JURNAL SEGARA
http://ejournal-balitbang.kkp.go.id/index.php/segara

ISSN : 1907-0659
e-ISSN : 2461-1166
Nomor Akreditasi: 766/AU3/P2MI-LIPI/10/2016

MONITORING PERMUKAAN LAUT IOT: STUDI PENGEMBANGAN DAN UJI LAPANGAN

IOT SEA LEVEL MONITORING: A STUDY ON THE DEVELOPMENT AND FIELD TESTING

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Received: 4 February 2023; Revised: 7 March 2024; Accepted: 8 April 2024

ABSTRAK

Pengukuran ketinggian permukaan laut merupakan hal yang penting dalam bidang oseanografi, karena dapat memberikan informasi penting mengenai lingkungan laut, termasuk pasang surut, arus, dan suhu air. Penelitian ini bertujuan untuk mengembangkan perangkat pemantau ketinggian permukaan laut berbasis IoT yang dapat mengukur ketinggian permukaan laut secara akurat dan mengirimkan datanya secara real time. Perangkat ini terdiri dari berbagai komponen: Mikrokontroler ESP32, Modul GSM, sensor MS5803-14BA, dan baterai. Komponen-komponen tersebut dirakit pada papan PCB dan ditempatkan di dalam kotak kedap air untuk melindungi perangkat elektronik dari lingkungan laut. Uji coba lapangan dilakukan selama 17 jam di Pelabuhan Kantor Distrik Navigasi Kelas 1 Tanjungpinang, dan data dimonitor melalui platform Ubidots. Hasilnya menunjukkan bahwa alat tersebut mengukur ketinggian permukaan laut secara akurat, dengan nilai RMSE 0,69 cm dan tingkat akurasi 99,47%. Namun, uji lapangan juga menunjukkan adanya masalah transmisi data, dengan 18,81% data tidak terkirim ke server. Tingkat transmisi data yang rendah ini mungkin disebabkan oleh tingkat RSSI yang rendah dan masalah kualitas sinyal operator. Penelitian lebih lanjut diperlukan untuk memahami alasan di balik kehilangan data ini dan untuk meningkatkan kinerja perangkat secara keseluruhan. Penelitian ini menunjukkan kelayakan penggunaan perangkat pemantauan ketinggian permukaan laut berbasis IoT untuk mengukur ketinggian permukaan laut secara akurat dan mengirimkan data secara real time. Hal ini memberikan informasi yang berharga untuk pengembangan lebih lanjut dan peningkatan sistem pemantauan permukaan laut.

Kata kunci: IoT, Pemantauan ketinggian permukaan laut, sensor MS5803-14BA, Akurasi sensor, RMSE, Transmisi data.

ABSTRACT

The measurement of sea level is important in oceanography, as it provides critical information about the ocean environment, including tides, currents, and water temperature. This study aimed to develop an IoT-based sea level monitoring device that can accurately measure sea level and transmit the data in real time. The device consisted of various components: an ESP32 Microcontroller, a GSM Module, an MS5803-14BA sensor, and a battery. The components were assembled on a PCB board and placed inside a waterproof box to protect the electronics from the ocean environment. The field test was conducted for 17 hours at the Tanjungpinang Class 1 Navigation Office Port, and the data was monitored through the Ubidots platform. The results showed that the device accurately measured sea level, with an RMSE value of 0.69 cm and an accuracy rate of 99.47%. However, the field test also revealed data transmission issues, with 18.81% of the data not being sent to the server. This low data transmission rate may have been due to low RSSI levels and issues with operator signal quality. Further research is needed to understand the reasons behind these data losses and to improve the device's overall performance. This study demonstrated the feasibility of using an IoT-based sea level monitoring device to accurately measure sea level and transmit the data in real time. It provides valuable information for further development and improvement of sea level monitoring systems.

Keywords: IoT, Sea level monitoring, MS5803-14BA sensor, Sensor Accuracy, RMSE, Data transmission.

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INTRODUCTION

Measuring tidal patterns and sea level is critical to stakeholders, including coastal communities, disaster relief organizations, the tourism industry, and the maritime sector (Intergovernmental Oceanographic Commission, 2006; Kusuma et al., 2021a). In response to this need, numerous studies have been conducted on designing sea level measuring devices utilizing various technologies. For instance, Missa, Lapono, & Wahid (2018), Wijaya, Mudin, & Farhamsah (2016), dan Putra (2015) utilized acoustic sensors in their studies, while Egistian (2021) developed a sea level measuring device that utilized the water pressure sensor. However, this device has some limitations, such as the use of a temporary accumulator battery and the need for the Digital Number output of the pressure sensor to be converted before use. On the other hand, the advantage of the study is that it utilized the Internet Of Things (IoT) system and the Global System for Mobile Communications (GSM) module.

Another widely used air pressure sensor for water depth measurement is the MS5803-14BA, which has been studied by various researchers, (Kombo et al., 2021; Marzuarman et al., 2020; Prima, 2018). This sensor boasts a high accuracy of up to 0.2 mbar and has an optimal resolution of 1 cm water depth, with a range of 0-14 bar and a factory calibration data of 1000.5 mbar. It is also equipped with jelly protection and an anti-magnetic stainless-steel cap, making it resistant to up to 30 bar pressure in water (Lyman et al., 2020).

As the power supply is a crucial component in any electronic circuit, it is important to ensure that it provides a constant current and voltage supply. This study uses a battery power supply, but a solar panel supplements it as an alternative energy source. Solar panels, also known as solar cells, convert solar energy into electrical energy, providing a sustainable energy source (Tiyas and Widyartono, 2019).

To summarize, the proposed instrument for measuring sea level is designed using the MS5803-14BA water pressure sensor. The ESP32 microcontroller process the readings from the water pressure sensor, which is stored on an SD card. The measurement results are displayed on the Ubidots platform, which is connected to the internet via GPRS communication on the GSM module. The device will be powered by a battery, with a solar cell as an alternative power source.

METHODOLOGY

This research was carried out from July to December 2022. The design, fabrication, and testing of the device were conducted at the Electrical Engineering Laboratory of Maritime Raja Ali Haji University, Tanjungpinang. In addition, field testing of the device was conducted at the Class I Navigation District Office Port Tanjungpinang, Bintan Regency, Riau Islands, Indonesia (Figure 1).

Figure 1. Class I Navigation District Office Port Tanjungpinang

The sea-level measuring instrument is designed from several main components: the MS5803-14BA air pressure sensor, ESP32 microcontroller, DS3231 RTC module, Micro SD Card Shield, and SIM900A GSM module. This research device uses the MS5803-14BA pressure sensor to measure the water pressure, which is then converted into water depth. The microcontroller used in this research is the ESP32 module with two units. The first is a peripheral device that reads the data received from the MS5803-14B air pressure sensor and waits for characters from the Controller device to retrieve and send sensor data. The second ESP32 is used as a controller device to request data and awaken the peripheral device by sending characters. Finally, the obtained data is processed and stored on the micro SD and sent using the SIM900A GSM module to the Ubidots platform. The system design block diagram can be seen in Figure 2.

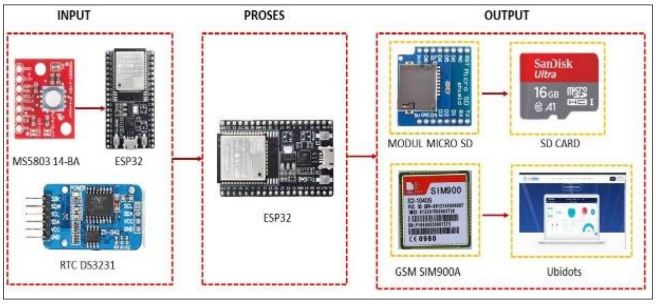

Figure 2. Diagram Block Design System

This study aims to determine the accuracy and precision of the MS5803-14BA water pressure sensor by converting the data obtained from the sensor into water depth using the hydrostatic pressure formula. The hydrostatic pressure formula considers the height of the water surface, pressure, water density, and earth's gravity.

After converting the data from the MS5803-14BA water pressure sensor, the next step is to perform calibration. This calibration result will help determine the difference between the sensor's measurement and the water depth reading. The Root Mean Square Error (RMSE) is used to compare the estimated results with field data to determine the accuracy and precision of the MS5803-14BA water pressure sensor. The smaller the RMSE value, the better the prediction results (Chai and Draxler, 2014; Hasniah et al., 2017). The standard deviation formula determines how precise the sensor measures water depth.

Linear regression establishes a relationship between a dependent variable and one or more independent variables. If there is only one independent variable, it is called simple linear regression (Briliant and Kurniawan, 2019). In this study, variable 1 represents the sensor data, and variable 2 represents the calibrator data.

After comparing the sensor data and calibrator data using linear equations, the coefficient of determination is obtained. Next, the coefficient of determination is used to determine the closeness of the sensor reading to the actual water depth (Saragih et al., 2020). Finally, a comparison is made between the sensor data and the server data using the Packet Data Ratio (PDR) equation. The Packet Data Ratio compares the data transmitted and the stored measurement data (Suprayugi et al., 2019).

RESULTS AND DISCUSSION

Instrument Development

The device is made by creating a schematic and a PCB board. This device operates as a controller device. Two parts to the PCB board are made, the top part and the bottom part. The top consists of the ESP32 Microcontroller, DS3231 RTC Module, and LED. The bottom consists of the Micro SD Card, SIM900A GSM Module, MS5803-14BA sensor, and battery. The components in this PCB are shown in Figure 3. This PCB is included inside the box (Figure 4).

Figure 3. The components attached to PCB

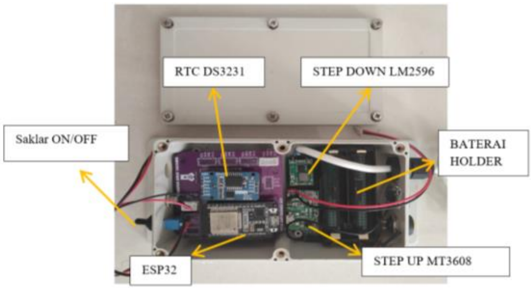

Figure 4. Components attached inside the box

The box was drilled with six holes on both sides. One side of the box has holes for the push button, solar panel cable, and voltmeter, while the other has holes for the switch, LED, and cable connection to the sensor and ESP32. The arrangement of these components within the box can be seen in Figure 5. The peripheral device comprises the ESP32 and MS5803-14BA sensors. Since it will be placed underwater, it has been waterproofed using resin (as shown in Figure 6). This device requires an average power of 0.59 W, with an estimated usage time of 1.63 days. Therefore, a solar panel is needed in this device to ensure a continuous power supply for the battery.

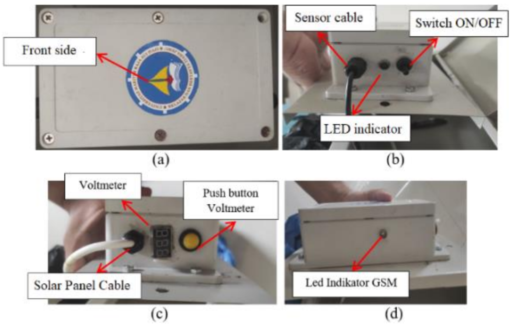

Figure 5. Components attached outside the box

Figure 6. Peripheral device

Field test

The field test was conducted for 17 hours from 12:46 on November 30, 2022, to 5:56 on December 1, 2022, at the Tanjungpinang Class 1 Navigation Office Port. The device sends data every 10 minutes and is monitored through the Ubidots platform. All data is stored on the micro SD Card. The placement diagram of the tool can be seen in Figure 7. The placement position of the device during the field test can be seen in Figure 8. The field test data on the Ubidots platform is shown in Figure 9.

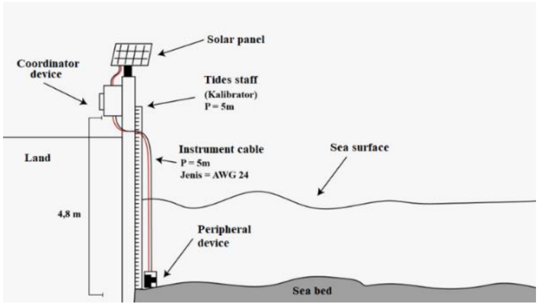

Figure 7. Placement the monitoring device diagram

Figure 8. Device placement at the harbour

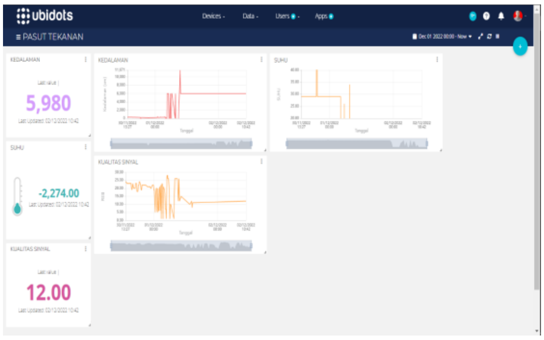

Figure 9. Sea level data display in Ubidots

Sea level validation

The comparison between the device sensor readings and the tides staff average is fairly good, as shown in Figure 10. During the high tide or the process towards high tide, the sensor reading is not much different from the manual average. However, during the process toward low tide, the difference between the sensor reading and the tides staff average is greater than during high tide. The comparison result between the sensor reading and the tides staff average gives an RMSE value of 0.69 cm, an accuracy rate of 99.47%, and an error rate of 0.53%. Based on the obtained values, it is concluded that the MS5803-14BA pressure sensor can measure the sea level.

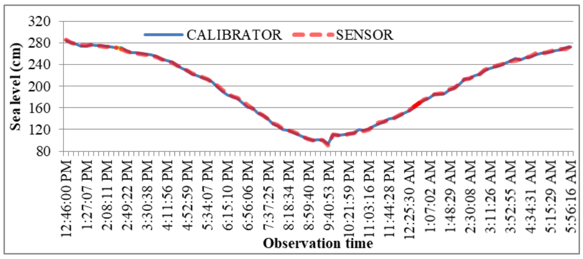

Figure 10. Sea level comparison between sensor and calibrator

Packet Data Ratio

During the 17-hour field data collection process, 101 data were stored on the micro SD card, but only 82 were sent to the server. As a result, the Packet Data Ratio was 81.19% (Figure 11).

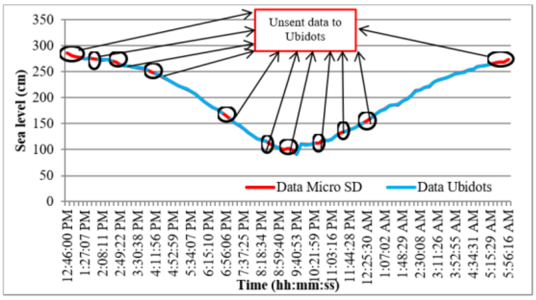

Figure 11. Data comparison between micro SD and server Ubidots

The Packet Data Ratio refers to the proportion of data packets successfully delivered over a network. In this case, 81.19% of the data collected during the 17-hour field data collection process was successfully sent to the server, meaning that 18.81% of the data may have been lost or failed to be transmitted. The number of data packets stored on the micro SD card (101) and the number of data packets sent to the server (82) suggests that there may have been issues with data transmission, such as poor network connectivity or data corruption. Therefore, it is important to understand why these data losses occurred and to take measures to improve data transmission in future data collection processes.

Discussion

In this study, a monitoring device was developed to measure the sea level. The device consisted of various components: the ESP32 Microcontroller, DS3231 RTC Module, LED, Micro SD Card, SIM900A GSM Module, MS5803-14BA sensor, and a battery. The components were assembled on a PCB board and placed inside a waterproof box. The device was field-tested at the Tanjungpinang Class 1 Navigation Office Port for 17 hours, and data was monitored through the Ubidots platform.

Esp32 is suitable for this application because it has a minimum power consumption. Based on

(Asenov and Tokmakov, 2020; Refly and Arief Kusuma, 2022), the power consumption can be reduced using the sleep mode function. Moreover, ESP32, programmed using Arduino IDE based on C/C++, was fast in executing time (Plauska et al., 2022).

The GSM module implemented in this instrument can make this instrument send the data to Ubidots. This SIM900A sends data using AT Commands (Prochazka et al., 2020; Shanghai SIMCom Wireless Solutions, 2011). AT+CIPSEND is the crucial command to ensure the server receives the data (Djajadi and Wijanarko, 2016). Ubidots offer a user-friendly interface to display data (Kanakaraja et al., 2020; Mohammed and Selman, 2020; Putra and Risfendra, 2021). he micro SD card embedded in this instrument secures the data when the network is unavailable.

The comparison between the device's sensor readings and the tides staff average showed a good correlation, with an RMSE value of 0.69 cm, an accuracy rate of 99.47%, and an error rate of 0.53%. These values suggest that the MS5803-14BA pressure sensor can accurately measure the seawater surface height (Beddows and Mallon, 2018; Cherqui et al., 2020). Furthermore, the peripheral device encapsulation using resin can protect the electronics for oceanographic applications (Laney, 2017).

However, the field test results also revealed some data transmission issues. During the 17-hour field data collection, only 81.19% (82 out of 101) of the data collected was successfully sent to the server, meaning that 18.81% of the data may have been lost or failed to be transmitted. The low RSSI level may cause packet loss and issues in operator signal quality (Kusuma et al., 2021b; Purba and Manurung, 2019; Purbakawaca et al., 2022).

It is important to understand the reasons behind these data losses and to take measures to improve data transmission in future data collection processes. This improvement could be achieved through improving network connectivity, implementing error detection and correction techniques, or using more reliable data transmission protocols. Further research is needed to fully address these issues and improve the device's overall performance.

CONCLUSION

An IoT sea level monitoring device was created and tested to assess its components' accuracy and effectiveness, including the ESP32 Microcontroller, GSM Module, MS5803-14BA sensor, and battery. The results showed good measurement accuracy with an RMSE of 0.69 cm and a 99.47% accuracy rate. However, the field test also highlighted data transmission problems, with 18.81% of the data not reaching the server.

It is imperative to examine the causes of these data losses and to implement measures to enhance data transmission in future tests. It can be achieved by improving network connectivity, employing error detection and correction methods, or using more dependable data transmission protocols. Further research is necessary to address these issues and enhance the device's overall performance.

ACKOWLEDGEMENTS

This research has been supported by Department of Electrical Engineering Universitas Maritim Raja Ali Haji. Thanks to Tauriq Fuji Nur Akbar, Irwan Saputra, and Oscar for helping in the calibration and field test observation.

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