Synchronization of Compass Module with Pressure and Temperature Sensor System for Autonomous Underwater Vehicle (AUV)

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Abstract

This paper describes the synchronization of compass module with pressure and temperature sensor system for an Autonomous Underwater Vehicle (AUV). In general this project is the result of a combination of existing technology for underwater sensory to produce a complete system that aims to identify the position of the AUVs based on AUV degree of freedom. This can be done with the help of compass module that can find and order the AUV is moving at a fixed angle. This created a system that aims to obtain data on pressure and temperature in the AUV. Not only that, the project also aims to prove that the relationship between pressure and depth of the water and the relationship between pressure and temperature. All data gathered is capable of helping in the preparation of an AUV that can accommodate high pressure according to the depth to destination.

Keywords: Compass module; pressure sensor; temperature sensor; Autonomous Underwater Vehicle

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1. Introduction

Throughout the history, navigation system formerly is a very rare system in the past few decades because of its specialty in determining location and as guidance to go anywhere but it was tremendously grown in today’s world. The concept of this navigation system is drawn since the beginning of time; mankind has been trying to figure out dependable way to know where they are and to guide them from one place to another [1]. This system is designed and built and is operated instead of maintained by the United State Department of Defense under its NAVSTAR satellite program in 1973 [2]. In 1978, the system is firstly used in US military to carry the Polaris nuclear missile by six satellites. By mid-1990 the system is fully operated with up to 24 satellites. Since it became fully operational on April 27, 1995, navigation system has become a widely used aid to navigation worldwide, and a useful tool for map-making, land surveying, commerce, scientific uses, tracking and surveillance, and hobbies such as geocaching. Also, the precise time reference is used in many applications including the scientific study of earthquakes and as a required time synchronization method for cellular network protocols such as the IS-95 standard for CDMA [3]. From the benefits of this very sophisticated technology, a navigation system can be developed in order to have the clearer along the desired path. Normally in navigation system, it involves a reference point which calls the waypoints. These waypoints are set by the diver or the person who needs to know her or his direction and then, the navigation process is taking the part to navigate the person to the set waypoints [4-5]. From its definition, navigation is the process of planning, reading and controlling the movement of a craft or vehicle from one place to another. This former Latin word use is also give the meaning as “to move” or “to direct”. Thus, with some research and development also with the use of other device, navigation system can be used as a medium to navigate a craft or vehicle for a wide variety especially in navigation system [6].

A pressure sensor measures pressure, typically of gases or liquids. Pressure is an expression of the force required to stop a fluid from expanding, and is usually stated in terms of force per unit area [7]. A pressure sensor usually acts as a transducer; it generates a signal as a function of the pressure imposed. For the purposes of this article, such a signal is electrical. Pressure sensors are used for control and monitoring in thousands of everyday applications. Pressure sensors can also be used to indirectly measure other variables such as fluid/gas flow, speed, water level, and altitude [8-11]. Pressure sensors can alternatively be called pressure transducer, pressure transmitter, pressure sender, pressure indicator and piezometer, manometer, among other names [12]. The HMC6352 integrates Honeywell's patented two-axis magnetic sensor with the required analog and digital support circuits for heading computation [13]. For the ultimate in electronic functionality, this innovative electronic compass provides an electronic compass function using two-axis magnetic field sensing. Honeywell's digital compass combines the sensor elements and all the processing electronics in a 6.5mm square package to satisfy smaller, next generation applications. Aimed for low power battery operation on OEM printed circuit boards, the HMC6352 uses an I2C digital interface slaved to the manufacturer's microprocessor to transfer compass heading data. Heading update rates from 1 to 20Hz are selectable.

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2. Methodology of project design

In this methodology part, it will focus on procedure that will take place after the research has been done. It's included software and hardware part that being developed based on the project development. All part in combination of software and hardware will be explained briefly according to the methodology as shown in Fig. 1. Refer to the Fig. 1, the complete hardware and software that are tested before are combined. Then, the systems are run after the combination of complete hardware and software part. The hardware is located inside the AUV in order to measure the pressure around the AUV. After that, this AUV is tested inside the water to make sure the software and hardware is functioning very well. The barometric pressure will detect pressure around the AUV and send the data to LCD display via PIC 16F876A. The receiver acts as a switch to switch on the GPS when pressure is low and switch off when pressure is high. Lastly, this project of Relating Pressure and Temperature with Collaborating to the Depth of the Water is done.

3. Result and Analysis

After complete researching about all the components used in this project, the PIC microcontroller start-up kit, barometric pressure sensor, capacitive sensor and compass module is combined to make one PIC board acts as a main controller in this project. This PIC board will receive signal from barometric pressure sensor and send data to LCD display in order to get a data about pressure and temperature. The PR22 board will be immersed in the 3 different medium which is tap water, hot water and cold water. This board is design to configure pressure, temperature and also capacitance in surrounding. Fig. 1 shows the process flow in order to obtain the relationship between pressure and depth for AUV.

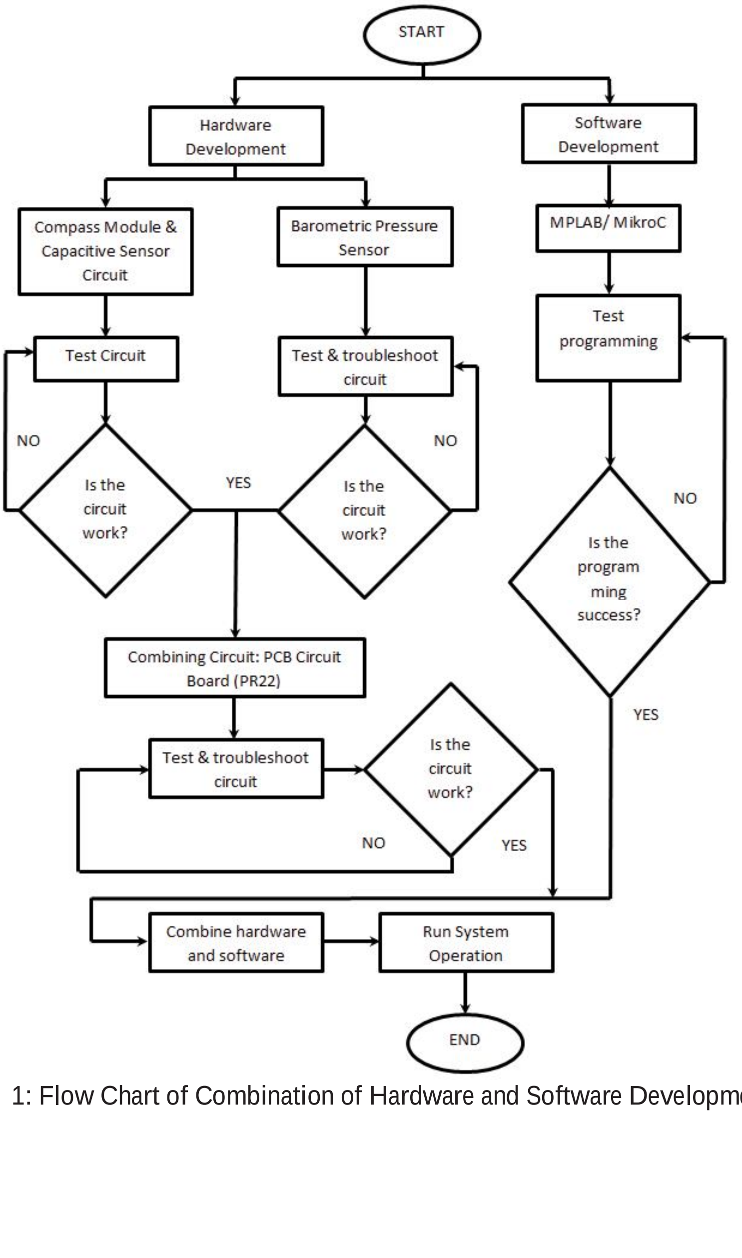

Fig. 1: Flow Chart of Combination of Hardware and Software Development

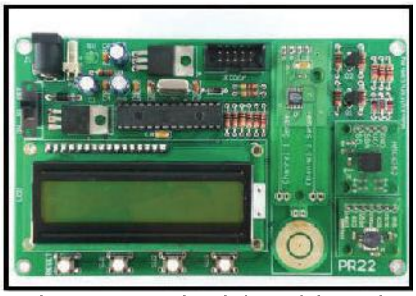

Fig. 2: PCB Circuit board (PR22)

Based on the data obtained, 3 analyses are to determine the relationship between pressure, temperature and depth. Three testing are conducted for different temperature modes such as normal, hot and cold water temperature. For normal water the range of temperature about 32.1- 32.5^{o}C , hot water that has a range temperature about 45.2-48.5 °C , and cold water that has a range temperature about 25.4-23.8 °C. Data are taken based on the experiment carried out in a bucket that has to 20cm by using different water temperature as shown in Table 1. Data were recorded every 2 cm depth PR22 immersed board.

Table 1: Experiment Data Using three modes water condition

Mode / Depth (cm)	Normal			Hot			Cold		
	Temperature (°C)	Pressure (kPa)	Compass (°)	Temperature (°C)	Pressure (kPa)	Compass (°)	Temperature (°C)	Pressure (kPa)	Compass (°)
0	32.1	102.383	188.5	45.2	102.59	182.4	25.4	102.113	183.2
2	32.1	102.598	181.3	45.5	102.836	187.1	25.1	102.431	181.3
4	32.2	102.813	186.2	45.7	103.147	184.9	24.9	102.557	182.6
6	32.3	102.980	178.4	45.9	103.368	176.2	24.8	103.021	181.3
8	32.3	103.189	176.2	46.4	103.521	179.2	24.6	103.277	184.0
10	32.4	103.351	181.4	46.8	103.645	185.3	24.3	103.653	180.9
12	32.4	103.585	184.3	47.3	103.972	184.6	24.0	103.992	186.2
14	32.4	103.763	183.5	47.6	104.211	181.2	23.8	104.323	184.5
16	32.4	103.967	181.6	47.9	104.537	181.4	23.6	104.529	181.4
18	32.4	104.165	187.1	48.3	104.634	183.1	23.5	104.776	183.1
20	32.5	104.464	180.8	48.5	104.885	180.9	23.2	104.814	180.7

From the data obtained, the pressure will always increase when collaboration with increasing water in depth. The water pressure increase as the depth is being increased as shown in Fig. 3. The presence of the pressure is different depth that makes breathing become difficult with a different situation when we breathe in our normal situation. This is because our bodies have the pressure of the water pressing our bodies that cause our breathing cavity narrowing. As such, we will have difficulty in breathing. As shown in Fig. 4 the arrows represent the pressure on the swimmer. The arrows show from all direction because the water exerts pressure in all direction. That’s why swimmers feel the water pressure on all parts of theirs body when they are underwater.

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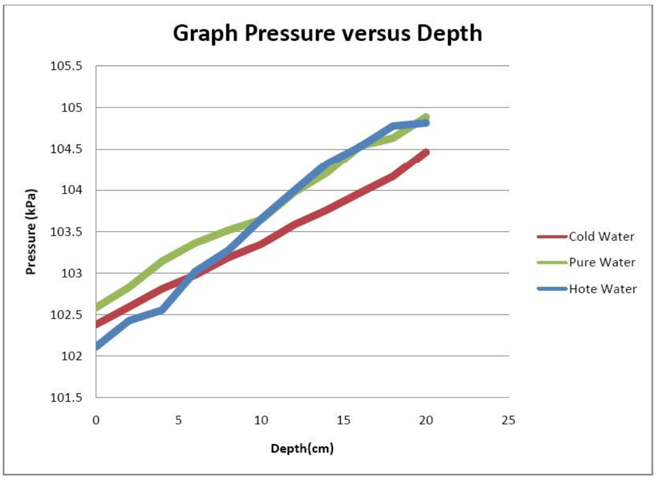

Fig. 3: Graph Pressure versus Depth for all Testing Method

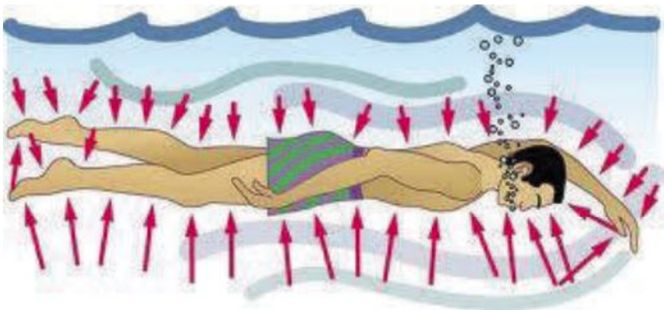

Fig. 4: Water Pressure around Swimmers

Based on data taken from Table 1, it can be concluded that the PR22 board when the experiment is on the south with an average of 182.7 degree for pure water, 182.6 for cold water and 182.4 for hot water. Therefore, the AUV will not only be determined by using the Global Positioning System (GPS) but also can be replaced with the compass module is capable of reading the degree of the AUV motion. Through experiments performed, if the experiment is done by pointing the compass module to the north it will give a reading close to 0, or 360 degree. This means that the system is also capable of acting as a medium other than the navigation system using GPS. Fig. 2 shows the PR22 board when the experiment 1, 2 and 3 carried out with different mediums.

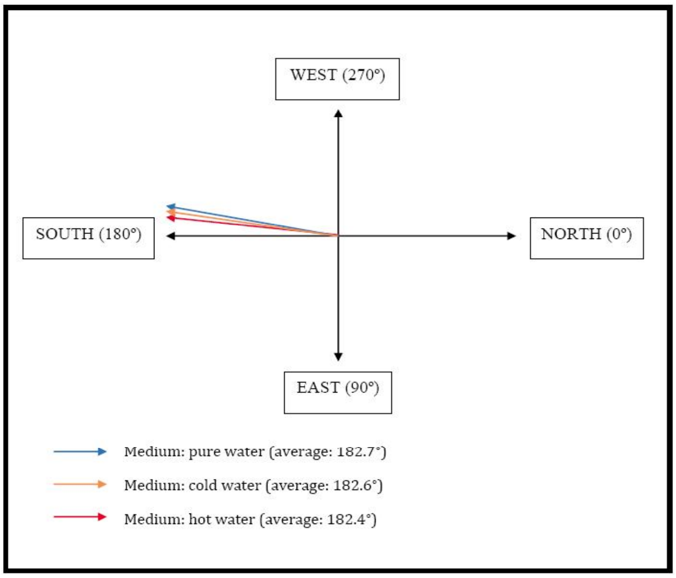

Fig. 4: Illustration of Compass Module

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The pressure related to the depth of the water according to the pressure equation but temperature has nothing to do with the pressure and depth. The objective of this project is to synchronizing the compass module with pressure and temperature sensor. The results of this project show that the direction each times the pressure and temperature data being recorded. So, we can detect the position of the AUV by reading the degree from the compass module and its can be as one of the medium as a navigation for AUV.

This Autonomous Underwater Vehicle is completed with intelligent navigation system where it can be used as a navigator to find out the position of the AUV. In this project, this AUV can be located by move it up above the water surface. So, barometric pressure sensor detects low pressure and send the data to PCB circuit board (PR22) and it send data to LCD display. This LCD display acts as a screen to display value while it receives signal low pressure and compass module detect the location of the AUV. As a result, the AUV location can be detected. In military section, this AUV can be used as guidance for doing investigation underwater and to prevent from using manpower that will cause them a dangerous situation. Not only that, this AUV called as a guardian in the sea because it can be a detector from any kind of situation in the sea.

4. Conclusion

This project can help in a survey conducted to determine the appropriate temperature and pressure to move the AUV in the water. Research also has many advantages that can help determine the level of AUV in the surrounding temperature and pressure of the AUV. Not only that, with the information about the relationship between pressure and depth could help researchers in further developing the existing AUV to be able to survive at high pressure and temperature. Starting from the problem statement encounter by some application in determining pressure and temperature relationship, this project will be the one of the system that can be implemented in Autonomous Underwater Vehicle (AUV) process. All the methods carried must be recorded based on the methodology planned, and all the necessary procedures are followed to achieve the objective upon completion. By doing the troubleshooting process or project execution, many arising problems can be solved through some innovation made from time to time. This project combines some of the useful technologies to develop a new system for ease of usage in underwater to determine pressure and temperature at surrounding of AUV. Not only that, this system can help the AUV to recognize its direction by using the compass module.

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References

1. Farrel, J. A., & Barth, M. (1999). The Global Positioning System & Inertial Navigation. United State: McGraw Hill.
2. Cytron Technologies, Incorporation. (2007). PIC Microcontroller Start-up Kit (SK40B) User Manual. Malaysia.
3. Cytron Technologies, Incorporation. (2007). Barometric Pressure Sensor (SCP1000-D01). Malaysia.
4. Cytron Technologies, Incorporation. (2007). Compass Module (HMC6352) and Capacitive Sensor (AD7746). Malaysia.
5. L. K. Baxter (2000). Capacitive Sensor. Retrived July 20, 2000
6. Julio Rosenblatt, Stefan William and Hugh Durrant-White, “Behavioured Based Control for Autonomous Underwater Vehicle,” University of Sydney, Australian Centre for Field Robotics. July 2006.
7. John Folkesson, Jacques Leederkerken, Rob Williams, Andrew Patrikalakis and John Leonard, “A Feature Based Navigation System for an Autonomous Underwater Robot,” Massachusetts Institute of Technology.
8. Mohd Aras, Mohd Shahrieel and Abdullah, Shahrum Shah and Shafei, Siti Saodah (2012) Investigation and Evaluation of Low cost Depth Sensor System Using Pressure Sensor for Unmanned Underwater Vehicle. Majlesi Journal of Electrical Engineering , Vol. 6, (No. 2).
9. Tamaki Ura, Takashi Obara, Kenji Nagahashi, Kangsoo Kim, Yuji Oyabu, Takashi Sakamaki, Akira Asada and Hisashi Koyama, “Introduction to an AUV r2D4 and its Kuroshima Knoll Survey Mission,” Institute of Industrial Science, The University of Tokyo.
10. Mohd Aras, Mohd Shahrieel, Shahrum Shah Abdullah**,** Ab Rahman, Azhan, and Muhammad Azhar Abdul Aziz, (2013) Thruster Modelling for Underwater Vehicle Using System Identification Method. International Journal of Advanced Robotic Systems, Volume 10 (252. 2013). pp. 1-12. ISSN 1729-8806
11. Mohamad Haniff , Harun (2010) Synchronization Of Compass Module With Pressure And Temperature Sensor System. Project Report. UTeM, Melaka, Malaysia.
12. Mohd Aras, Mohd Shahrieel and Mohd Farriz , Md Basar and Abdul Azis, Fadilah and Fara Ashikin , Ali (2013) Analysis Movement of Unmanned Underwater Vehicle using the Inertial Measurement Unit. International Journal of Emerging Science and Engineering (IJESE), 1 (10). pp. 47-53. ISSN 2319–6378.
13. Mohd Aras, Mohd Shahrieel and Md Basar, Mohd Farriz and Abd Azis, Fadilah and Ali, Fara Ashikin (2013) Obstacle Avoidance System for Unmanned Underwater Vehicle using Fin System. International Journal of Science and Modern Engineering (IJISME), 1 (9). pp. 24-30. ISSN 2319-6386.

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