powered by Front-End Intelligent Technology (FEI), which is a comprehensive embedded technology that is equipped with necessary artificial intelligence to mimic human intelligence in decision-making for quicker response, better accuracy and less dependence on a backend server. With less dependency on the backend, large scale fleet management system can be implemented more effectively.

[5] El-Medany, W.; Comput. Eng. Dept., Univ. of Bahrain, Bahrain ;Al-Omary, A.andAl-Irhayim, S proposed a paper that presents a real time tracking system that provides accurate location of vehicles with low cost investment.

The system is implemented using GM862 cellular quad band module. A monitoring server and a graphical user interface on a website have also been implemented using Microsoft SQL Server 2003 and ASP.net to view the current location of a vehicle on a specific map. The system provides information regarding the vehicle status such as speed, mileage. The prototype has been tested experimentally and the results are analyzed and discussed. The experiments are conducted in different areas on Kingdom Of Bahrain using Google maps and hence an effective tracking system is built.

[6] BdulqadirAlaqeeli, Janus Starzyk, Frank van GraasinSchool of Electrical Engineering and Computer Science University

In this paper Athens suggested Current GPS receivers that spend much time in base-band processing performing acquisition and tracking. This is due to the large number of required operations in the software-based signal processing. This paper presents a novel signal acquisition and tracking method that reduces the number of operations, simplifies hardware implementation and decreases the acquisition time. The implementation of this method in an FPGA provides very fast processing of incoming GPS samples that satisfies real-time requirements and processes the output that is the exact location of the required system.

[7] M. Braasch and A. J. Van Dierendonck proposed "GPS Receiver Architectures and Measurements," Proc. of The IEEE, vol. 87, no. 1 in January 1999.

This paper although is developed originally for military services, the Global Positioning System (GPS) has been proved valuable for a multitude of civilian application services. Each application required demands specific performance of the GPS receiver, and the associated requirements often vary widely. This paper describes the architectures and functions of civilian GPS receivers and then focuses on performance considerations. The fundamental receiver measurements are described and the qualities of these measurements are related to the aforementioned receiver architectures.

[8] Akos, D suggested "A Software Radio Approach to Global Navigation Satellite System Receiver Design," Ph.D. Dissertation, Ohio University ,in August 1997.

In this paper the author proposed Global navigation satellite systems (GNSSs) that are the most recent and fully operational Radionavigation systems. These two systems are currently in operation at the United States Global Positioning System (GPS) and the Russian Global Orbiting Navigation Satellite System(GLONASS). Although both are relatively new technologies, GPS is the more popular of the two and is expected to serve an ever-increasing role in the determination of relative and absolute position, velocity, and time for both civilian and military arenas. GPS is the most complex Radio navigation signal to date, employing code division multiple access (CDMA) spread spectrum modulation to supply an unaided horizontal position estimate to within 100 meters(95%) for civilian users. The

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Vol. 3, Issue 4 , April 2016

receivers for this technology are equally complex and somewhat diverse in their architecture. Considerable research is being directed toward ensuring that the GPS broadcast and receivers are robust enough to provide the extremely high reliability necessary for use in aviation.

IV. BLOCK DIAGRAM

The GPS receiver receives the signals and for the once that cannot be received when travelling in tunnels or buildings IMU's are used. The signals are received and processed in the microcontroller chip(Arduino mega) and sent through the RF transceivers and displayed in the pc.

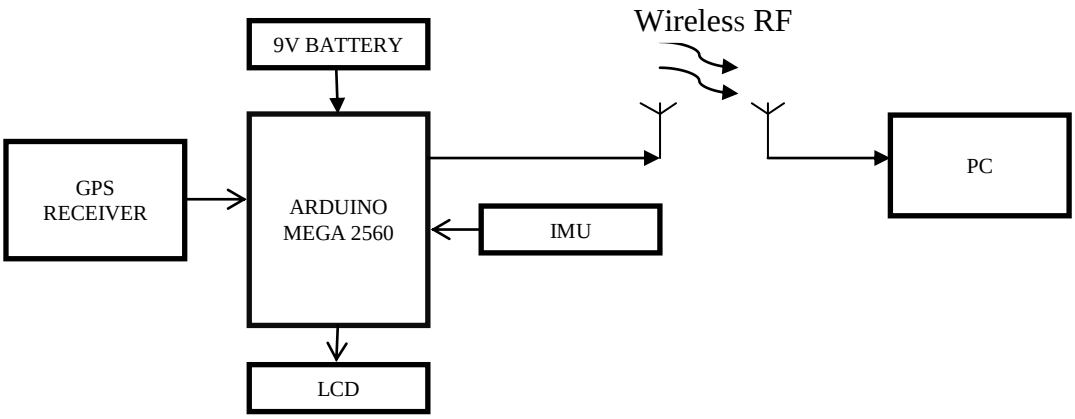

Figure 1- Block diagram of GPS/IMU system.

A. Arduino Mega 2560

The microcontroller board which is used for this design is based on the AT Mega 2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. This controller is connected to the computer with a USB cable or power it with a AC-to-DC adapter or battery. TheArduino Mega 2560 board is compatible with most shields designed for the Uno. The Arduino mega 2560 is the update of Arduino which replaces it.The power to the Arduino board can be supplied via USB connection or with an external power supply. The power source is selected automatically.

B. GPS Receiver

It is the newest family of standalone positioning chips from u-blox.It delivers exceptional sensitivity and acquisition times.The main feature of this GPS receiver is its ultra low power consumption and its enhanced software algorithms.The RF architecture and interference suppression ensures maximum performance in GPS environments.It also supports to the user's application by providing voltage range from 1.8volts to 3.0 volts.This GPS receiver combines low power consumption and high sensitivity. It has minimal board space of about less than 30mm and also it is exceptional for jamming immunity,By using GPS we can do route computing and mapping.It also provides point to point visual mapping.

C. RF Transceiver

CC2500 is developed by Texas instruments ,it is an wireless transmitter receiver and it is used in 2400-2483.5MHz ISM/SRD band systems.There are total 47 configuration registers in CC2500 which is programmed using SPI interface after each time the chip reset.This GPS receiver enters into transmitting or receiving mode by programming into these

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Vol. 3, Issue 4 , April 2016

registers,to configure the data into the register ATmega sends two bytes to CC2500 through SPI interface,these two bytes are sent one after the other.The CC2500RF module is a low cost 24GHz used in very low power applications.By using CC2500 it provides a easy communication at 2.4GHz.

D. Liquid Crystal Display

A liquid-crystal display (LCD) is a flat-panel display. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images or fixed images which gives the low information content, and this information can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock. This uses the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements. LCDs are used in a wide range of applications including computer monitors, televisions, instrument panels, aircraft cockpit displays, and signage. They are common in consumer devices such as DVD players, gaming devices, clocks, watches.

E. Inertial Measurement Unit

An Inertial measurement unit is an electronic device that measures and reports a body's specific force, angular rate, and sometimes the magnetic field surrounding the body, using a combination of accelerometers and gyroscopes, sometimes also magnetometers. IMU are typically used to maneuver aircraft, including satellites andLanders. It has 24 bit internal resolution,it is also used for IP65 rating An IMU allows a GPS receiver to work when GPS-signals are unavailable, such as in tunnels, inside buildings, or when electronic interference is present.

V. DESIGN FLOW

Both the IMU and GPS are integrated together to obtain the complete information of the status of the Air plane. The I/O ports 2 is initialized for IMU and I/O port 3 is initialized for GPS.The baud rates are set for both and the NMEA0183 sentence is read from GPS receiver and if there is a GPRMC sentence found then the time in UTC, latitude, longitude, speed, course and date information are extracted .In the meanwhile the Roll,Pitch and Yaw is read from IMU. If there is an ANG sentence detected the Roll, Pitch and Yaw are extracted .The information extracted by both GPS and IMU are sent to the serial port (port 0) from where it can be sent to a PC directly or connected to the RF transceiver which transmits the information to remote PC at the other end.

ISSN: 2350-0328
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Vol. 3, Issue 4 , April 2016

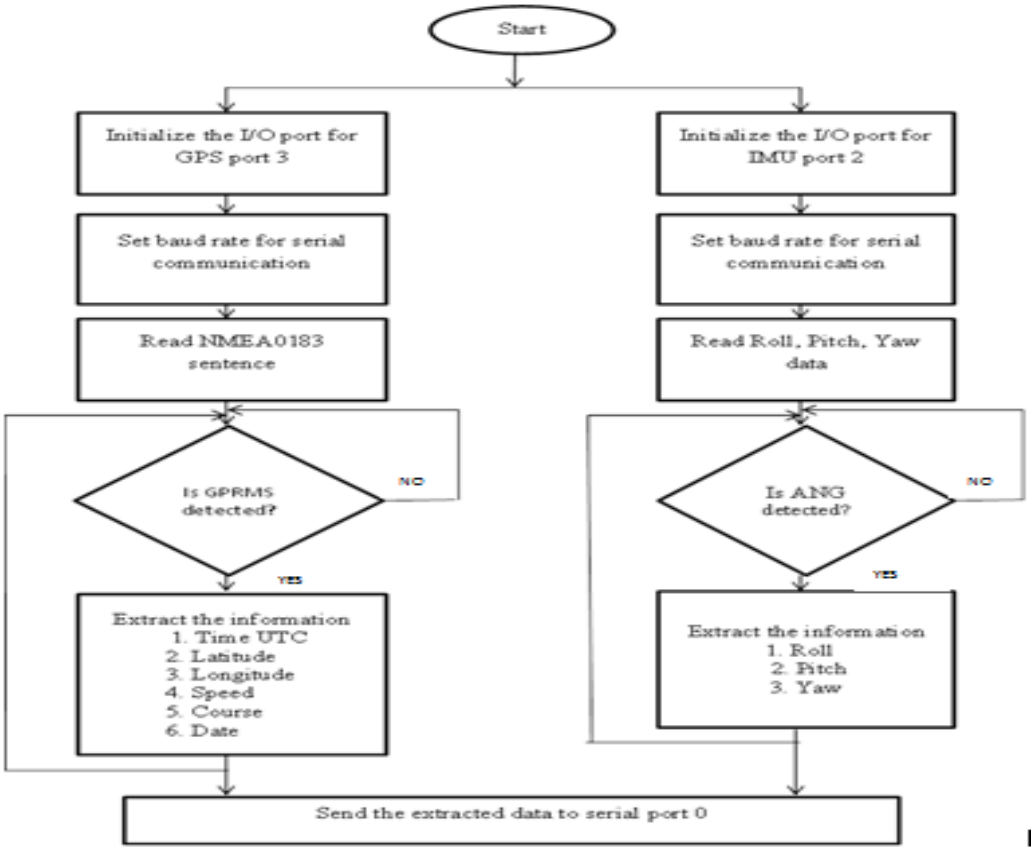

Figure 2-Flow of GPS/IMU system

V.RESULT

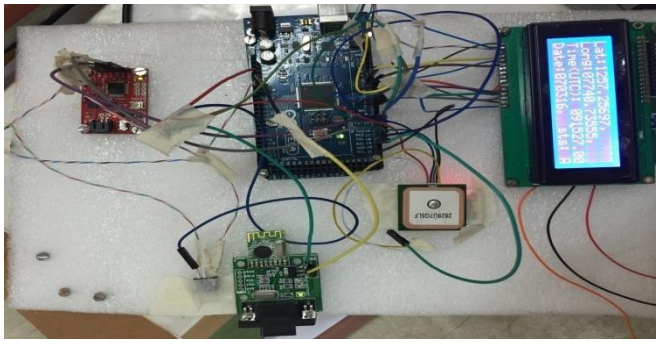

Figure 3- RF transceiver connected to ARDIUNO MEGA along with GPS-IMU system with LCD display

The integrated system is connected to an RF transceiver in order to send the acquired data to a remote PC. The figure above shows the GPS receiver system connected to the Arduino mega along with IMU and LCD display the TX0 and RX0 of the arduino is connected to the TX and RX of the RF transceiver respectively. A 5v power supply is also required by the transceiver which is given by the microcontroller board.In the other end the RF transceiver is connected

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Vol. 3, Issue 4 , April 2016

to a PC. The RF requires an external 5v supply so, we are using a 9v supply with a 5v regulator to provide the required voltage to the RF transceiver and the serial port is connected to the PC.

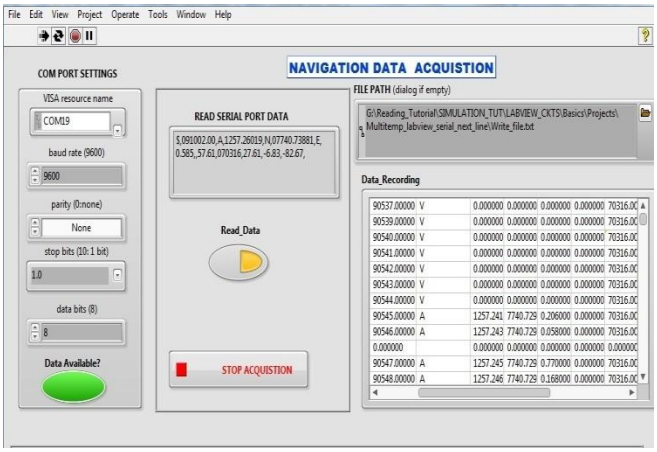

Figure 4-Hardware output displayed inLabview

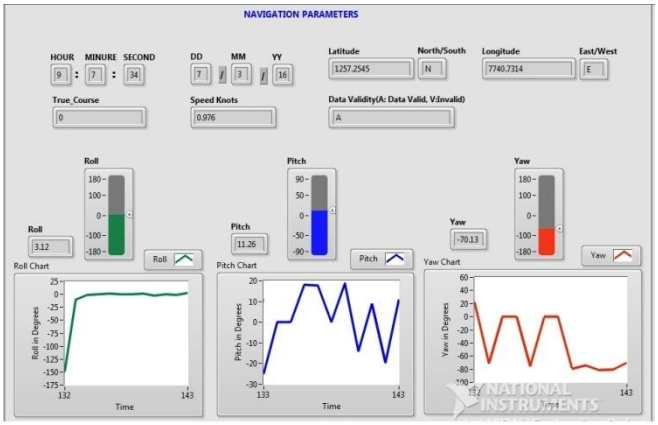

Figure 5-Displaying of hardware simulated navigation parameters in labview

VI. CONCLUSION

An GSM/IMU system is built that helps to navigate , display and capture the movements of the airplane. It provides an overview in the process of designing such a System that can determine the user's position. It also addresses some of the enhancements that can be accomplished in the designed system. The main feature of this Navigation System is its ease of use along with the compact size and visual display of results using PC and LCD display. Hardware description along with a case study implementation detail of the system, its features and possible enhancements in the system.

The analysis of the GSM/IMU position observations indicates both global and systematic flying directions. The location, date, time and pressure of the airplane will be displayed in the LCD and simultaneously in PC.

The height of the aircraft can be obtained by adding an Altimeter to the GPS-IMU system, Altimeter is a device which is used to know the height of an Aircraft. We can install solar panels on the aircraft and connect it to our system instead of the power supply .The same GPS-IMU system can be installed in a UAV by disabling the LCD display.

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International Journal of Advanced Research in Science, Engineering and Technology

Vol. 3, Issue 4 , April 2016

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