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Design, Construction, and Implementation of Water Level Recorder With Communication of Information Approach Using GSM and GPRS

Amir Hossein Moadeli[1], Ayob Khodaprast [2], Omid Ghasemiabnavi[3]

[1] *PhD student, Department of Telecommunications, Faculty of Electrical Engineering, Shiraz University of Technology, Shiraz, Iran, a.moadeli@sutech.ac.ir*

[2] *Ph.D., Control Department, University Complex of Air Sciences and Technology, Shiraz, Iran, khodaparast@mut-es.ac.ir*

[3] *Master's degree, Department of Electronics Education, Faculty of Engineering, Islamic Azad University of Shiraz, Shiraz, Iran, omidghasemi115@gmail.com*

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ABSTRACT

The conventional methods of measuring tides are primarily based totally on direct observation of the water level on a graded-index whose information is examined in certain time intervals, although this work is very tiring and elements which include detrimental climate conditions, wind, rain, heat, darkness, people`s fatigue and negligence in wearing out the obligation have brought on the exceptional of accumulated information to decrease. Therefore, new generation mechanical and electronic devices have been used to lessen the error. In these systems, because of the presence of movable parts and parts that are in direct contact with seawater, wear and tear are inevitable. Therefore, fully electronic systems based on ultrasound and water pressure measurement have attracted various attentions due to the fact that they no longer have an operator and mechanical components are not in contact with water. In those systems, the gathering of tidal records is carried out routinely with non-touch electronic measurement, which has greater accuracy, speed, and simplicity of labor in comparison to conventional systems. This study is a report of the construction process and comparison of the results of the construction of an electronic device for measuring tides with the possibility of real-time transmission of tidal data. The advanced tide gauge device calculates the height of the water surface with the use of ultrasonic waves and measuring water pressure continuously. This system is also equipped with a microcontroller that has the mission of collecting, recording, and dealing with data and dealing with the peripheral parts, including managing information communication and receiving settings. In the constructed system, the water level values measured by pressure sensors and ultrasonic range finder are transmitted to a mobile number and a designed server through SMS and GPRS networks. The constructed tide gauge device was hooked up next to the Bushehr tide gauge and the overall performance and accuracy of the device were evaluated and compared via way of means of reconstructing the Topax/Poseidon satellite data and the Bushehr tide gauge records. By examining the results, it can be concluded that the use of two measurement sensors in the constructed system has been capable of enhancing the accuracy of water level measurement, and the communication of information from two different channels reduces the lack of records. These two factors increase the safety factor of using the device

1. Introduction

The phenomenon of tides, like many different natural phenomena, influences human life. This phenomenon has affected the duplicate of fish and ocean plants. Tides stability the temperature at the planets and additionally desire the climate situations via way of means of growing turbulence inside the oceans. By flood tide, the ships attain the shore without problems whilst the water involves the shore. Because the frequency of this phenomenon is numerous instances the afternoon and night, it will likely be great as a renewable energy source [1]. In the traditional technique of measuring the tide level, which is based on the direct observation of the water level on a graded-index [2], its information is read every ten minutes for at least a month, which is, of course, a very tiring task and factors such as unfavorable weather conditions, wind, rain, heat, In the conventional technique of measuring the tide degree, that is primarily based totally at the direct observation of the water degree on a graded-index [2], its statistics is examined every ten mins for as a minimum a month, that is of route a completely tiring venture and elements consisting of unfavorable climate conditions, wind, rain, warmth darkness, people`s fatigue and negligence in wearing out their duties caused a lower withinside the fine of amassed statistics [3] [4]. Due to the problems of conventional methods, mechanical equipment and an aggregate of mechanical and electronic devices were used. Due to the presence of moving parts and parts that are in direct touch with seawater, these systems' wear and tear is inevitable, and therefore they require regular periodic visits so that they do not lose their precise function [5] - [8].

Therefore, all electronic structures based on ultrasound and water pressure measurement have solved the issues of different strategies because they no longer want an operator and mechanical components in touch with water. In those systems, the gathering of tidal statistics is accomplished robotically with non-touch measurement with unique features, fully electronic, which are more accurate, faster, and easier to work with compared to traditional systems.

2. Methodology

The developed tide gauge system continuously measures the height of the water level using ultrasonic waves and water pressure and is also equipped with a microcontroller, that's chargeable for collecting, recording, and handling facts and handling peripheral parts, such as managing communique of facts and receiving settings.

Due to the evolution and development of the mobile network and the Internet, these two platforms are reasonably priced and have alternatives for information transmission. The values measured by the sensors are transmitted to a mobile number and a designed server through SMS and GPRS networks.

The general diagram of the way the device system works is shown in Figure (1). In general, this system has 5 parts: 1- The structure part, 2- The electricity and energy supply part, 3- The control and telecommunication part, 4- The sensors, and 5- The server. In the following, we will examine each part.

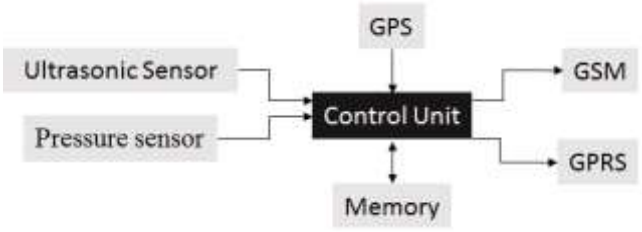


Figure 1: Functional diagram of the constructed tide gauge system

2.1. Structure Sector

A structure was designed and built to install the ultrasonic sensor and hold the solar panel and since the structure must be installed next to the dock or anchorage, its material is chosen from steel and protected with 5 layers of paint and rust so that it has excessive resistance against high humidity and bad weather conditions and does not wear out. The height of this structure is one meter and according to figure (1) this structure has an arm, which is placed at the end of the arm of the altimeter sensor or the ultrasonic sensor of the system. At the time of installation, this arm should be placed on the water surface and create a distance from the edge of the dock so that the water height sensor can measure the water height correctly. Also, the solar panel system is placed on top of this structure with a bolt and nut connection.

To protect the control board and the battery of the system, a metal box with a base that is covered by electrostatic paint is used. Figure (2) it shows an overview of the structure.



Figure 2: overview of the structure

According to Figure (3), a 6-meter aluminum ingot was used to restore the pressure gauge sensor in depth. Due to the position of this element in seawater, a defensive layer in opposition to moss and corrosion because of salt water has been created at the aluminum ingot.



Figure 3: Pressure sensor mounted on an aluminum ingot

2.2. Electricity and energy supply sector

To deliver energy to different parts of the system, direct voltages of 12 V, 5 V, 1.4 V, and 3.3 V are needed. For this purpose, two methods of power supply have been considered for the level recorder system. The first mode is the usage of urban electricity, in this case, switching power sources are used to lessen the city's 220-volt alternating current and convert it into the direct power required by the control board and system sensors. The second mode is the use of solar power systems. This system is installed to enable the use of the system in situations where city electricity is not available or in case of emergency. According to figure (4), it consists of a 30-watt solar panel with mono manufacturing technology, a charge control circuit, and a 12 Volt 9-Amp battery, which is converted to the required voltages of different parts of the system by the battery voltage regulator Acs.



Figure 4: Solar energy system including solar panel, battery charge control, and lead-in wires

2.3. Control and Telecommunications Sector

Microcontrollers or MCUs are small ICs that contain a combination of units and different capabilities and are used to control processes or read sensor values and control operators. Microcontrollers have wide capabilities that vary depending on the type and model. Microcontrollers usually differ from each other in terms of processing power, and the quantity of memory that consists of program memory (Flash memory) and data memory (RAM). Also, input and output ports that allow communication with devices, sensors and operators, and other parts such as timers, and protocols that can be supported

in different categories and series. are positioned differently. The microcontroller for processing system data is from the AVR series of microcontrollers based on the Arduino platform with the technical number Atmega 328. The traits of this microcontroller include 32 kilobytes of memory, low energy consumption, and high speed. [9] - [13].

To save the data of the sensors, the time, and the clock of the measured values, a data logger shield compatible with Arduino was used so that the information could be saved on an SD card. This shield is connected to the microcontroller with the I2c communication protocol, and due to the use of the internal clock, it also provides the possibility of saving the clock. Figure (5) shows the set of control board.

A SIM800L module is used to transmit information in the form of SMS on the global mobile network platform and also to upload it to the server. These modules use the GSM network and provide the ability to send and receive SMS, make calls, and connect to the Internet on the GPRS platform [9] [11] and [14].

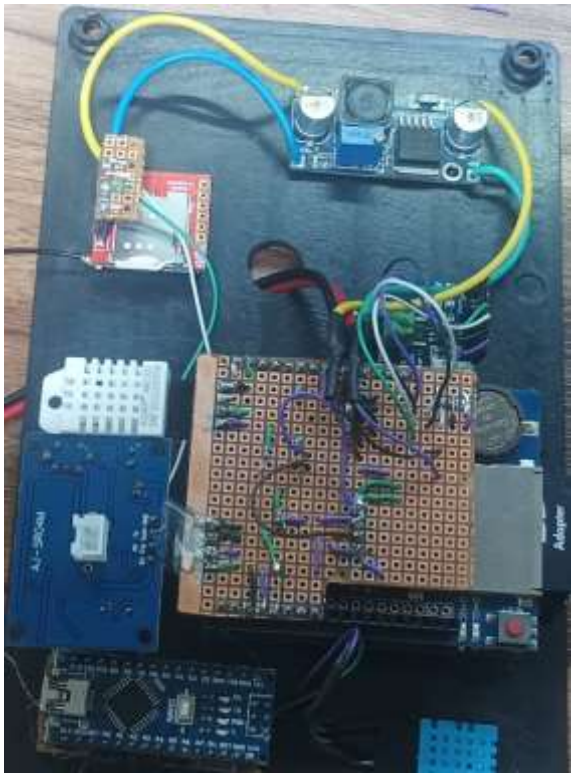


Figure 5: The control board set is placed in the box.

2.4. Sensors

2.4.1. Pressure Sensor

Fluid pressure sensors are used to measure the pressure of liquids such as water, oil, gases, and other fluids. These sensors usually work based on the change in fluid volume in reaction to the pressure. As the fluid volume increases, the pressure also increases, and the sensor can measure this pressure change, and a signal corresponding to the measured pressure is generated on the output, which is used in control systems. These sensors have different models, including diaphragm models, resistance models, etc [15] [17].

The Wika A10 series pressure transmitter (pressure sensor) is made of stainless steel and has a small design. This product also has a digital processing circuit that converts weak signals into standard current signals.

This sensor has many features. The features of this transmitter include small size, lightweight, easy installation and use, and stable performance. This equipment is mainly used in industrial automation equipment and has good compatibility with difficult environmental conditions, which shows the high quality of the sensor [17].

2.4.2. Altimeter

Ultrasonic range finder sensors use high-frequency sound waves that are sent and reflected to the sensor after hitting an object or surface. To use these sensors, after feeding the sensor, the desired control signal must be sent to the sensor so that the sensor can measure the distance. Ultrasonic sensors have two types of analog output and digital output, and to accurately read the distance, the sensor must be placed in a plane perpendicular to the object so that the distance can be measured correctly.

The 04SRF sensor is an electronic range-finding module based on ultrasound, which is used to measure the height of the water surface in this project. This sensor can measure the distance up to 10 meters and the measurement accuracy is millimeters, which is a good option considering the changes in the water level of the Persian Gulf. [18]

2.4.3. Temperature and humidity sensor

Temperature and humidity affect the speed of propagation of waves. With the assistance of a sensor, the temperature and humidity of the environment are measured so that the measurement error of the ultrasonic range finder sensor can be minimized. The DHT-22 temperature and humidity sensor is a good sensor for measuring the temperature and humidity of the environment. This sensor is a digital sensor that communicates with the microcontroller using the I2C communication protocol.

DHT-22 consists of two parts: a capacitive humidity sensor and a resistance temperature sensor. Inside this sensor, a chip is used to convert analog to digital. The humidity measurement range of the sensor is from 0 to 100 percent and it also can measure temperature from -40 degrees to +80 degrees [19] [20].

2.4.4. positioning

Remote sensing measures the Earth's parameters using satellites in the Earth's orbit or airplanes equipped with sensors (without physical contact). The data obtained from this technology provides the possibility of extensive projection and analysis of the parameters of the earth by using data collection through reflected energy from the earth. Remote sensing has a wide range of applications, including recording the water level. Therefore, the use of the GPS global positioning system to receive location information with the help of satellite signals provides information such as geographical longitude and latitude as well as height, which is used to adapt the data measured by range-finder sensors and System pressure is used with satellite data. However, it should be noted that remote sensing systems have far lower accuracy than coastal tide gauges, and comparing the data received from both methods can reduce the measurement error [21].



Figure 6: Port of Bushehr city, the installation site of the level recorder system built next to the level recorder device of the Geographical Organization

3. Results and Discussion

To evaluate the performance of the system, the built tide gauge was installed for 6 months from April 30, 2023, to November 1, 2023, next to the tide gauge of the Geographical Organization located in Bushehr port. Tide-gauge system data is read every 10 minutes and stored in the server. This makes it possible to reveal waves with an interval of 20 minutes or more in tidal modeling based on the principle of sampling. The installation location of the system is shown in Figure (6).

3.1. Tide modeling of satellite data

To examine the performance of the tide gauge, the information from the Topex-Poseidon altimetry satellite has been used. In tide modeling with the assistance of the information acquired from the satellite, it is necessary to perform corrections and processing on the satellite data to see the altimetry information. After observing the altimetry data, a height time series should be made. These series include altitude and time information [22].

One of the problems that sometimes exists in the construction of time series is the reconstruction of lost information. Various methods can be used to solve this problem. One of these methods is the use of the autocorrelation function, which can estimate the statistical correlation between the data and the missing data.

The time series is defined as the following equation (1).

$$r_k = \frac{\sum_{t=1}^{N-K}(x_t - \bar{x})(x_{t+k} - \bar{x})}{\sqrt{\sum_{t=1}^{N}(x_t - \bar{x})^2}} \quad (1)$$

In the above relation, the time series $X_1, X_2, \dots, X_n$ is known. and $r_1, r_2, \dots, r_n$ is the correlation between time series. If it is necessary to calculate X_{n+1} ,the above series can be expanded as $X_1, X_2, \dots, X_n, X_{n+1}$ thatX_{n+1} is unknown.

The remarkable thing about relation (1) is its non-linearity, and to calculate X_{n+1} it is necessary to linearize the relations using the least squares method (2). The relationship (2):

$$F(X) = F(X_0) + \frac{dF}{dX_{(X_0)}}(X - X_0) \quad (2)$$

We can use the value of x_n or $\bar{X} = \frac{1}{N}\sum_{t=1}^{N} X_i$as the initial value of x_{n+1} .

$$F(X) = F(X_0) + \frac{dF}{dX_{(X_0)}}(X - X_0) \quad (3)$$
$$\rightarrow \boldsymbol{dl} = A\delta\boldsymbol{X}$$
$$dX = X - X_0 \rightarrow X = dX + X_0$$
$$A = \frac{dF}{dX_{(X_0)}}$$

This process is repeated until the last answer is calculated. Finally, with the help of Fourier analysis and the least squares method, the

frequencies in the series were calculated and the tide model was extracted. According to Figure (7), the measurements made by the tide gauge are consistent with the data extracted from the satellite, and the difference between the monthly graph of the satellite data and the data measured by the tide gauge can be due to the low accuracy of the obtained data. come from satellites.

3.2. Tides measured by Bushehr tide gauge

To check the tide gauge data more accurately, the tide data measured by the tide gauge of the Geographical Organization located at the Bushehr Customs Wharf was used. Tide information has been compared in daily and monthly intervals. As shown in Table (1) and Figure (8) of the monthly comparison, the measured level is almost identical and has a much smaller error than the satellite data. This matching of data can also be visible in the diagram of Figure (8). But in the daily chart of Figure (9) sometimes the quantity of measurement error is a little higher than in the monthly chart, the cause for this could be the waves of the sea surface, because the weather conditions may cause waves that cause errors in the measurement process. but to study the tides, the average data is studied, which reduces the measurement error.

Table 1: Comparison of the values measured by the tide gauge of the Geographical Organization and the built tide gauge

		April	May	June	August	September	October	November
Maximum Flood Tide	Geographical Organization	2/32	2/42	2/38	2/34	2/28	2/18	2/26
	Tide gauge System	2/33	2/41	2/38	2/33	2/28	2/18	2/27
Mean	Geographical Organization	1/25	1/21	1/24	1/28	1/22	1/21	1/20
	Tide gauge System	1/25	1/21	1/23	1/28	1/23	1/21	1/20
Minimum Ebb	Geographical Organization	0/38	0/29	0/21	0/20	0/22	0/35	0/41
	Tide gauge System	0/37	0/29	0/2	0/2	0/22	0/24	0/41

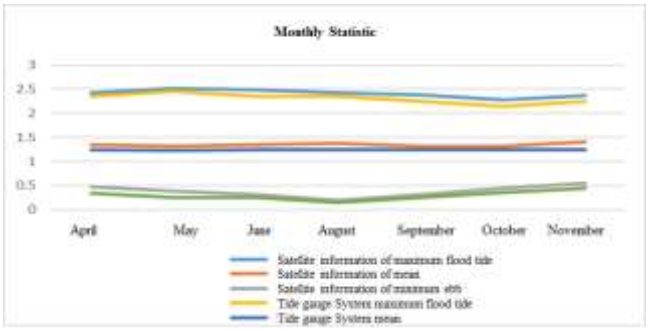


Figure (7): Comparison of monthly tide statistics measured by the constructed tide system and satellite data.

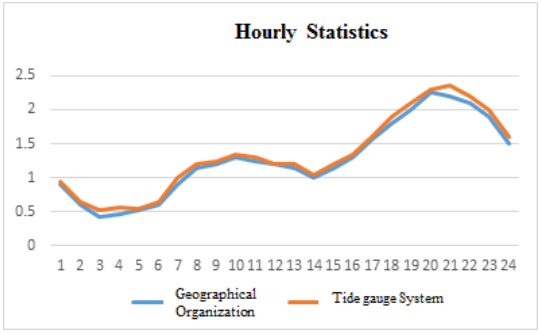


Figure (9): Comparing the hourly error of the level recorder and tide gauge of the Bushehr system

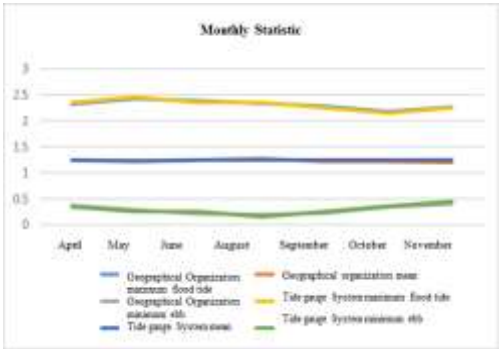


Figure (8): Comparison of the monthly error of level recorder and Tide-gage of Bushehr system

4. Conclusion

Tidal is a very important natural phenomenon that has huge consequences from the life process of organisms to navigation, therefore accurate measurement of this phenomenon could be very vital and allows lots inside the navigation of ships, fishing, etc. According to the results acquired from the assessment of the information measured with the aid of using the tide gauge made with the aid of using the authors of the thing with satellite data and the active tide gauge of the Geographical Organization in Bushehr region, similar to the accuracy of the system and automated

communication, top accuracy within side the tidal measurement is achieved.

Resources

[1] Gregory, J. M., Griffies, S. M., Hughes, C. W., Lowe, J. A., Church, J. A., Fukimori, I., ... & van de Wal, R. S. (2019). Concepts and terminology for sea level: Mean, variability and change, both local and global. *Surveys in Geophysics*, *40*, 1251-1289.

[2] Pugh, D., & Woodworth, P. (2014). Sea-Level Science: Understanding Tides, Surges, Tsunamis and Mean Sea-Level Changes (2014).

[3] Oppenheimer, M., & Hinkel, J. (2019). Sea Level Rise and Implications for Low Lying Islands, Coasts and Communities Supplementary Material.

[4] Kopp, R. E., Kemp, A. C., Bittermann, K., Horton, B. P., Donnelly, J. P., Gehrels, W. R., ... & Rahmstorf, S. (2016). Temperature-driven global sea-level variability in the Common Era. *Proceedings of the National Academy of Sciences*, *113*(11), E1434-E1441.

[5] Meyssignac, B., Piecuch, C. G., Merchant, C. J., Racault, M. F., Palanisamy, H., MacIntosh, C., ... & Brewin, R. (2017). Causes of the regional variability in observed sea level, sea surface temperature and ocean colour over the period 1993–2011. *Integrative Study of the Mean Sea Level and Its Components*, 191-219.

[6] Wöppelmann, G., Pouvreau, N., & Simon, B. (2006). Brest sea level record: a time series construction back to the early eighteenth century. *Ocean Dynamics*, *56*, 487-497.

[7] Palmer, H. R. (1831). XII. Description of a graphical registrer of tides and winds. *Philosophical Transactions of the Royal Society of London*, (121), 209-213.

[8] Woodworth, P. L., & Aarup, T. INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION. (IOC) of UNESCO, 2002.

[9] Xiaohui, W., & Kewei, L. (2018). The Monitoring and Wireless Transmission System of PM2. 5 in the Scenic. *International Journal of Advanced Network, Monitoring and Controls*, *3*(2), 71-74.

[10] Zulu, C. L., & Dzobo, O. (2023). Real-time power theft monitoring and detection system with double connected data capture system. *Electrical Engineering*, *105*(5), 3065-3083.

[11] Essien, V., Bolu, C. A., Azeta, J., Okokpujie, I. P., Kilanko, O., & Afolalu, S. A. (2021, April). Application of data logger for monitoring indoor and outdoor temperature of buildings: A review. In *IOP Conference Series: Materials Science and Engineering* (Vol. 1107, No. 1, p. 012181). IOP Publishing.

[12] Badhiye, S. S., Chatur, P. N., & Wakode, B. V. (2011). Data logger system: A Survey. *International Journal of Computer Technology and Electronics Engineering (IJCTEE)*, 24-26.

[13] Mahjoubi, A., Fethi Mechlouch, R., & Ben Brahim, A. (2011). A low cost wireless data acquisition system for a remote photovoltaic (PV) water pumping system. *Energies*, *4*(1), 68-89.

[14] Abd Rahman, N. A., Ibrahim, N. H., Lombigit, L., Azman, A., Jaafar, Z., Abdullah, N. A., & Mohamad, G. H. P. (2018). GSM module for wireless radiation monitoring system via SMS. In *IOP conference series: materials science and engineering* (Vol. 298, No. 1, p. 012040). IOP Publishing.

[15] Nikolov, G. T., Nikolova, B. M., & Marinov, M. B. (2005). Data logging system for pressure monitoring. *ELECTRONICS'2005, 21–23 September*, *3*, 81-86.

[16] Sahu, S., Bhuyan, M. R., Rudra, S., Biswas, S., Mohanty, B., & Sahu, P. K. (2015). Design and fabrication of a data logger for atmospheric pressure, temperature and relative humidity for gas-filled detector development. *arXiv preprint arXiv:1507.03575*.

[17] https://assets.rsonline.com/v1698979971/Datasheets/a017ec792c4d81996f6d6a370ef2d4ea.pdf

[18] Aliew, Fuad. "An Approach for Precise Distance Measuring Using Ultrasonic Sensors." Engineering Proceedings 24.1(2022):8.. https://www.mdpi.com/2673-4591/24/1/8

[19] Ahmad, Y. A., Gunawan, T. S., Mansor, H., Hamida, B. A., Hishamudin, A. F., & Arifin, F. (2021, June). On the evaluation of DHT22 temperature sensor for IoT application. In *2021 8th international conference on computer and communication engineering (ICCCE)* (pp. 131-134). IEEE.

[20] Neis, P., Warch, D., & Hoppe, M. (2023). Testing and Evaluation of Low-Cost Sensors for Developing Open Smart Campus Systems Based on IoT. *Sensors*, *23*(20), 8652.

[21] Verma, G., Kumar, M., & Khare, V. (2015). Low power techniques for digital system design. *Indian Journal of Science and Technology*, *8*(17), 1.

[22] Hashemi Farahani, Hassan. "Analysis of tidal conditions and preparation of maps of both amplitude and phase using thesis data, Topex/Poseidon satellite altimeter." Master's degree, Faculty of Engineering, University of Tehran, 2003