Development of Measuring Instrument for the Constructed Wireless Surface and Submarine Vehicle

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DOI: https://doi.org/10.56293/IJASR.2024.6021

IJASR 2024
VOLUME 7
ISSUE 4 JULY – AUGUST **ISSN: 2581-7876**

Abstract: A measuring instrument designed for use in developed and fabricated Wireless Surface and Submarine Vehicle for water body exploration. These the developed instrument pave way for indigenous research on the oceanography to explored the water body within local environment with less cost. The oceanography measuring instrument developed consists of the following: turbidity, salinity, temperature, pressure, magnetic field sensor, microcontroller, microSD shield, Electrically Erasable PROM (EEPROM), trans-receiver module, and web application alongside with graphical interface. The turbidity and salinity sensor were developed and remain sensors were obtained from the shelf. The turbidity sensor and salinity sensor were design and constructed and respond was very good with MBE of 0.003836 g/l for turbidity and -2.105564 ml/mg for salinity. Also, correlation obtained by the two developed sensors is above 0.9. All the pick from shelf have very good respond. The data was transmitted wireless the obtained were with the on store on EPROM and microSD card when tested with instrument system with Wireless Surface and Submarine Vehicle (WSSV) in dam. Result obtained were strong in agreement and measured correctly. The developed ocean measuring instrument is found to be viable and capable for field deployment.

Keywords: oceanography, instrument, sensors, submarine vehicle, wireless system

Introduction

Currently, monitoring of the marine environment require modems technology advance that involved Marine autonomous systems which including submarine gliders and Autonomous Underwater Vehicles (AUV), are revolutionizing our ability to map the water body and activities going on it (Yoerger *et al.*, 2007a; Caress *et al.*, 2008; German *et al.*, 2008). The autonomous systems are typically deployed from a research vessel, as they are not tethered to the vessel and do not require direct human control while collecting data (Yoerger *et al.*, 2007b; Griffiths, 2003; Yoerger *et al.*, 2007a). They therefore provide opportunities for data acquisition in parts of the ocean previously inaccessible to vessel-based instruments, for instance, beneath ice sheets in polar regions (Bellingham *et al.*, 2000; Brierley *et al.*, 2002; Nicholls *et al.*, 2006; Wadhams *et al.*, 2006; Dowdeswell *et al.*, 2008; Jakuba *et al.*, 2008; Graham *et al.*, 2013), and are improving the spatial and temporal resolutions of a broad spectrum of marine measurements. Marine autonomous systems also have an increasing range of applications in the defense, industry and policy sectors, such as geo-hazard assessment associated with oil and gas infrastructure (Eddy and George, 2004). In addition, recent economic drivers, such as rapidly increasing vessel fuel oil costs, are making autonomous systems a potentially attractive proposition to organizations responsible for large-scale and cost-effective marine data collection programmes (Wynn *et al.*, 2012). This contribution will focus on Autonomous Underwater Vehicles, as these platforms are most relevant to geoscience studies that are targeted at or close to the interface between the seabed and the water column. This is a critical interface, as it is a key physical habitat for benthic organisms as well as a zone of focused sediment transport and deposition. The ability to collect high-resolution data from this platform is essential, but technologically challenging (especially in deep water).

In this work instrumentation attached to WSSV developed at Department of Climate change, The Federal University of Technology, Akure, Nigeria was designed and constructed for data collection at various depth below and top of the water surface.

Method and Materials

The Block Diagram of Measuring Instrument with Data Logger for WSSV

The complete block diagram of measuring instrument with data logger system consists of three separate modules for data collection, data storage and data communication. The modules communicate with each other serially and are controlled by ATMEGA1284P microcontroller Figure 1. The data collection module is interfaced to a set of sensors to collect weather parameters such as turbidity, salinity and sea surface temperature. The data storage module that saves the captured data in real-time to an EEPROM. The data transmission module transmits data to a central station through a GPRS network. The selection of the network takes place automatically before transmitting data. The oceanic data can be viewed in real-time through a Microsoft Excel.

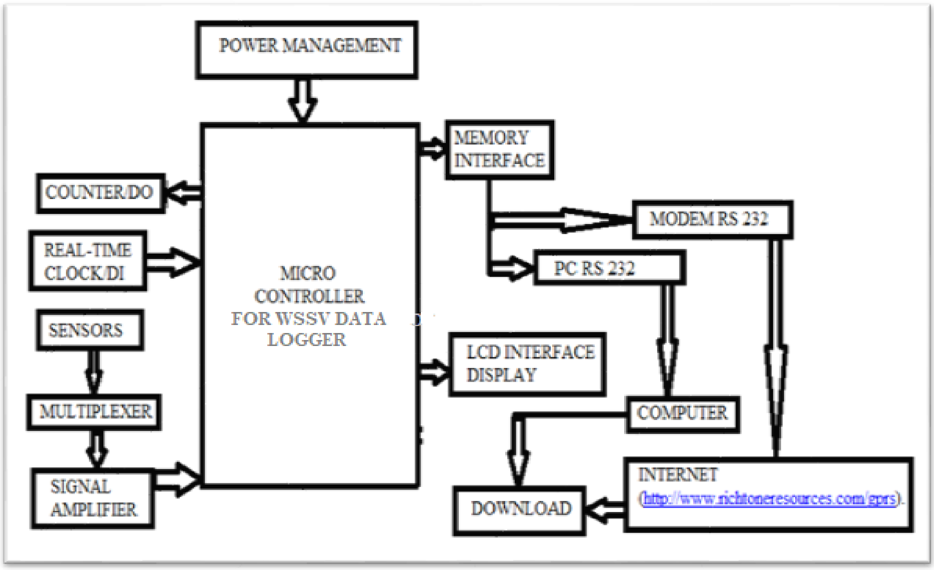

Figure 1: The Block Diagram of Data Logger for the WSSV.

Central Processing Unit (CPU) for the WSSV

The main component here is the ATmega1284P microcontroller which works as CPU. This microcontroller not only controls the system but also synchronizes all the module operations. The CPU use calibrated 8 MHz internal RC oscillator. ATmega1284P provides eight channels ADC (Analog to Digital Convertor) which can be used in 10-bit mode (Figure 2).

The Display Circuit for the WSSV

The device uses LCD module for real-time display. The module has on-board display controller, which relieves the main microcontroller from manually generating dot-matrix character display. The display unit is composed of 20x4 LCDs dots matrix alphanumeric LCD. The LCD is configured in 4-bit mode with read-write control (WR) pin grounded. This configuration requires a smaller number of I/O pins of microcontroller, typically 6 only (Figure 2).

Data Logging and Remote Monitoring Circuitry for the WSSV

The device allows the selection of amount of data and the time intervals between them through a multiplexer. The current time for data-logging purposes is provided by the time-keeping circuit typically from 30 sec to 99 min. The

Microchip 24LC512 is a 64K x 8 (512 Kbit) Serial Electrically Erasable PROM is connected to the microcontroller for storing the sensors readings to store more than 100 days reading for 30-second sampling interval. Interfacing of the Microchip 24LC512 to Atmega1284P (Figure 2). The microcontroller sends current monitored parameters through Microchip in the time interval specified by user to the internet.

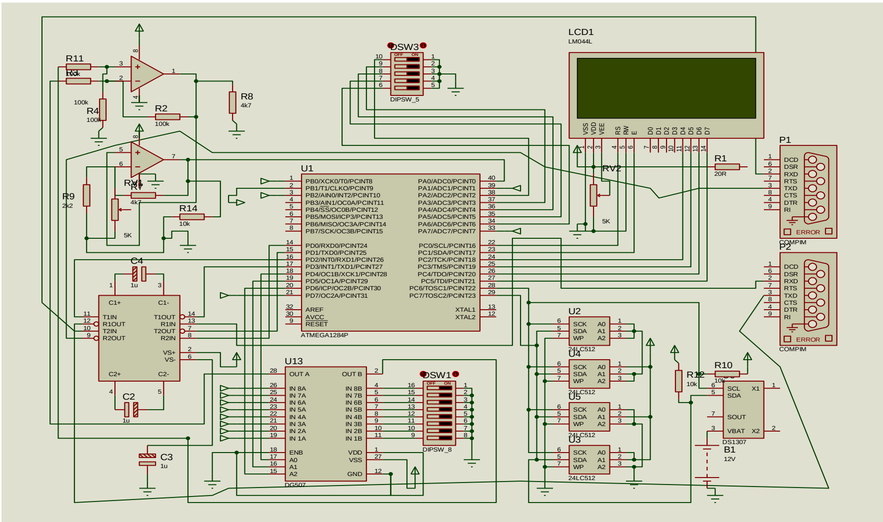

Figure 2: Schematic Diagram of Weather Remote Monitoring Data Logger for the WSSV

Power Supply Unit for the WSSV

The power supply circuit is designed to provide low voltage of 5 and 12 volts for the system, as shown Figure 3. Due to high sensitivity of digital devices to voltage, an internal DC power supply is used. The first element in the unit is three-terminal adjustable regulator, bridge rectifier, implemented as a network of IN4001 diodes. Fluctuations and ripples superimposed on the rectifier DC voltage are filtered out by a 2200 µF, 25V and 0.1 µF capacitors. The transistors TIP 42C, D882, C9014 and three-terminal adjustable regulator was used to boost and regulate the output DC voltage. The three-terminal adjustable regulator acts as voltage regulator to control the DC supply, which makes the internal voltage independent of fluctuations that may occur at the main outlets in the course of using the digital access monitor.

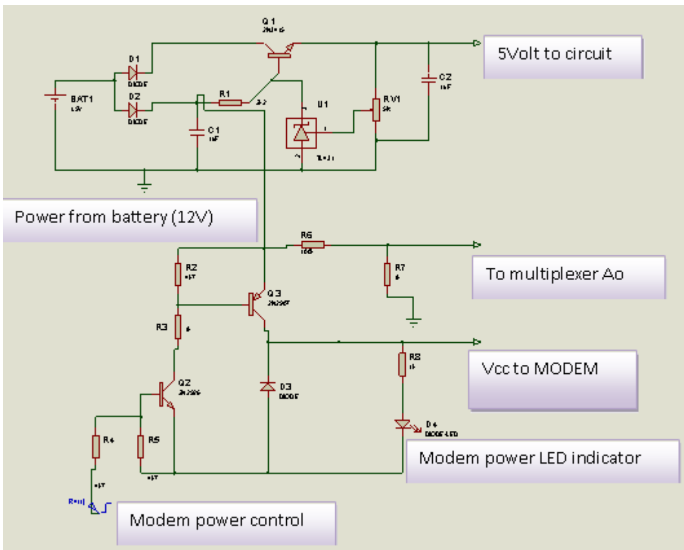

Figure 3: The WSSVPower Supply Circuit Diagram for Data Logger.

Internet and Computer Interface for the WSSV

EEPROM holds the raw values uploaded from the GPRS logger, and this consists of 16 different variables and can be a virtual table since not all variables from it are used, but still have to be in the database for computation. Plate 3.3 shows the design logger panel and Plate 3.4 shows the data logger panel design with LCD display and EEPRON Integrated Circuit. Table 3.4 show the values uploaded to the web page.

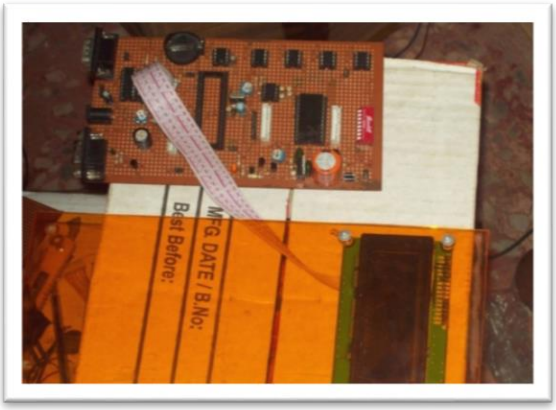

Plate 1: Data Logger Panel Design for the WSSV **Plate 2:** Data Logger Panel Design with LCD display and EEPRON Integrated Circuit for the WSSV

Sensors Design for the WSSV

a. Turbidity Sensor Design for the WSSV.

The main component is Infrared LED and photo-transistor for clearness of the water.

i. Block diagram for Turbidity and Salinity Design Sensors Board (Figure 4).
ii. Circuit for Turbidity Design Sensor (Figure 5).
iii. Turbidity Design Sensor (Plate 3).
iv. Laboratory calibration of Design Turbidity Sensor at Physics Department FUTA (Plate 4).
v.

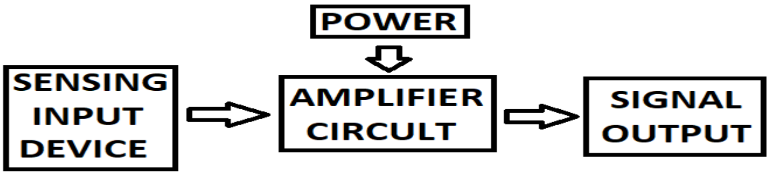

Figure 4: Block Diagram for Turbidity and Salinity Design Sensors Board for the WSSV.

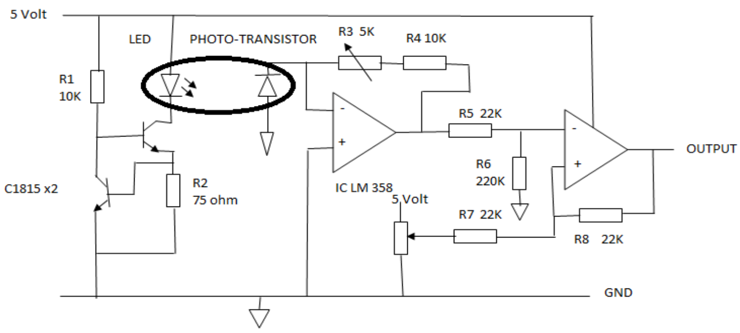

Figure 5: Circuit for Turbidity for the WSSV.

Plate 3: Turbidity Design Sensor for the WSSV

Plate 4: Laboratory Calibration of Turbidity Sensor at Physics Department FUTA for the WSSV

b. Salinity Design Sensor for the WSSV.

The main component is two Aluminum rod and operation amplifier circuit.

i. Circuit for Salinity Design Sensor in Figure 6.
ii. Design Salinity Sensor (Plate 5).
iii. Laboratory calibration of Salinity Sensor at Physics Department FUTA (Plate 6).

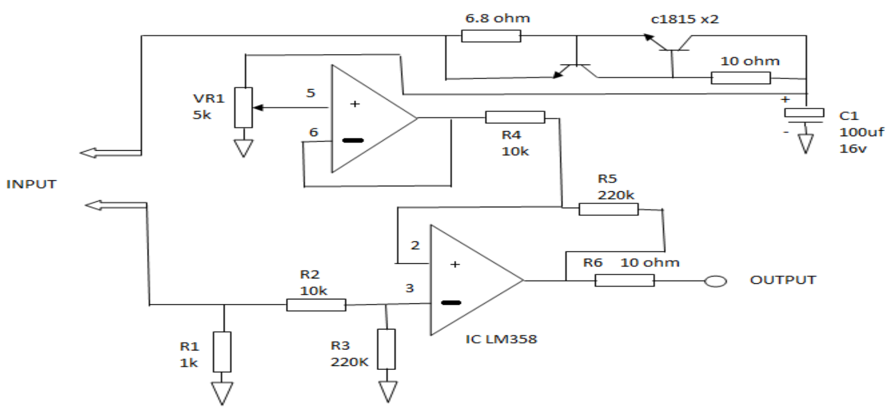

Figure 6: Circuit for Salinity Design Sensor for the WSSV

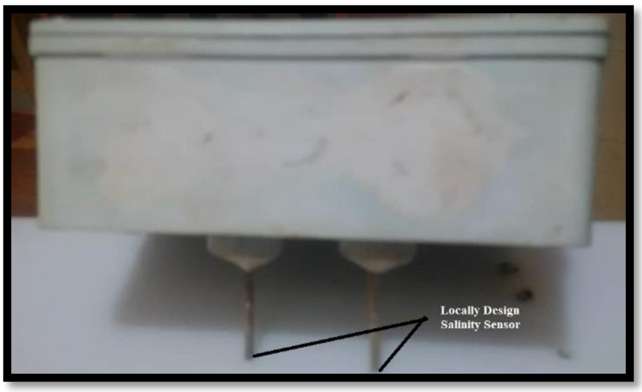

Plate 5: Salinity Design Sensor for the WSSV

Plate 6: Laboratory calibration of Design Salinity Sensor at Physics Department FUTA for the WSSV.

c. Pressure Sensor

The pressure, MS5803-14BA, it has a linear relationship between water pressure and water depth, the pressure sensor was used to measure pressure and the device depth. The selected pressure sensor is the MS5803-14BA shown on Figure 7 and Figure 8, a new generation of high-resolution pressure sensors with I2C interface. It is optimized for depth measurement systems with a water depth resolution of 1cm and below. A high-resolution temperature output allows the implementation of a depth measurement system and thermometer function without any additional sensor. A gel protection and antimagnetic stainless-steel cap protects against 30 bar overpressure waterproofs.

d. Temperature Sensor

In this digital sensor (ST-11), a unique capacitive sensor element is used to measure relative humidity while the temperature is measured by a band-gap sensor. Serial I2C interface and factory calibration, allow easy and fast system integration. Board is set to use 3.3V power supply by default. Solder PWR SEL SMD jumper to 5V position if used with 5V systems. Is a high precision digital sensor to measure temperature, the sensor has a 5V power supply a high precision digital sensor to measure temperature (Figure 9 and Figure 10), the sensor has a 5V power supply.

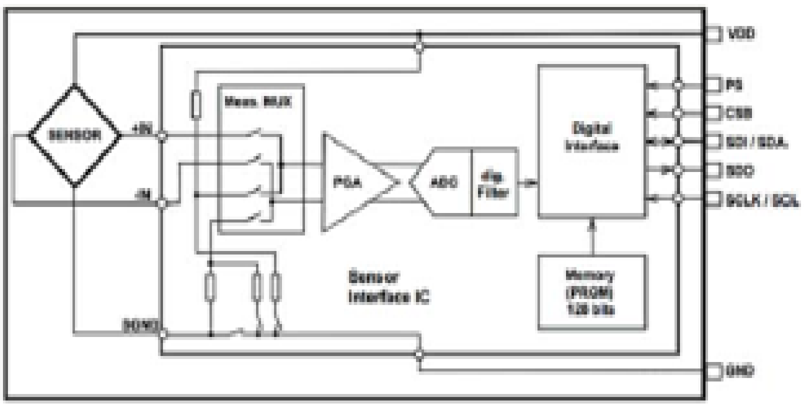

Figure 7: Block Diagram of Pressure Sensor MS5803-14BA and Sensor Board for the WSSV.

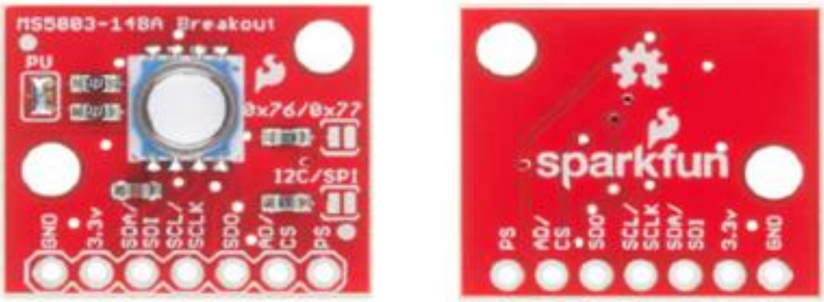

Plate 8: Pressure Sensor MS5803-14BA and Sensor Board for the WSSV.

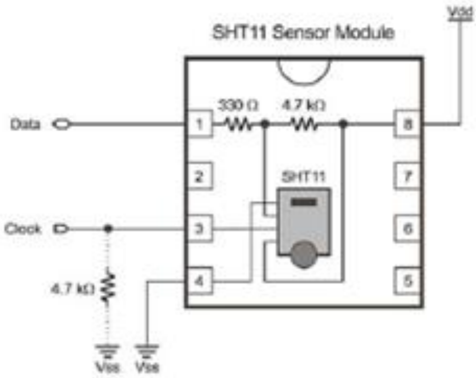

Figure 9: Temperature Sensor for the WSSV.

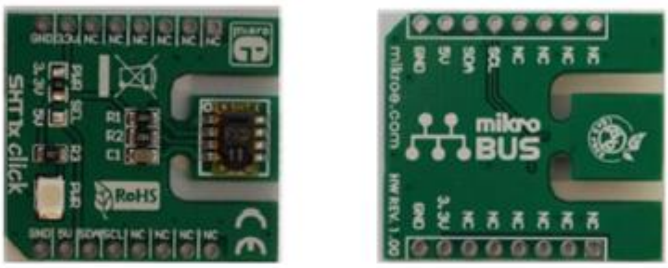

Figure 10: Temperature Sensor for the WSSV.

Plate 7: Sea Surface Temperature Design Sensor for the WSSV

Calibration of Developed Sensors: Turbidity and Salinity

The turbidity and salinity were the responded according to cloudiness and concentration of salt leave present in the water. As the mud clay powder increases the value turbidity increases, also for the salinity difference salt sources were added gradually, the value salinity increases as well. Also, the calibration was carrying out for the two sensors, the calibration Table 1 and Table 2 show the turbidity and salinity reading during the process.

Table 1: Turbidity Calibration Table.

	Volume of Water	**0.375 Litre**
Mass of Clay Powered (g)	Output Voltage (V)	Mass of Clay powered/Volume of Water (g/l)
2.26	0.00035	6.02
5	0.80000	13.33
10	1.66000	26.67
12	1.78500	32.00
15	2.22000	40.00
16	2.10800	42.67
20	2.40000	53.33

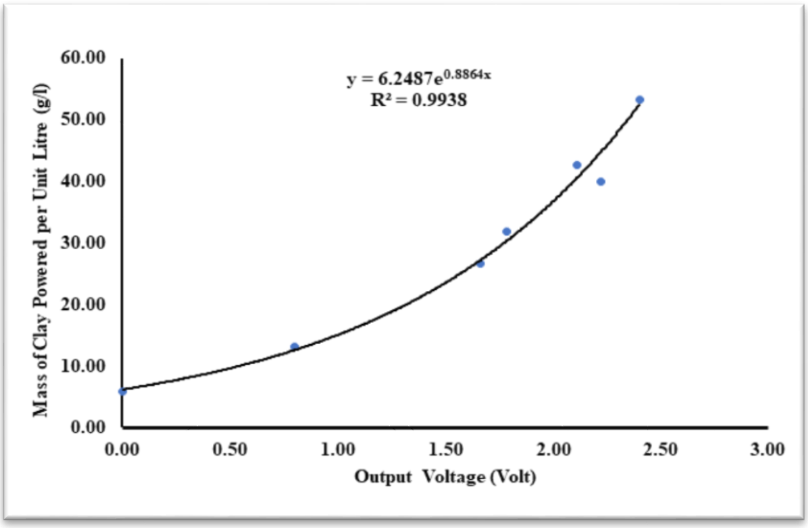

Figure 3: Calibration of Designed Turbidity Sensor Graph

Table 2: Salinity Calibration

Volume of Water	**200 ml**	
Output Voltage (V)	**Amount of Salt (mg)**	**volume of water/unit mass of Salt (ml/mg)**
0.47	0.074	2702.70
0.83	0.186	1075.27
1.13	0.226	884.96

1.57	0.304	657.89
1.76	0.352	568.18
2.24	0.408	490.20
2.34	0.468	427.35
3.00	0.600	333.33

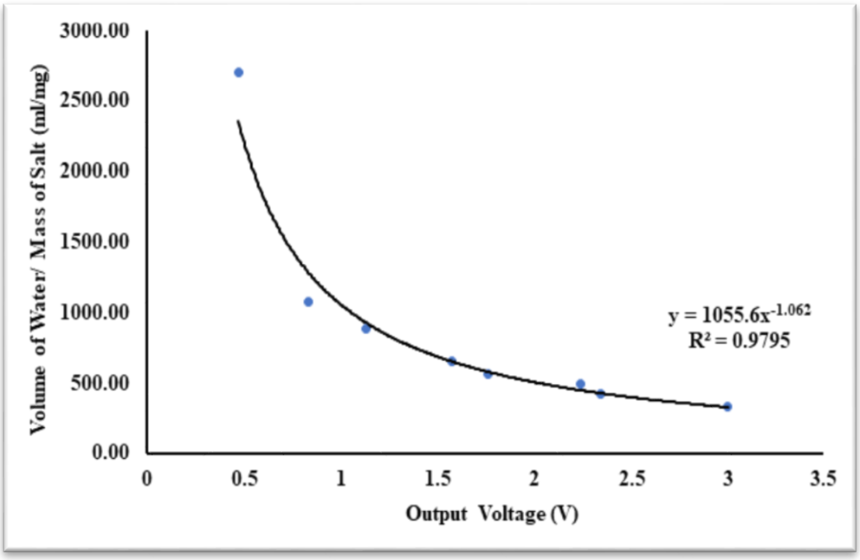

Figure 4: Calibration of Designed Salinity Sensor.

The Transceiver System for the WSSV

All the WSSV design processes including camera/sensor data, detecting obstacles, controlling motor operation, etc., can be managed via a main processing board. In this work, we used the mini-PC board Giada i200-BG000, Celeron. Considering the amount of data to manage in real time, the WSSV operation needs a high-speed processor to efficiently receive and send commands. With its high processing speed, supporting USB ports, and 802.11ac dual band wireless network, Giada i200-BG000 board is in fact one of the most appropriate devices used. Furthermore, its light weight, small size, and low power consumption make it the most suitable for our application. This board has the following features:

i. Mounting: optional VESA mounting kit.
ii. Adapter1: optional video adapter for HDMI Connector.
iii. Adapter2: optional video adapter for Display Port.
iv. Wi-Fi: 802.11ac dual band wireless network.
v. 12V to 19V supply voltage.

The function and mission of WSSV is to work in water at a maximum depth of 100 m. The Mini PC (Giada i200-BG000, Celeron) uses Wi-Fi and Bluetooth systems. However, due to underwater antenna issues in terms of cost and power supply, it was decided to use two transceiver modules in order to evaluate the system performance during the mission and controlling the WSSV in emergency modes. The RF7020 (ADF7020) was selected, a low power of size 37.5 × 18.3 × 2.54 mm^3. The reason for choosing this module is its AUV's good mileage performance (about 3 km), its USB port connection, and its light weight as well. One of the two modules is connected to the external controller while the second is inside the WSSV and is connected to the Mini PC through a USB port. The transceiver uses the GFSK modulation and is directly connected to the main processor board via a Serial USB adapter and a USB port. It can be fed from the same port.

Result and Discussion

Measuring instrument was constructed using wireless system for surface and submarine vehicle. The wireless instrumentation system with the following sensors: temperature, pressure, depth, magnetic field, turbidity and salinity. The first four sensor on the were obtained as from shelf, where are tested and was found responding as expected and result accurate and precise when compared campbell instrument. Also, turbidity and salinity have sensitivity of 1055 ml/mg and 6.8 g/l respectively. The performance of the turbidity and salinity were highlight in Table 3 and their respond variability is display in table 4. The receiver GUI interface is shown in Figure 7 and Figure 8. The data transmission where observed on the Figure 8 stored data view on the computer screen when the instrument was place marine vehicle at nearby dam for test the data correctly transmitted and received.

Table 3: Correlation Coefficient and Sensitivity Analysis of the Constructed Sensors

CONSTRUCTED SENSORS	CALIBRATION EQUATION	SENSITIVITY
Turbidity	6.2487e0.8864 v/g/l	1.1211ln(x) - 2.0445 g/l/v
Salinity	$1055.6x^{-1.062}$ v/ml/mg	$620.92x^{-0.923}$ ml/mg/v

Table 4: Results of Statistical Analysis of the Sensors

Constructed Sensors	MBE	RMSE	STDEV	R
Turbidity	0.003836 g/l	21.53173 g/l	1.68282	0.9938
Salinity	-2.105564 ml/mg	145.8701 ml/mg	6.73501	0.9795

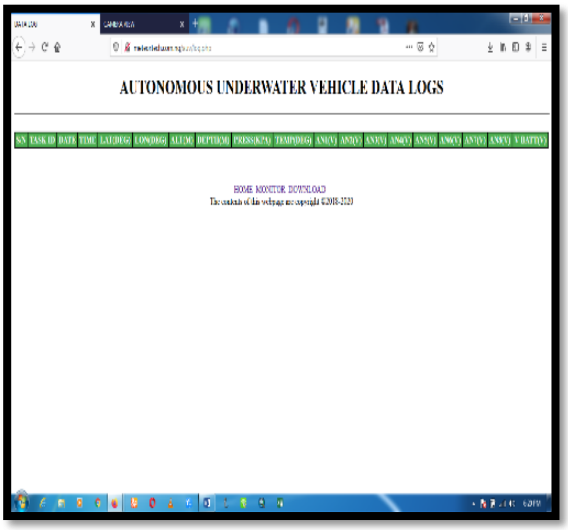

Figure 7: Interface for the WSSV Web Page Data Logs

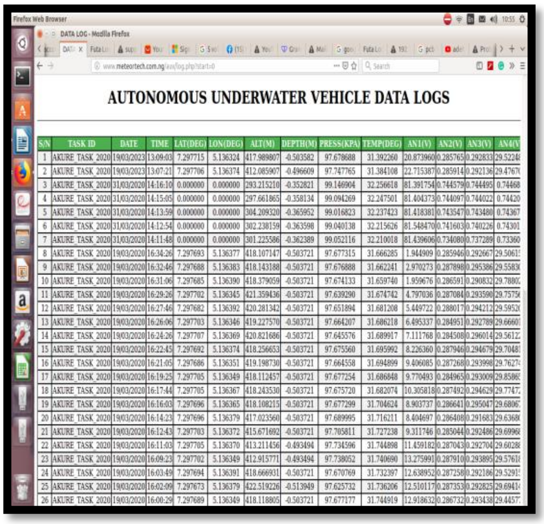

Figure 8: Data Store Shows on Computer Screen

Conclusion

The design oceanography sensors and data logger were built and installed to transmit digitized data at regular intervals without significant problems via the internet and were also stored in micro-SD cards and EEPROM. The data obtained from the design oceanography sensors were calibrated at the Physics Instrumentation laboratory, The Federal University of Technology, Akure. Nigeria. The oceanography instrument that were constructed was installed into Marine autonomous vehicle and work very well. It found viable and capable for field deployment. There was a very high correlation with all the designed oceanography sensors. Finally, after testing the instrument with local fabricated WSSV under operating conditions in the dam environment, the designed WSSV successfully responded to all commands and efficiently detected fixed obstacles by taking appropriate decisions and the developed WSSV and oceanic sensors respond very good and can be useful for Marine and oceans related studies to predict, manage and modify changes in the marine environment. The developed ocean measuring instrument is found to be viable and capable for field deployment.

Acknowledgment

The team where grateful to TetFund for provide financial surpport for carryout the research successfully and to make the Ph.D research an essay journey, more blessing to TetFund and the Federal Republic of Nigeria.

References

1. Yoerger, D.R., Bradley, A.M., Jakuba, M., German, C.R., Shank, T., Tivey, M., 2007a. Autonomous and remotely operated vehicle technology for hydrothermal vent discovery, exploration, and sampling. Oceanography 20, 152–161.
2. Yoerger, D.R., Jakuba, M., Bradley, A.M., 2007b. Techniques for deep sea near-bottom survey using an autonomous underwater vehicle. International Journal of Robotics Research 26, 41–54.
3. Wadhams, P., Wilkinson, J.P., McPhail, S.D., 2006. A new view of the underside of Arctic Sea ice. Geophysical Research Letters 33, L04501.
4. Wynn, R.B., Bett, B.J., Evans, A.J., Griffiths, G., Huvenne, V.A.I., Jones, A.R., Palmer, M.R., Dove, D., Howe, J.A., Boyd, T.J., MAREMAP partners, 2012. Investigating the feasibility of utilizing AUV and Glider technology for mapping and monitoring of the UK MPA network. Final Report for Defra Project MB0118. National Oceanography Centre, Southampton (244 pp.).
5. Jakuba, M.V., Roman, C.N., Singh, H., Murphy, C., Kunz, C., Willis, C., Sato, T., Sohn, R.A., 2008. Long-baseline acoustic navigation for under-ice autonomous underwater vehicle operations. Journal of Field Robotics 25, 861–879.
6. Griffiths, G., 2003. Technologies and Applications of Autonomous Underwater Vehicles. Taylor and Francis, London (360 pp.).
7. Graham, A.G.C., Dutrieux, P., Vaughan, D.G., Nitsche, F.O., Gyllencreutz, R., Greenwood, S.L., Larter, R.D., Jenkins, A., 2013. Seabed corrugations beneath an Antarctic ice shelf revealed by Autonomous Underwater Vehicle survey: origin and implications for the history of Pine Island Glacier. Journal of Geophysical Research 118, 1356–1366.
8. Nicholls, K.W., Abrahamsen, E.P., Buck, J.J.H., Dodd, P.A., Goldblatt, C., Griffiths, G., Heywood, K.J., Hughes, N.E., Kaletzky, A., Lane-Serff, G.F., McPhail, S.D., Millard, N. W., Oliver, K.I.C., Perrett, J., Price, M.R., Pudsey, C.J., Saw, K., Stansfield, S., Stott, M.J., Wadhams, P., Webb, A.T., Wilkinson, J.P., 2006. Measurements beneath an Antarctic ice shelf using an autonomous underwater vehicle. Geophysical Research Letters 33, L08612.
9. German, C.R., Yoerger, D.R., Jakuba, M., Shank, T.M., Langmuir, C.H., Nakamura, K., 2008. Hydrothermal exploration with the Autonomous Benthic Explorer. Deep-Sea Research I 55, 203–219.
10. Dowdeswell, J.A., Evans, J., Mugford, R., Griffiths, G., McPhail, S., Millard, N., Stevenson, P., Brandon, M.A., Banks, C., Heywood, K.J., Price, M.R., Dodd, P.A., Jenkins, A., Nicholls, K. W., Hayes, D., Abrahamsen, E.P., Tyler, P., Bett, B., Jones, D., Wadhams, P., Wilkinson, J. P., Stansfield, K., Ackley, S., 2008. Autonomous Underwater Vehicles (AUVs) and investigations of the ice–ocean interface in Antarctic and Arctic waters. Journal of Glaciology 54, 661–672.
11. Caress, D.W., Thomas, H., Kirkwood, W.J., McEwen, R., Henthorn, R., Clague, D.A., Paull, C. K., Paduan, J., 2008. High-resolution multibeam, sides can and sub bottom surveys using the MBARI AUV D. Allan B. In: Greene, H.G., Reynolds, J.R. (Eds.), Marine Habitat Mapping Technology for Alaska. Alaska Sea Grant College Program, University of Alaska, Fairbanks, pp. 47–69.
12. Bellingham, J.G., Streitlien, K., Overland, J., Rajah, S., Stein, P., Stannard, J., Kirkwood, W., Yoerger, D., 2000. An Arctic Basin observational capability using AUVs. Oceanography 13, 64–70.

13. Brierley, A.S., Fernandes, P.G., Brandon, M.A., Armstrong, F., Millard, N.W., McPhail, S.D., Stevenson, P., Pebody, M., Perrett, J., Squires, M., Bone, D.G., Griffiths, G., 2002. Antarctic krill under sea ice: elevated abundance in a narrow band just south of ice edge. Science 295, 1890–1892