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DESIGN OF AN AUTOMATIC TEMPERATURE RECORDER FOR FISHERY VESSELS USING INTERNET OF THINGS TECHNOLOGY

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ABSTRACT
Fishery products, especially capture fisheries, must be safe and high-quality. The treatment of captured fish from capture to consumption is crucial to maintaining its quality. Temperature impacts fish quality. Fish putrefaction can be prevented at a specific temperature. Maintaining optimal fish quality requires temperature monitoring at the holding hatch of fish captured on board. Indonesia requires hatches with fish storage to have automatic temperature recorders and monitors. Inspections by authorities who issued certifications of acceptable fish handling practices found many breaches on Indonesian fishing vessels without automatic temperature monitoring systems. Indonesian fishery exports to the EU have been rejected due to the lack of automatic temperature recording systems on fishing vessels. Existing automatic temperature recording equipment for fishing vessels does not meet technical and legal requirements. The lack of autonomous temperature monitoring devices on fishing vessels was solved via design thinking in an exploratory study. Thus, fishing vessel temperature recording devices were designed using Internet of Things technology. Literature is utilized to choose resources. Hatch temperature recorder, MAX 31865 module, and PT100 thermocouple sensor use ESP 32 as a microprocessor. Raspberry Pi4 controls, displays, and stores data. This fish hatch temperature recorder has a GPS module for coordinates. This utility manages display and storage with Home Assistant software. Commercial low-temperature recorders are utilized for comparison testing. Before calibration, the pesuotokapi tool had a variance coefficient of 9.39%, whereas the comparison tool had 12.09%. The pesuotokapi tool has a coefficient of variation of 11.96% after calibration, whereas the comparison tool had 13.28%. The pesuotokapi tool regularly yields a lower coefficient of variation than the comparison tool. This shows that the pesuotokapi tool generates data with less divergence from the average recorded temperature than the comparison tool. Pesuotokapi devices regularly outperform comparator devices in temperature before calibration, improving fish hold quality.
Keywords: *Fish Quality, EU Export, Automatic Temperature Recorder, Internet of Things*

1. Introduction

The fishing industry plays a crucial role in the economy, making major contributions and having notable economic, political, social, and environmental impacts on the area's economy. The fisheries contribute to the overall economy of a region and encompass several industries and intermediaries that allow the movement of products from producers to consumers (Akbari et al., 2023). Presently, there is an ongoing effort to establish a sustainable economy in the marine and fisheries sector, sometimes referred to as the blue economy. The blue economy aims to enhance human well-being and social fairness by effectively mitigating environmental hazards and addressing ecological scarcities (Pauly, 2017). The catch fisheries sector is a component of this. The quality of fish caught matters. Fish quality impacts selling price, consumer safety, product image, and species sustainability. High-quality fish affects the selling price. Because it influences fish taste, scent, and texture, fish meat quality affects the selling price. Fish with fresh, succulent, and flavourful meat sells for more because buyers value it more. Fish meat quality also affects storage and processing resistance. Fresh, high-quality fish meat is more durable and easier to process, improving seafood supply chain efficiency. Therefore, fish producers and collectors must pay attention to fish meat quality during manufacturing and processing to maintain a high selling price and increase revenues. Fish with good flesh quality can encourage a healthier and more sustainable lifestyle by improving health and nutrition. Quality assurance of fisheries products gives consumers confidence. ISO (FAO, 2015) defines quality assurance as all planned and systematic procedures to ensure a product or service meets quality standards. Quality assurance is a strategic management function that sets policy direction, adapts programs to meet goals, and implements them correctly. Fish poisoning can be caused by excessive histamine levels (Witria, 2021). Decarboxylated histidine amino acids decompose into histamine(Yusni, 2019). Histamine production from fresh fish during storage. If fish are improperly preserved, bacteria can create histidine decarboxylase, which converts histidine into histamine. Fish contaminated with these bacteria produce histamine faster at higher temperatures. Therefore, fish must be stored at the appropriate temperature and cooked or frozen promptly after being caught to prevent bacterial development and histamine generation. Histamine-rich seafood can induce food poisoning, called food histaminosis. Food histaminosis causes headaches, redness, low blood pressure, and breathing problems. Both raw materials for the fishing sector and export commodities, as well as quality assurance and safety of fishery products, are crucial. Capture fisheries businesses operate by fishing and transporting fish. Government Regulation 57 of 2015 regulates good fish handling in catch fisheries commercial activities to ensure quality, safety, and value. Additionally, the Minister of Marine Affairs and Fisheries Regulation Number 7 of 2019 governs the certificate of good fish handling methods requirements and procedures. The sustainable export of fisheries products depends on their quality and standard. Delayed handling accelerates bacterial proliferation, resulting in the fish deteriorating. This is evident by the development of slimy body surfaces, the meat becoming soft and mushy, and the emission of unpleasant odours (Lokollo & Mailoa, 2020). Poor fish handling and skill also affect the quality (Purwanto et al., 2024). Temperature is a critical metric, particularly in the realm of food safety (Zhou et al., 2020). According to (Purwanto et al., 2024), the absence of an automatic temperature recording device in fishing vessel storage hatches was one of the most significant findings during the Good Fish Handling Practices (GFHP) certificate process at the Nizam Zachman Ocean Fishing Port Jakarta. The issuance of GFHP certificates despite the lack of automatic temperature recording devices and the lack of marketed products for fishing vessels are two reasons for the lack of such devices. Products that record temperature automatically have various drawbacks. Battery and memory constraints have hindered progress. The lack of a way to monitor temperature recording results is another challenge for commonly available temperature recording devices.

The quality of fishery products also plays an important role in the continuity of fishery product export activities abroad. Mistakes in handling fish on board and in the wrong way will reduce the quality of fish. The government and fish farmers face a burden when fishery exports are refused owing to noncompliance with food safety laws (Indrotristanto et al., 2022). The destination countries of fishery exports have determined the quality standards of fish products they will import; if they do not meet the requirements of the quality standards and quality of fishery products they have set, the fishery products will be rejected. Cases of refusal to export Indonesian fishery products have occurred several times. The diagram below shows cases of refusal to export to the European Union for fishery products from 2016 to 2020.

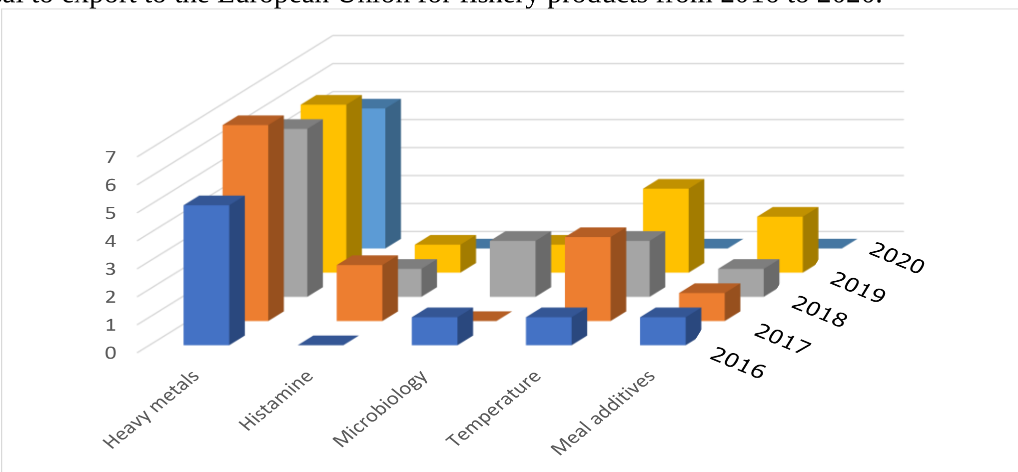


Fig. 1. Case of Export Refusal of Indonesia Fishery Products to the European Union from 2016 to 2020 (Source: (Triwibowo & Rachmawati, 2021)).

Figure 1 above shows that cases of refusal to export fishery products occur in the European Union, either caused by heavy metals, histamine, microbiology, temperature, or Food Additives.

Export requirements for fishery products to several countries, such as the European Union, the United States, and Japan, impose several conditions on quality assurance and food safety. The export requirements for fishery products can be divided into 5 (five) parts, namely: completeness of licensing documents, quality and safety factors, sustainability, third-party certification, and traceability (Astagia et al., 2022). Especially when exporting to European Union countries while maintaining fish quality. After fishing, ships must be equipped with automatic temperature recording devices. This is stated in the quality control inspection checklist form sheet based on the Regulation of the Director General of Capture Fisheries Number 7 of 2019. Article 6, letter K states that the standard requirements for fish storage handling facilities on fishing vessels must be an automatic temperature recording device/recorder or logbook recording temperature data during fishing if it is not equipped with an automatic temperature recording device/recorder. Furthermore, to reduce contamination of putrefactive bacteria such as *Salmonella Spp*., it is necessary to prioritize providing facilities to maintain the cold chain during processing. In addition, educating workers to properly handle materials during processing is also important (Indrotristanto et al., 2022). An effective method to assess the sustainability of the cold chain using Baiak is by implementing automated temperature logging devices on fishing vessels.

The manufacture of automatic temperature recording devices is needed to make it easier to obtain them specifically for fishing vessels and fishing vessel business actors. This is following the Regulation of the Minister of Marine Affairs and Fisheries Number 10 of 2021 concerning Requirements and Standards for Business Activities and Products in the Implementation of Risk-Based Business Licensing in the Marine and Fisheries Sector, where it is stated that the hatch where fish is stored must be equipped with an automatic temperature recorder. In addition, it is also mentioned that fishing vessels that freeze fish must be fitted with ABF (Air Blast Freezer) or CPF (Contact Plate Freezer), which can reduce the temperature quickly so that the central temperature of the fish reaches the same or less than -18 ° C and is equipped with an automatic temperature recording device. The freezing method with ABF is continuously freezing fish with a cold air dispersion technique with freon material for 13 (thirteen) hours with temperatures ranging from -25ºC - 40ºC (Haya & Restuwati, 2022). At the same time, the CPF freezing method is a method of freezing fish using a series of cooling machine units that can maintain the freshness of fish (Bestari et al., 2013). In the freezing process of this CPF system, the frozen fish is flanked by 2 (two) hollow plates filled with freezing materials such as CFCs (chlorofluorocarbons) and HCFCs (hydrochlorofluorocarbons).

However, most vessels based at Jakarta's Nizam Zachman Ocean Fishing Port are dominated by wooden vessels equipped with refrigerated hatches, so the process of freezing caught fish is carried out in fish holds. There are 4 (four) types of hatches found on fishing vessels: insulated hatches, uninsulated hatches, insulated hatches equipped with mechanical cooling systems for cooling purposes, and insulated hatches equipped with mechanical cooling systems for freezing purposes (Astawan, 2019). Of the 4 (four) types of hatches, insulated hatches equipped with freezing systems dominate the fish hatches on fishing vessels based at PPS Nizam Zachman Jakarta.

Fishery goods are often cooled to reduce deterioration. Due to its long-term low-temperature retention, wet ice is limited for cooling. Treating fish collected on board properly during the voyage until they reach the consumer is crucial. Effective management requires cold chain systems, cleanliness, and hygiene. However, Indonesian fishermen, especially traditional fishermen, have not efficiently merged post-harvest management and cold storage technologies. Most landed fish had a considerable quality decline, incurring nutrition and economic losses for fishermen and customers (Litaay et al., 2018). Maintaining fish quality on board and upon unloading requires careful handling. Research by (Metusalach et al., 2014) showed that Fish quality was 58.58% affected by purse seine fishing, boats, handling facilities, and processes. However, trawl fishing and fish transit time had a 27.27% influence: Gill nets and other undiscovered variables affected fish quality by 14.15 percent.

Furthermore, the Good Fish Handling Practices assessment checklist form states that fishery products that can be shipped to the European Union must use an automatic temperature recorder and have implemented a HACCP system. Automatic temperature recording devices are very important for maintaining the quality of the fish (Hutapea et al., 2020). Overall, the automatic temperature recorder is a very important tool in the fishing industry, helping to ensure the quality of fishery products, compliance with regulations, and operational efficiency of the fishing industry's activities. Ministry of Maritime Affairs and Fisheries Regulation Number 10 of 2021 concerning Requirements and Standards for Business Activities and Products in Implementing Risk-Based Business Licensing in the Marine and Fisheries Sector applies to Fishing Ports throughout Indonesia.

The Internet of Things (IoT) is rapidly expanding as a result of advancements in sensor technology and widespread broadband communication. The Internet of Things (IoT) introduces a novel concept, where numerous objects in our environment will be connected to the network in various ways. The incorporation of sensors/actuators, RFID tags, and communication technologies is the basis of IoT. In the field of Internet of Things (IoT), various tangible things and devices in our surroundings can be connected to the Internet. This enables these objects and devices to collaborate and exchange information with each other in order to achieve shared objectives. It is widely recognized that the Internet of Things (IoT) enables interconnected machines and users to communicate, resulting in a significant amount of data regarding their location and status. Furthermore, it has been acknowledged that by the year 2020, enterprises are projected to allocate approximately £250 billion annually towards the Internet of Things (IoT), with half of this expenditure originating from the manufacturing, transport, and utilities sectors (Mondragon et al., 2020). Several studies in the field of fisheries based on the internet of things have been carried out, such as research on fishery internet of things and big data industry in China (Song & Zhu, 2019), development of internet of things in smart fishery in ornamental fish (Nurzaman, 2023), utilization of internet of things in intelligent fishery monitoring system design (Ding et al., 2022), GPS relative positioning strategy for fisheries Internet of Things (Cao et al., 2020) and remotely monitoring the quality of water in fisheries in realtime (Haldar et al., 2022).

Research related to automatic temperature recording devices is dominated by human temperature, such as research on recording human temperature during covid 19 (Whittington et al., 2020), digital recorder of the human's body fast temperature oscillations (Kuliabin et al., 2018) and non-invasive human body temperature detection for online event data recorder (Sani et al., 2023). In the field of fisheries, research on automatic temperature recording devices has been carried out on the design and development of marine temperature data recorder system based on single-chip microcomputer (J. Li, 2020).

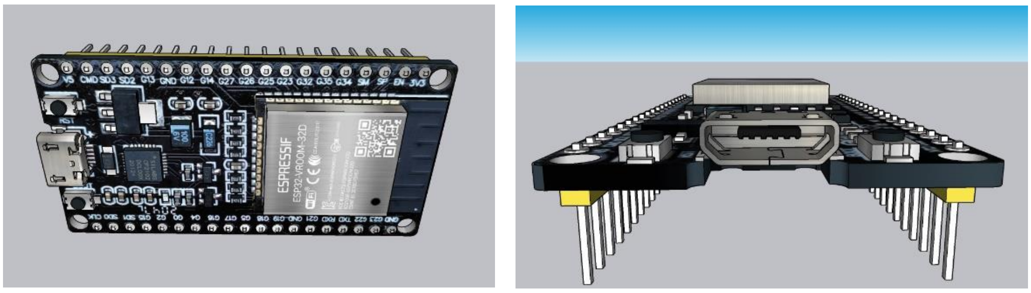
No research on automatic temperature recording systems in the field of fisheries, particularly in catch fisheries, has been found. Despite the widespread availability of automatic temperature recording devices on the market, these tools have not been able to offer satisfactory technical and legal answers. The absence of a display screen to track temperature, limited storage memory, and battery life constraints are the primary factors preventing fishing boat owners from installing temperature recording devices. This research provides solutions to these issues.

2. Literature Review

2.1. Microcontroller ESP 32

The ESP32 microcontroller is a system-on-chip (SoC-System on Chip) developed by Espressif Systems. ESP32 is one of the popular microcontroller platforms often used in Internet of Things (IoT) projects due to its advanced capabilities and extensive connectivity support. The ESP32 is a dual-core microcontroller based on the Xtensa LX6 architecture, with up to 240 MHz clock speeds. It features rich connectivity, including 802.11 b/g/n Wi-Fi, Bluetooth (Classic and Bluetooth Low Energy-BLE), and support for other networks and protocols. It has several digital and analog inputs/outputs that can be used to control various devices and sensors. Support multiple interfaces such as UART (Universal Asynchronous Receiver/ Transmitter), I2C (Inter-Integrated Circuit), SPI (Serial Peripheral Interface), I2S (Inter-IC Sound), and others that make it easy to communicate with other devices. Supports various programming languages, including C, C++, and MicroPython (Prafanto et al., 2021). Various applied studies have been carried out by utilizing ESP 32 microcontrollers, such as the application of microcontrollers in automatic door locks (Prafanto et al., 2021), the application of microcontrollers in web-based door monitoring (Nizam et al., 2022). ESP 32 has been used in previous studies, one of which is the use of ESP 32 in the Supervisory Control and Data Acquisition (SCADA) system for home monitoring and control system (Zare & Iqbal, 2020). In this study, ESP32 was able to become a controller in helping users to monitor temperature, air humidity, air pressure and light intensity in the house. The concept of utilizing ESP32 for industry with the aim of data collection, security and data analysis (Gatial et al., 2020). Making prototypes of assistive devices for people with eye disorders by utilizing the ESP32 microcontroller has also been carried out. The research was conducted by collaborating ESP32, mobile phones and convolutional neural networks (Kushnir et al., 2019). From some of these studies, the choice of ESP32 as a controller because it has a low price. Other research on the use of ESP32 as a controller for safety in the gas cylinder factory environment has also been carried out, this is to detect gas leaks in the factory environment (Abdullah et al., 2018). In the health sector, the use of ESP32 as a controller to monitor group heart rates (Škraba et al., 2019). The ESP32 qualities, among numerous more, make the board the best choice for electronic hobbyists and experts (Rai & Rehman, 2019).

Several factors influence the selection of the ESP32 microcontroller, and in addition to having a Wi-Fi connection and Bluetooth, the resulting data is also more accurate. Research conducted by (Widyatmika et al., 2021) shows that measuring electric current and voltage is more stable than using an Arduino Uno microcontroller. The parts of ESP32 can be seen in Figure 2 below.

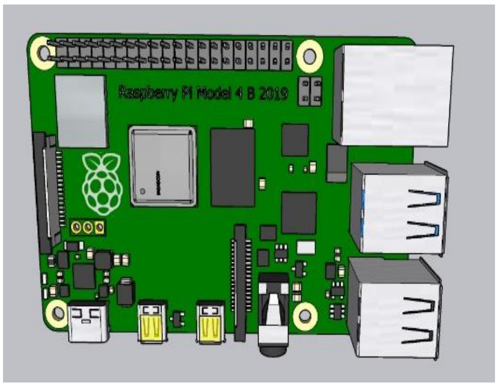


ESP 32 front view ESP 32 side view

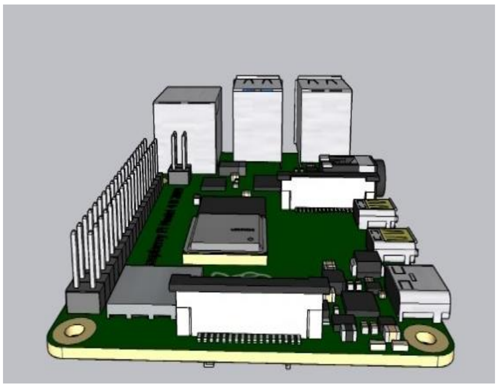
Fig. 2. ESP 32 microcontroller used in this study

2.2. Raspberry

The Raspberry Pi, better known as the Raspi, is a single-board computer the size of a credit card that can be used to play high-resolution video, games, and office applications. Raspberry Pi was designed by a group of developers and computer scientists affiliated with Cambridge University in England to create a charitable foundation called the Raspberry Pi Foundation (R. Setiawan et al., 2018). Raspberry has features like those on computers, using an on-chip system (SOC) that is packaged and connected to a portable circuit board (PCB). Raspberry pi's advantages include a tiny board with high computing power, various interfaces (HDMI, multiple USB, Ethernet, inbuilt Wi-Fi and Bluetooth, several GPIOs, USB powered),Supports Linux and Python (simple app development), Examples with community support readily available (Kondaveeti et al., 2021). Some uses of raspberries include the use of Raspberry Pi as a web server for scheduling remote light control (Prihatmoko, 2017), the use of raspberries as a web server at home for distance control systems and temperature monitoring (Prabowo et al., 2014), the use of raspberries to design a server room door security system with facial recognition using the triangle face method (Wijaya et al., 2017). Raspberries have use in the medical field for identifying lung segmentation and detecting COVID-19 (Alam & Rahmani, 2021). In this investigation, raspberries exhibit enhanced performance in recognizing aru-lung segmentation. Raspberries are utilized as controllers in various applications such as indoor air quality monitoring systems (Zhang et al., 2021), home security monitoring systems (Desnanjaya & Arsana, 2021), facial expression recognition (Wahab et al., 2021), automated vehicle systems (Dewangan, 2021), health monitoring systems (Kamarozaman & Awang, 2021), COVID-19 diagnosis (Hosny et al., 2021), and personal health tracking and analysis (Karthika et al., 2023). Details of the shape of the raspberry can be seen in Figure 3 below.

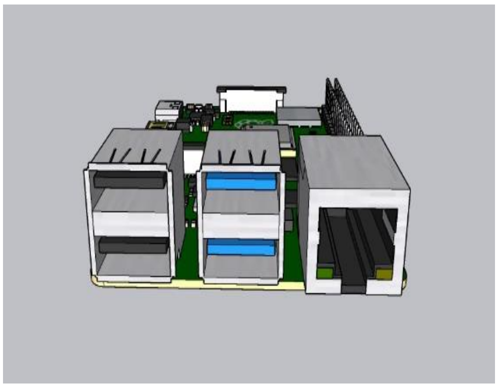


Raspberries front view



Raspberries side view

Raspberries side view



Raspberries side view

Fig. 3. Raspberry Pi 4 used in this study

The components contained in raspberries can be seen in Figure 4 below.

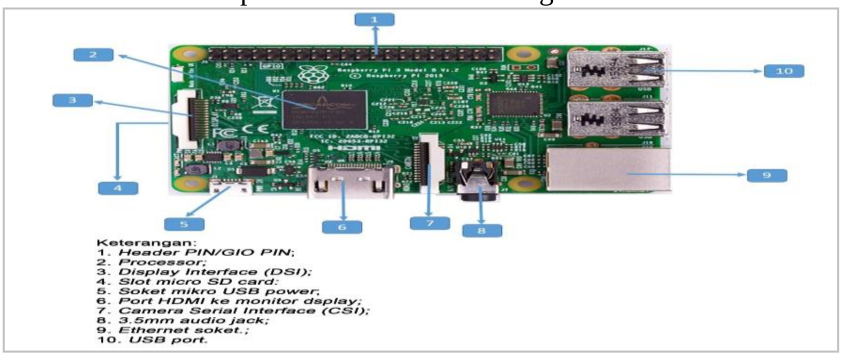


Fig. 4. Raspberry Pi 4 components used in this study

The details and functions of the GPIO PIN section on raspberries can be seen in Figure 5 below.

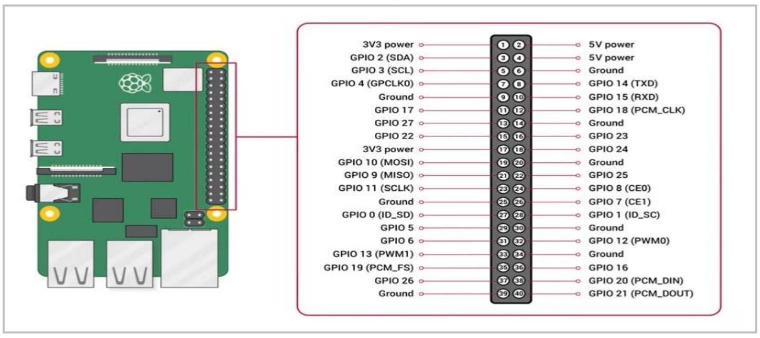


Fig. 5. Details and functions of the GPIO PIN section on raspberries

2.3. MAX31865 Temperature Module

The PT100 temperature MAX31865 module is a device from Pt100 that obtains accurate temperature values. Amplifiers are designed to read low resistance and have amplifiers that can adjust and compensate for the results. The MAX31865 module has a 15-bit ADC (Analog to Digital Converter) precision with a temperature resolution of 0.03125 °C (Sanzay et al., 2020). The MAX31865 module has been utilized in several prior research works, including as its application in the design and analysis of high-power thermostatic control systems (Y. Li et al., 2020) and automatic room temperature monitoring and control systems (Ega et al., 2023). The model of the MAX31865 temperature module used in this study can be seen in Figure 6.

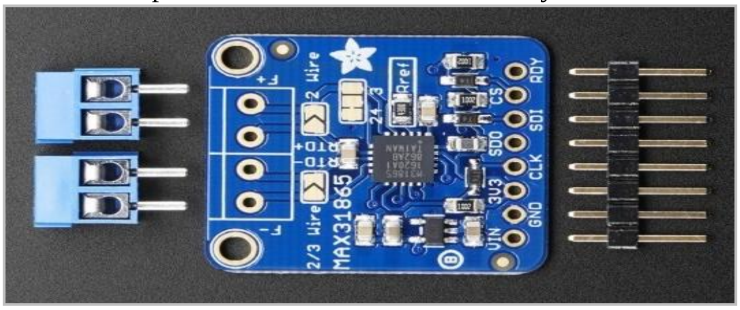


Fig. 6. The MAX31865 module used in this study

2.4. K Type 3 Wire Thermocouple Temperature Sensor

A thermocouple is a device that functions to measure temperature. The basic working concept of thermocouples was first introduced by Seebeck in 1821, who discovered that conductors under a thermal gradient would produce voltage, called the thermoelectric effect (Santoso & Ruslim, 2019). This additional conductor will then experience a temperature gradient and undergo a voltage change opposite to the temperature difference of the object. If the circuit consists of two different metals and the temperature at the terminals of the two wires is not the same, an electric force will appear. According to (Rosman N., 2018), thermocouples generate electrical energy at the connection point of two different metals (hot point/measurement point). The other end of the metal is often called the cold point, where the temperature remains constant. Generally, thermocouples are used to measure temperature based on changes in the temperature of electrical signals. If there is a temperature difference between the reference and measurement points, electromotive force occurs, causing a current in the circuit. If the reference point is closed by connecting it to the logger, the gauge will be proportional to the temperature difference between the hot end (measurement point) and the cold end (reference point).

Type K thermocouples were used in this study because they have a high-temperature measurement distance (Wendri et al., 2012). Thermocouples consist of various types with differences in manufacturing materials, measuring ranges, and sensitivity. The type K PT 100 thermocouple temperature sensor model used in this study can be seen in Figure 7.

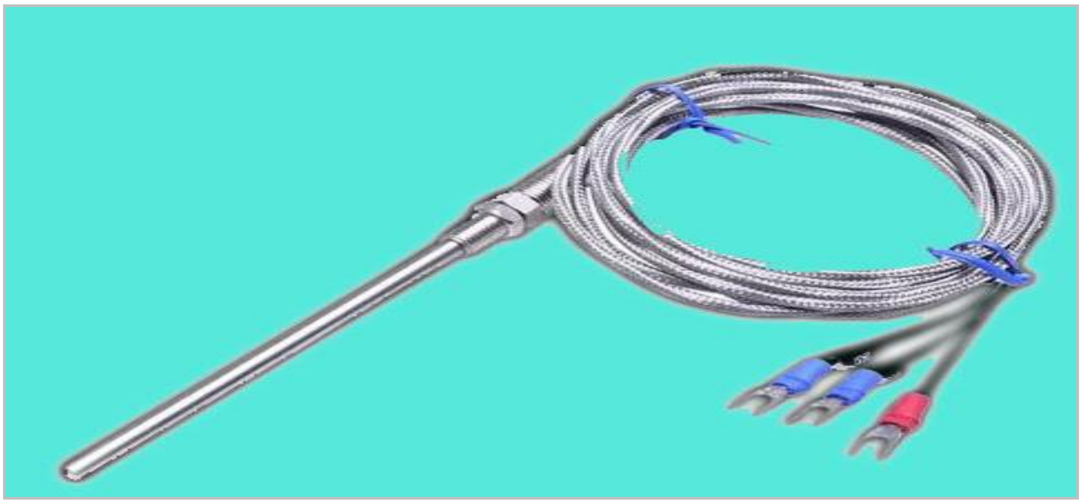


Fig. 7. Type temperature sensor Thermocouple 3 type K PT 100 cables used in this study

2.5. Software Home Assistant

The open-source Home Assistant is a sophisticated smart home control platform with advanced automation, grouping, and UI customization. Home Assistant can automatically link external devices for users. Home Assistant's front-end interface lets users manually call device-registered services or configure automation components. Home Assistant core relays user and automation component instructions to the device entity. Home Assistant core connects to External Environment but does not directly communicate (Kang et al., 2020). The HomeAssistant software is both more lucrative and simpler to implement. The decision was made to use the HomeAssistant software due to its open source nature and lack of additional expenses (Akhmetzhanov et al., 2023). Python-based open source program Home Assistant can monitor and manage MGs in addition to home automation. It allows real-time monitoring of several MG units, programming management techniques, and establishing operational instructions with a simple interface. The program offers a decentralized solution available over the communication network. It can also be accessed remotely via smartphone app (Izquierdo-Monge et al., 2023). These advances can improve comfort, efficiency, and productivity in household settings. One of the technological devices that can be utilized is a smartphone. The application of smart home technology is feasible in residential homes or commercial structures occupied by individuals. The concept of a smart home involves integrating information technology and computer-based information processing. The primary purpose of deploying smart home technology is to achieve safety, comfort, and energy efficiency in residential environments. Smart Home technology can be implemented using the Internet of Things (IoT) paradigm, which integrates sensors, actuators, communication systems, and computer processing capabilities (Rizal et al., 2018).

3. Research Methods

This research was conducted from September 2023 – February 2024, located at the Basic Laboratory (workshop) of the Jakarta Technical University of Fisheries.
The tools and materials to be used in this study can be seen in Table 1 below:

Table 1 - Details of the tools and materials used in the study.

Tool and Material Name
Raspberry Pi4
ESP32 Microcontroller Do it and micro USB cable
Soldering tools 936 60 W adjustable temperature control
LCD Character 20x4 2004 5 V
Tin
Jumper cable female to female

5V buzzer module KY-024
Baseplate Extension ESP 32 and adapter
Access Point TP-Link 4G LTE Router TL-MR100
MAX31865 Temperature PT100 Temperature Module
Type K type 3-wire thermocouple temperature sensor
Small 3-pin CB connector 12 mm
Acrylic box with a size of 30 x 25 x 10 cm
Huawei Matepad ® 10.4 Android tablet
freezer machine brand GEA AB 108 R
Ultra Low Temperatus Data Logger
Global Positioning System (GPS) Garmin Oregon 650

The software used in this study is Home Assistant technology. To design and code, 1 (one) laptop device is also needed.

The design of this automatic temperature recording device is divided into 2 (two) parts: the first is the design of hardware, and the second is the design of software. The result of the design on hardware (hardware) uses an ESP32 microcontroller, MAX 31865 module, PT100 thermocouple sensor, GPS module, alarm relay, and LCD OLED display. Each component is assembled on a PCB (Printed circuit board) that was designed before.

3.1. PCB (Printed circuit board)

A printed circuit board is a board that contains metal circuits that are interconnected between other electronic components, making it possible for them to interact with each other without the need for wires. A printed circuit board containing a layer of copper on only one side is called a single-sided PCB. In contrast, printed circuit boards (PCBs) with copper coatings on both surfaces are called double-sided or multilayer PCBs. Using PCBs makes assembling components of automatic temperature recording devices for fishing vessels easier. In addition to making it easier to assemble components, PCBs can also produce neat tool models. The hardware design process is carried out using the schematic method, starting with designing the connection and layout of the components using the Fritzing application. Then, the design and layout of the finished components, namely in the form of Gerber files, are stored, and orders are placed to be printed into PCBs. The design of the PCB used in this study can be seen in Figure 8 below.

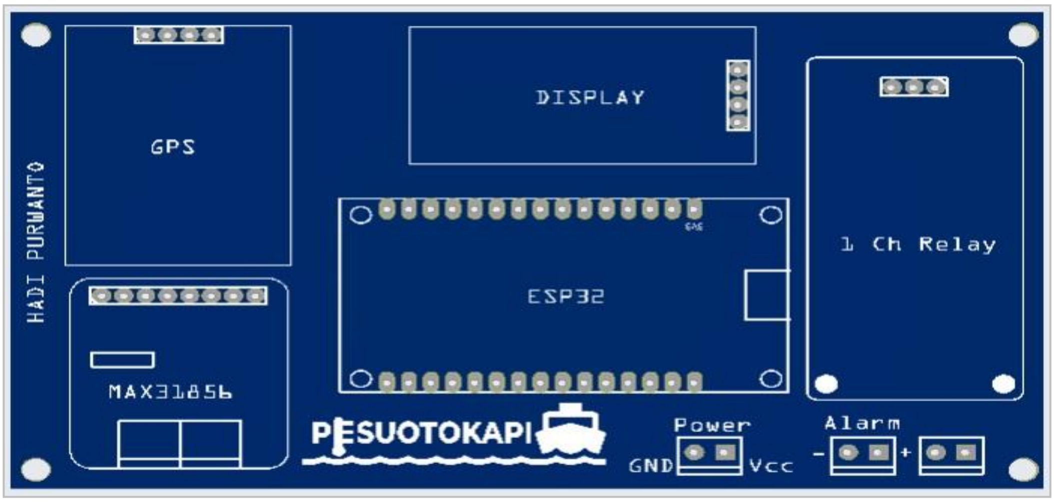


Fig. 8. The PCB (printed circuit board) design of a fishing vessel's automatic temperature recording device.

Meanwhile, the configuration of PIN / GPIO (General Purpose Input / Output) on automatic temperature recording devices for fishing vessels can be seen in Table 2 below.

Table 2 - Configuration of PIN/GPIO (General Purpose Input/Output) on automatic temperature recorders for fishing vessels

ESP32	LCD OLED	GPS	MAX31865	BUZZER	POWER
VIN			3V3	VCC	
GND			GND	GND	GND
D13					
D12					
D14					
D27					
D26					
D25					
D33			CLK		
D32			SDO		
D35					
D34					
VN					
VP					
EN					
3V3	VCC				VCC
GND	GND				
D15				IN1	
D2					
D4					
RX2					
TX2					
D5		RX			
D18			CS		
D19		TX			
D21	SDA				
RXO					
TXO					
D22	SCL				
D23			SDI		

The soldering method carries out the assembly process of the components used in designing automatic temperature recording devices for fishing vessels. The soldering method carried out in this study is the manual soldering method. The series of components on the automatic temperature recording device for fishing vessels can be seen in Figure 9 below.

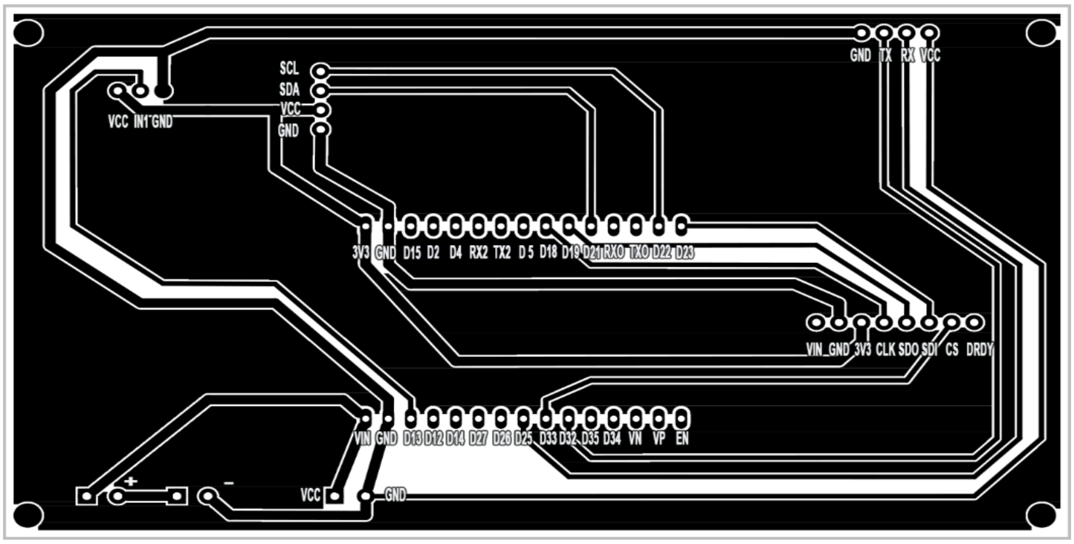


Fig. 9. A series of components in automatic temperature recording devices for fishing vessels.

3.2. Automatic temperature recording device cover design

The cover of the automatic temperature recording device is made of clear acrylic. Acrylic material was chosen because it has several advantages. In addition to being strong, clear acrylic can also display the components used in the series of this automatic temperature recording device. Thermoplastic acrylic resins, usually poly (methyl methacrylate), are transparent because to their amorphous nature, lightness, and ease of synthesis. Acrylic resins can replace inorganic glasses in aquarium water tanks, eyeglasses, windows, and vehicle lighting covers due to their advantages. Filler addition, cross-liking creation, and supramolecular association have been used to modify the physical properties of amorphous glassy polymer materials, especially thermal toughness, to increase their application range (Hayashi et al., 2021). In detail, the design of the cover of the automatic temperature recording device that will be placed on the hold of the fishing vessel can be seen in Figure 9.

Fig. 10. Container/cover design of automatic temperature recording device for fishing vessel

The PCB depicted in figure 10 has been equipped with an ESP32 controller device, an oled screen, a MAX31865 module, a GPS, and a Buzzer alarm. To enhance its durability against water and corrosion, the PCB has been encased in acrylic. The assembled automatic temperature recording device can be seen in Figure 11.

Fig. 11. Automatic temperature recording device that has been assembled

3.3. Design a controller (server) circuit flow

The controller component functions as a regulator of data storage and appearance (display) on the monitor and as an internet or LAN network source. The elements that make up the controller (server) consist of Raspberry Pi 4 and an access point. The design of the display controller circuit and data storage can be seen in Figure 12.

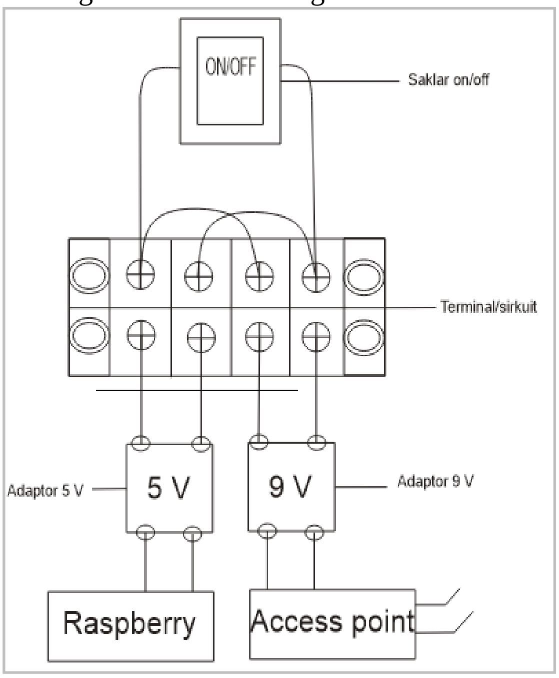


Fig. 1. Display and storage controller circuit design.

Figure 12 depicts the flow of electrical current from the on/off switch to the circuit/terminal. The current is then split, with a portion being directed to a 5 V adapter for the Raspberry Pi and another portion being directed to a 9 V adapter for the access point. Improper voltage connection might result in a short circuit, hence it is important to carefully choose the appropriate adapters.

3.5. Design cover of controller (server)

The cover/container of the display controller and data storage is made using clear acrylic material; this means that the components of the tool circuit can be seen directly. The cross-sectional design of the display controller and data storage container can be seen in Figure 13.

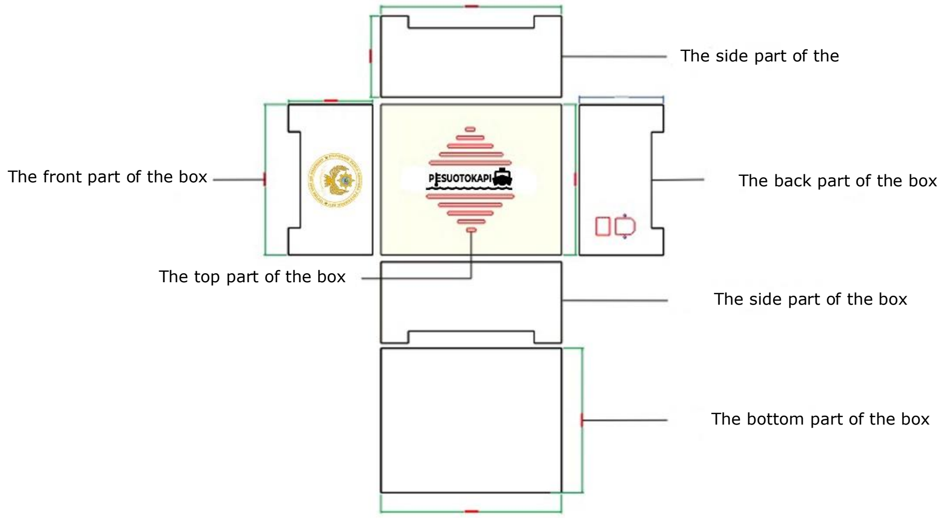


Fig. 2. Design Cross-section container of display controller and data store.

Figure 13 above illustrates the many views of the controller container, including the top, side, front, and bottom. Based on the figure, the dimensions of the container are 30 x 25 x 10 cm.

3.6. Software installation

The software used in this study was Home Assistant platform. Home Assistant is an open-source software platform that controls and automates various devices. Home Assistant is open-source software, meaning developers can access and modify its source code. This allows users to adapt the system as needed. Home Assistant supports a variety of protocols and devices from various vendors. This includes integrating IoT (Internet of Things) devices such as bright lights, thermostats, security cameras, temperature sensors, and more. The platform strives to support as many devices and protocols as possible to cover various aspects. Home Assistant allows users to create automation according to their preferences. Automation can include timing, specific conditions (for example, room temperature), or user actions. Home Assistant provides a web-based user interface that allows users to control the devices used, create automation, and view the status of their smart home. This interface can be accessed from various devices, including computers, tablets, or mobile phones.

This study installed software by adding Home Assistant platforms. This study included ESP home, file editor, grafana, cloudfare, and influxdb. Open-source firmware platform ESP Home targets ESP8266 and ESP32 microcontrollers. ESPHome turns gadgets into Home Assistant-integrated smart devices. Home Assistant's File Editor lets you edit system configuration files. This file editor automates temperature logger data collection in this investigation. Open-source data visualization and analysis software Grafana generates dashboards and monitors system performance. Grafana's Home Assistant integration lets users create visually appealing dashboards to view entities, sensor data, and analytics. Grafana can summarize and analyze data, but graphs can explore it further. This investigation used Cloudflare's tunneling service. The Home Assistant will receive traffic from the configured domain via Cloudflare tunneling. Home Assistant and Influxdb, an open-source database, can store and manage time-series data.

Installing ESP home. Home ESP installation converts and controls devices like temperature sensors for Home Assistant integration. Yaml is used on ESP home. YAML is an acronym for Yet Another Markup Language. It is a data serialization language commonly employed for composing configuration files. YAML files are straightforward to implement, highly customizable, and easily readable by humans. They possess a high degree of expressiveness and can be effortlessly transferred between other programming languages. Converting between JSON and YAML format is a straightforward process (Le & Yoo, 2021). This study's yaml configuration includes the name (device name to be used in Home Assistant), platform (ESP8266 or ESP32 microcontroller platform), board (type of microcontroller board), wifi (settings for connecting the device to a Wi-Fi network), SSID (name of the Wi-Fi network to connect to), password (Wi-Fi network password), API (settings for API-application interface programs that allow integration with Home Assistant), and pass. Figure 14 shows the home ESP platform's yaml configuration. The figure 14 below displays the yaml setup, which comprises several components such as the friendly name, the internet network source utilized, GPI / O configuration, and GPS configuration.


palka02.yaml

```yaml
esphome:
  name: palka02
  friendly_name: palka02

esp32:
  board: esp32dev
  framework:
    type: arduino

# Enable logging
logger:

# Enable Home Assistant API
api:
  encryption:
    key: "bmg8e2izWNLkB3UmkLk0WBUJ2tYQFTkp7UUoCN6Zrow="

ota:
  password: "8c1065247f265109d574ebce1c839d86"

wifi:
  networks:
  - ssid: "TP-Link_BDE8"
    password: "57013701"
  - ssid: "AIRIN"
    password: "16122011"
  - ssid: "KANTOR_Ext"
    password: "vaname12345"

  # Enable fallback hotspot (captive portal) in case wifi cc
```

palka02.yaml

```yaml
- file: "Roboto-Regular.ttf"
  id: my_font01
  size: 19
- file: "Roboto-Regular.ttf"
  id: my_font02
  size: 10

i2c:
  sda: GPIO22
  scl: GPIO21

spi:
  miso_pin: GPIO19
  mosi_pin: GPIO23
  clk_pin: GPIO18

uart:
  rx_pin: GPIO32
  baud_rate: 9600

gps:
  latitude:
    name: "Latitude"
    id: "lat"
  longitude:
    name: "Longitude"
    id: "lon"
  altitude:
    name: "Altitude"
    id: "altitude"
```

Fig. 3. The configuration of yaml on the home ESP platform in this study.

3.7. Installation of editor files

Installing the editor file in the Home Assistant configures the interface directly in the Home Assistant. Without using a terminal or external text editor, file editors can access and modify various configuration files, such as YAML configurations, automation, or other files. This study used the file editor as a temperature logger data collection backup. An overview of the file editor platform configuration can be seen in Figure 15 below.

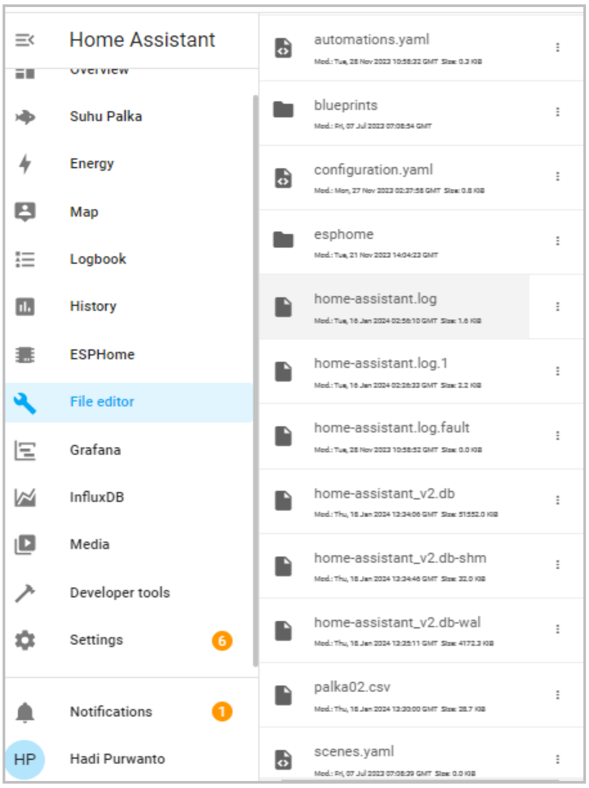


Fig. 4. Configure the file editor menu in this study.

The image in Figure 15 illustrates the file editor menu, which includes several options such as automations and YAML settings. Additionally, it shows the CSV palka02 folder, which serves as a backup for temperature recording data.

3.8. Grafana installation

The grafana installation is a visualization and analysis tool often used to create interactive graphs and dashboards on the Home Assistant platform. In addition, grafana is this study's main source of temperature data loggers. Grafana also provides more accessible and flexible data within the desired time frame. The grafana image can be seen in Figure 16 below.

Fig. 5. Visualization of temperature logger data presented on graphana platform.

3.9. Installation of influxdb

Influxdb is a firmware that cannot be separated from grafana. Influxdb presents data required by Grafana to be visualized into a graph, gauge, and table. Grafana is a visual application, and influxdb is a time series database. It is discretionary and related to the capacity of a home assistant to personalize data visualization. The installation of influxdb is done in the add-on settings menu, then select influxdb, as shown in Figure 17 below.

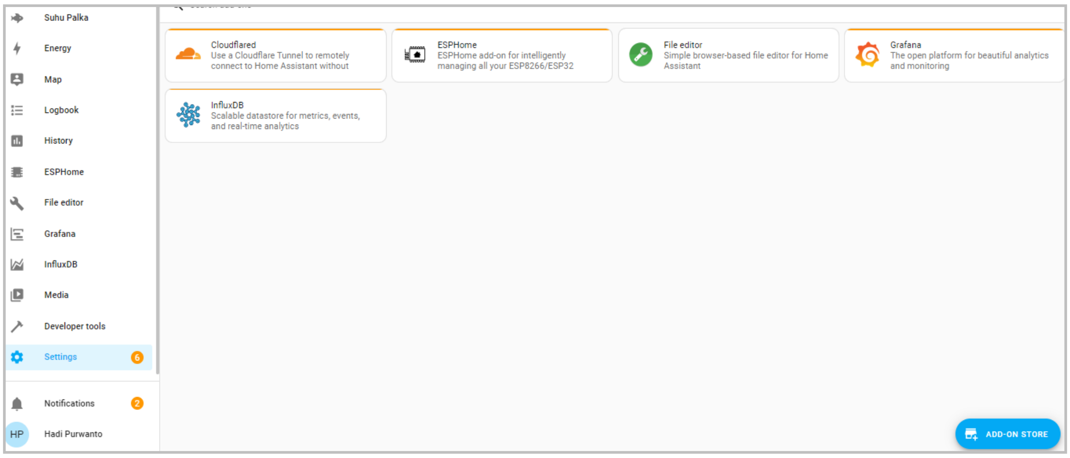


Fig. 6. Installation of influxdb on the add-on store on the Home Assistant platform.

3.10. Cloudflare installation

Cloudflare installation in this study bridges the website domain we choose with the Home Assistant platform so that it can be accessed via the internet network. Cloudflare is a web security and performance services company that provides various services such as content distribution, security enhancement, and website performance optimization.

Automatic temperature recording devices that have been designed can work well. The results of this tool's work can be seen in Figure 18 below.

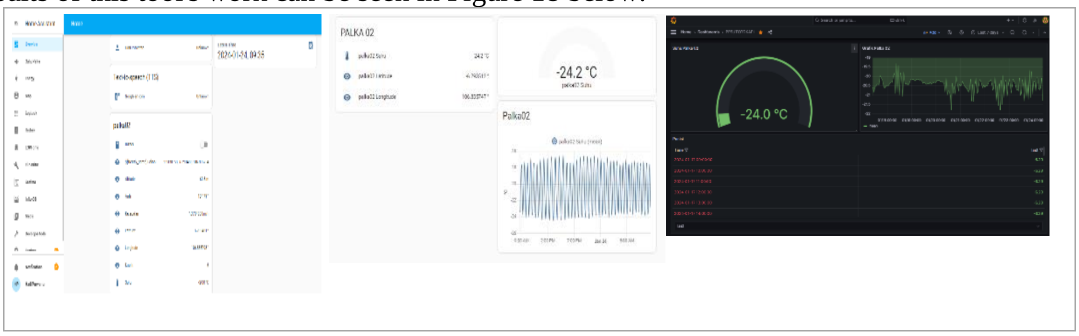


Fig. 7. Visualization of the work of automatic temperature recording devices for fishing vessels.

3.11. Data collection

The data collection process uses trial, error and comparative techniques by comparing devices made with temperature recording devices commercially sold in the market. Data collection will be obtained from various tests that will be carried out, namely battery endurance tests on tools, internet data consumption tests, and tool comparative tests. The comparative test of the test equipment was carried out two times, with each data collection duration of 355 (three hundred fifty-five) hours. The first comparative test compared the results of temperature data loggers of pesuotokapi devices and temperature recorders sold commercially. The second comparative test is carried out by adjusting the temperature value of the device that has been made to be synchronized with temperature recording devices sold commercially.

Statistical analysis. Data analysis was carried out using a T-test with a comparison tool, namely temperature data loggers sold commercially, which in this study used ultra-low temperature data logger unit test equipment. The T-test is used to see the average difference between 2 (two) samples of a study (Sarwono & Herlina, 2012). Before the independent sample t-test was carried out, normality tests were first carried out with the Kolmogorov Smirnov method and homogeneity tests with Levene's Test method from the data of each sensor and its comparison as a prerequisite for the t-test. A normality test is performed to determine whether the data is usually distributed, and a homogeneity test is performed to determine whether the data has homogeneous variance. The confidence level is 95%, with an error tolerance of 5% (α=0.05). Statistical data analysis was performed using the SPSS 26 program.

4. Results and Discussions

The battery is installed on a pesuotokapi device that will be installed on the ship's hold. The specification of the battery used is 2,000 mAh, installed as many as 3 (three) pieces on the pesuotokapi. The endurance test is carried out by turning on the pesuotokapi without any other source of electric current. From the results of the endurance test, it was found that the battery lasted for 32 hours 57 minutes. This time is considered sufficient as a backup source of electric current when the primary source of electric current is interrupted, in contrast to the electric current backup system for the transmitter system at the Airport Terminal, which has an electric current backup time using a UPS for 34.16 minutes (Azhary & Lorenza, 2021). The sole purpose of the battery on the pesuotokapi is to serve as a secondary power source. When discussing Indonesian government laws, it is necessary to monitor and document the hatch temperature at least once every 2 hours. The battery life of 32 hours and 57 minutes provides sufficient time for the fishing boat crew to monitor the temperature in the fish hatch. Furthermore, this instrument is equipped with an alert that serves as a warning system in the event of an increase in the temperature of the fish hatch. Signs of susceptibility to degradation in the quality of fillets The species *Pangasius sp.* suggests that the fish remains fresh for a duration of at least 6 to 9 hours (Ningtyas et al., 2023). It is imperative to regularly inspect fish hatcheries at intervals of no more than 6 hours in order to ensure optimal fish quality.

The next test is the internet quota data usage test**.** This test is carried out to find out how much internet data is needed when accessing the website of the automatic temperature recording device that has been designed. The internet data quota in question is internet data installed on the pesuotokapi controller. The internet quota data used is internet data with the Indosat Ooredoo provider. Data collection is carried out for 7 (seven) days, where every day the pesuotokapi website is accessed 3 (three) times for 1 (one) minute each. The calculation of the amount of quota per unit of time needed to send data accessed through the pesuotokapi website can be calculated using the following formula:

$$\text{Quota amount per unit time} = \frac{\text{The amount of quota used}}{\text{Usage time}}$$

Details of trial data on quota usage can be seen in Table 3 below.

Table 3 - Trial data of internet quota usage when the website pesuotokapi accessed

Open Web		Time (Minutes)	Remaining Quota (GB)
Date	Hit		
21/12/2023	14.15	1	5,1
21/12/2023	20.02	1	5,1
22/12/2023	08.38	1	5
22/12/2023	15.23	1	5
22/12/2023	20.00	1	5
23/12/2023	03.49	1	5
23/12/2023	13.15	1	4,9
23/12/2023	18.00	1	4,9
24/12/2023	10.35	1	4,9
24/12/2023	19.20	1	4,9
24/12/2023	22.30	1	4,9
25/12/2023	19.55	1	4,8
25/12/2023	22.55	1	4,8
25/12/2023	23.45	1	4,8

26/12/2023	10.54	1	4,8
26/12/2023	18.30	1	4,8
26/12/2023	20.47	1	4,8
27/12/2023	08.55	1	4,7
27/12/2023	14.25	1	4,7
27/12/2023	19.40	1	4,7
Sum		20	0,4

Table 3 above shows that the total quota used to send data through pesuotokapi website access is 0.4 GB for 20 (twenty) minutes. By doing the calculation using the formula above, the amount of quota value needed per unit of time will be obtained, which is 0.02 GBMinute-1 according to the calculation below:

$$\text{quota amount per unit time } = \frac{0{,}4}{20}$$

= 0.02 GBMin-1

The purpose of calculating internet data usage in this study is to calculate the expenses incurred when using the website from pesuotokapi (www.pesuotokapi.net) by measuring the utilization of internet allowance. Based on the test calculation results, the quota use when accessing the website is 0.02 GB per minute. The price of a 1GB data package (valid for 1 month) on the Thuraya WE MIS Data/Credit Package (Thuraya WE Only) Prepaid, accessed through the Tokopedia e-commerce platform on May 04, 2024 at 07.28 AM, is IDR 4,999,000, so accessing the pesuotokapi website for a duration of 1 minute incurs a cost of IDR 99,980. According to a study conducted by Mubarak et al., (2020), satellite internet is highly suited for implementation in Indonesia. However, it requires a period of 5 years and 8 months to recoup the initial investment, with a Net Present Value (NPV) of USD 555,804,583 and an Internal Rate of Return (IRR) of 7%.

Subsequently, evaluate the amount of memory consumed by the storage system. The storage memory consumption test determines the memory needed to store temperature recording data per unit of time. The downloaded data is in the form of time and magnitude of the recorded temperature value. This test is carried out by downloading temperature recording data per one hour for 355 (three hundred fifty-five) hours. The result of downloading data on Grafana obtained the memory needed to store temperature data per hour per 355 (three hundred fifty-five) hours, amounting to 20 (twenty) kb. Backing up data downloaded from the editor file with a recording time of 355 (three hundred fifty-five) hours with a recording time range of 30 (thirty) minutes requires 87 kb of memory. The limited storage capacity of commercially available devices, coupled with the lack of a screen for monitoring, results in the loss and overwriting of temperature recording data. Nevertheless, energy efficiency and storage memory have the capability to avert data loss (Hejazi & Ferrari, 2018).

Additionally, GPS accuracy tests were conducted on the installed device in this investigation. A GPS comparative test is performed to determine the accuracy of the GPS installed on the device and compare it with the GPS used in the test. In this study, the GPS module used was NEO 6MV2 GY-GPS6MV2, while the test GPS, as a comparison, was the Garmin Oregon 650 brand. The test is carried out by taking 24 (twenty-four) different coordinate points. After getting the coordinate points on each tool, the coordinate point data is plotted into Google Earth to determine the accuracy of the location between the two tools. The most significant difference in distance values is obtained at the 8th coordinate point, which is 41.55 m. The minor distance difference is found at the 4^{th} coordinate point with a distance difference value of 0 m. The average distance difference between the GPS pesuotokapi and the GPS test is 8.86 m. The results of the GPS comparative test can be seen in Table 4 below in detail.

Table 4 - Coordinates of GPS comparative test results attached to Pesuotokapi compared to Garmin Oregon 650 GPS

Coordinate Point No.	PESUOTOKAPI	Garmin Oregon 650 GPS	Distance difference (m)
1	-6,51257° - 106,77882°	-6,51258° - 106,77881°	1,66
2	-6,51357° - 106,77967°	-6,51359° - 106,77964°	4,19
3	-6,51230° - 106,78037°	-6,51231° - 106,78049°	13,2
4	-6,51091° - 106,78043°	-6,51091° - 106,78043°	0
5	-6,50904° - 106,78043°	-6,50903° - 106,78042°	1,38
6	-6,51031° - 106,77869°	-6,51030° - 106,77866°	3,5
7	-6,50852° - 106,77491°	-6,50852° - 106,77493°	2,17
8	-6,50429° - 106,77335°	-6,50418° - 106,77371°	41,55
9	-6,49979° - 106,77271°	-6,49969° - 106,77281°	15,67
10	-6,49914° - 106,77032°	-6,49918° - 106,77038°	7,95
11	-6,50097° - 106,76784°	-6,50101° - 106,76785°	4,4
12	-6,50517° - 106,76924°	-6,50526° - 106,76934°	14,86
13	-6,50608° - 106,76716°	-6,50608° - 106,76710°	6,65
14	-6,50669° - 106,75857°	-6,50670° - 106,75855°	2,45
15	-6,50539° - 106,76302°	-6,50536° - 106,76301°	3,43
16	-6,50637° - 106,76763°	-6,50642° - 106,76769°	8,58
17	-6,50857° - 106,76804°	-6,50858° - 106,76807°	3,42
18	-6,50932° - 106,76974°	-6,50931° - 106,76979°	5,58
19	-6,51062° - 106,77061°	-6,51057° - 106,77063°	5,93
20	-6,51153° - 106,77386°	-6,51158° - 106,77392°	8,52
21	-6,51092° - 106,77412°	-6,51097° - 106,77408°	7,11
22	-6,51330° - 106,77590°	-6,51330° - 106,77607°	18,76
23	-6,51414° - 106,77630°	-6,51435° - 106,77629°	22,83
24	-6,51266° - 106,77637°	-6,51267° - 106,77645°	8,94
	Average		8,86

These coordinate points will appear in Figure 19 below if plotted into the Google Earth Pro application.

Fig. 8. Comparison of coordinate plotting patterns between the pesuotokapi and the Garmin Oregon 650.

The comparative test of temperature values is carried out by comparing pesuotokapi devices and temperature recording devices sold commercially. This study's commercial temperature recording device was the ultra-low temperature data logger Tzone TempU06 L100 Ice PC. The comparative test process is carried out on the tool's performance and statistical tests of temperature values. A comparative test of tool performance is carried out to determine how effective peusototokapi devices are compared to temperature recording devices sold commercially. Statistical tests are used to determine whether there is a significant difference between the temperature measurement results of pesuotokapi devices and temperature recording devices sold commercially.

This test compares the ups and downs of temperature values recorded by pesuotokapi and temperature recording devices sold commercially without adjustment of temperature values produced by pesuotokapi. A comparative test of temperature values is carried out on peusototokapi and a comparison device at room temperature 24 (twenty-four) hours in advance. This is done to find out the performance of the two tools. From the measurement results, the average temperature difference value is 1.2°C. Visually, the results of recording the two tools at room temperature can be seen in Figure 20 below.

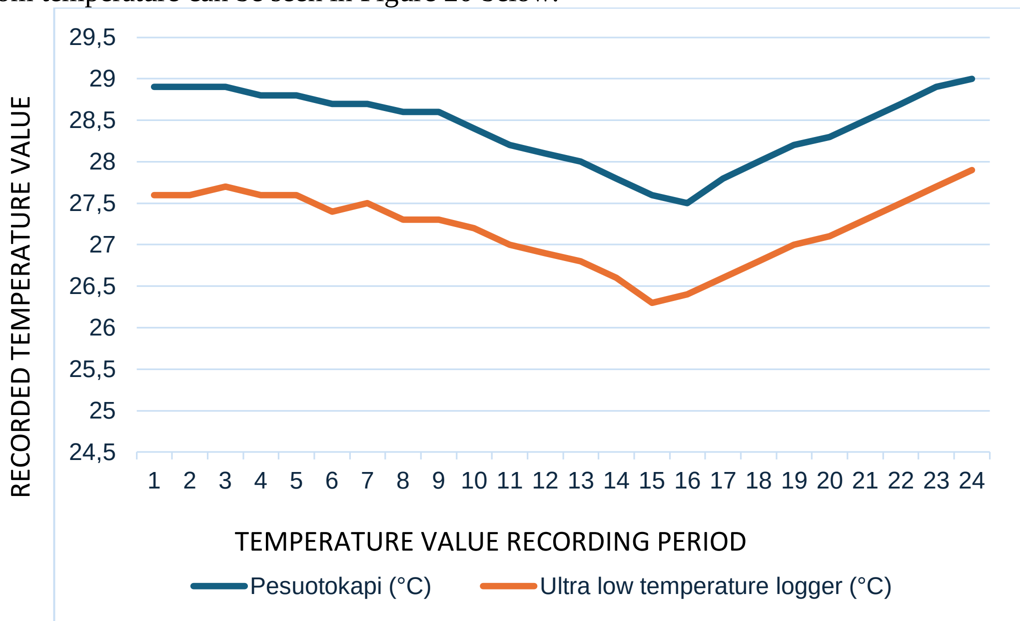


Fig. 20. Comparison of temperature value recording patterns between pesuotokapi devices and ultra-low temperature logger at room temperature.

Figure 20 above shows that the pesuotokapi and the comparison device have the same temperature recording pattern. However, a statistical test is carried out to determine whether there is a noticeable difference between the recorded temperatures, namely the T-test. The statistical test results showed a noticeable difference in temperature values recorded by pesuotokapi and comparison devices. The results of these statistical tests can be seen in Table 5 below.

Table 5 - Statistical test results between temperature values recorded by pesuotokapi with comparison devices at room temperature.

Independent Samples Test

				t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TEMPERATURE VALUE	Equal variances assumed	.052	.820	9.396	46	.000	1.2167	1.295	.9560	1.4773
	Equal variances not assumed			9.396	45.987	.000	1.2167	1.295	.9560	1.4773

The comparative test of temperature values was then carried out by measuring the temperature of the cooling machine used in this study. From the measurement results, the largest difference value is -2.7 °C. A comparison of temperature value recording patterns between pesuotokapi devices and temperature recording devices sold commercially can be seen in Figure 21 below.

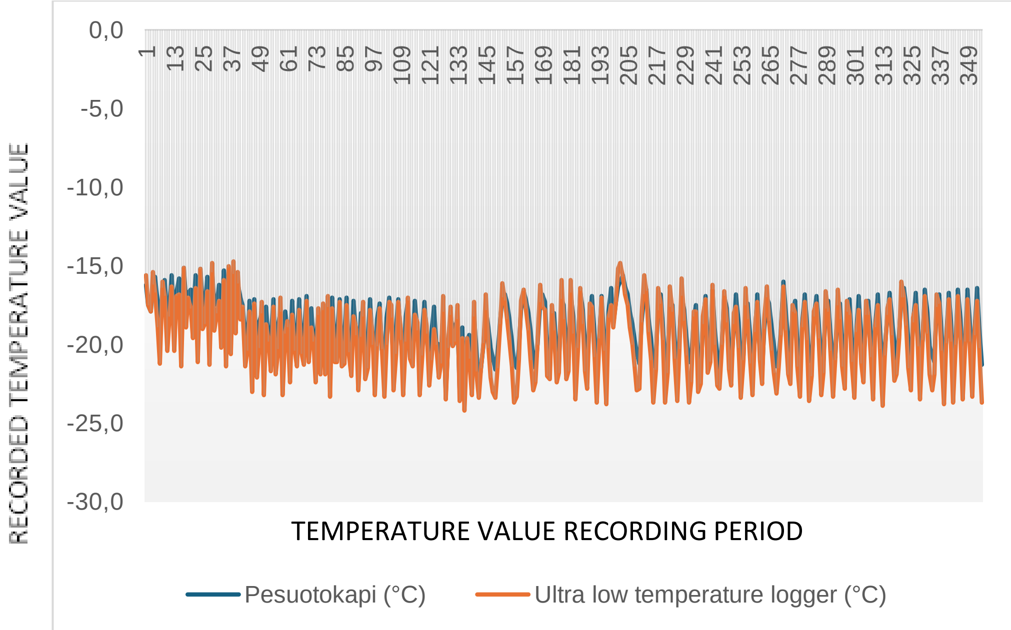


Fig. 9. Comparison of temperature value recording patterns between pesuotokapi devices and commercially sold devices.

Figure 21 above shows that the measurement pattern of pesuotokapi and recording devices sold commercially has the same recording pattern. It can be concluded that the temperature recording performance of pesuotokapi can work well with the average difference in temperature values between pesuotokapi and comparison devices, which is -0,8 °C. However, to determine whether there is a fundamental difference between the temperature value recorded by pesutokapi and the equipment sold commercially, there is a fundamental difference, it is necessary to do a statistical test. The statistical test used in this study was the T-test utilizing the SPSS program version 26. Before conducting the T-test, the number of samples must be determined because the number of data samples obtained is large. The number of samples is determined using the Slovin formula below (N. Setiawan, 2007).

$$n = \frac{N}{1 + (N \times d^2)}$$

Information

n = Sample size
N = Population
d = Estimating error

Data collection in this study was carried out for 355 (three hundred fifty-five) hours, so the number of samples was 355 (three hundred fifty-five). Using the Slovin formula, the number of samples used in the statistical test is 188 (one hundred and eighty-eight). The results of the T-test at temperature values recorded by pesuotokapi with temperature recording devices sold commercially are presented in Table 6 below.

Table 6 - Statistical test results between temperature values recorded by pesuotokapi and comparison tools.

Independent Samples Test

				t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TEMPERATURE VALUE	Equal variances assumed	18.705	.000	3.889	374	.000	.840	.216	.415	1.265
	Equal variances not			3.889	351.208	.000	.840	.216	.415	1.265

assumed

Table 6 above can be the value of sig. (2 tailed) of 0.000, it can be concluded that there is a noticeable difference between the temperature value recorded by the pesuotokapi and the temperature recording device sold commercially at a confidence interval of 95%.

Standard deviation calculation is carried out to determine the precision of the measurement results of a tool (Saptadi, 2014). Standard Deviation is a statistical measure used to assess the spread of data within a sample and the proximity of individual data points to the mean value of the sample. A standard deviation of zero in a data set indicates that all values are identical, while a higher deviation indicates that each data point deviates significantly from the mean. Variance and standard deviation are general variabilities used by individuals to measure the distribution of data within a group (Hidayat et al., 2019). Each tool's average recorded temperature and standard deviation are calculated to determine the average recorded temperature and standard deviation of both the pesuotokapi and the comparison device before calibration. The calculation was carried out using the SPSS Ver.26 program, so the average value for pesuotokapi was -18.9 °C and a standard deviation of 1.77. As for the comparison tool, the average temperature recorded was -19.7 °C, and the standard deviation was 2.38. The results of calculating the average temperature recorded and the standard deviation of both pesuotokapi and comparison tools are presented in Table 7 below.

Table 7 - The calculation of the average temperature recorded and standard deviation both on pesuotokapi and comparison tools.

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
PESUOTOKAPI	355	-23.1	-15.1	-18.856	1.7718
Valid N (listwise)	355				
COMPARISON TOOL	355	-24.2	-14.7	-19.691	2.3840
Valid N (listwise)	355				

The comparative test of temperature values between calibrated pesuotokapi and ultra-low temperature logger(comparison tool) aims to determine whether there is a fundamental difference in the pattern of recording temperature values and fundamental differences in statistical tests. The calibration process uses a polynomial calibration model by entering the temperature value listed on the comparison device. The process of taking temperature calibration values is carried out by measuring 12 (twelve) times, starting from the highest to the lowest temperature. The results of measuring temperature values used in the calibration process are presented in Table 8.

Table 8 - The temperature value used in the calibration process

No	Pesuotokapi	Comparison Tool
1	30	29,6
2	29,7	29
3	29,8	28,9
4	28,3	27,6
5	28,2	27,2
6	15,1	14,1
7	12,5	11,5
8	-18,9	-20,5
9	-19,3	-20,8
10	-19,8	-21,4
11	-20,1	-21,8

12	-20,5	-22,1

The values in Table 8 above are entered into the esphome coding in the Home Assistant program. The temperature value entered results from pesuotokapi measurements, which are then substituted with the results of the temperature values measured by the comparison tool. Details of temperature values entering the Home Assistant program can be seen in Figure 22 below.

× palka02.yaml

```
      - calibrate_polynomial:
          degree: 2
          datapoints:
           # Map 0.0 (from sensor) to 0.0 (true value)
           - 30.0 -> 29.6
           - 29.7 -> 29.0
           - 29.8 -> 28.9
           - 28.3 -> 27.6
           - 28.2 -> 27.2
           - 15.1 -> 14.1
           - 12.5 -> 11.5
           - -18.9 -> -20.5
           - -19.3 -> -20.8
           - -19.8 -> -21.4
           - -20.1 -> -21.8
           - -20.5 -> -22.1
```

Fig. 10. Details of temperature values were entered into the program Home Assistant.

After the calibration process, a comparative test of the performance and accuracy of the pesuotokapi and comparison device is carried out at room temperature. Data collection is carried out for 24 hours. The results of the recording pattern of the comparative test between pesuotokapi and the comparison tool can be seen in Figure 23 below.

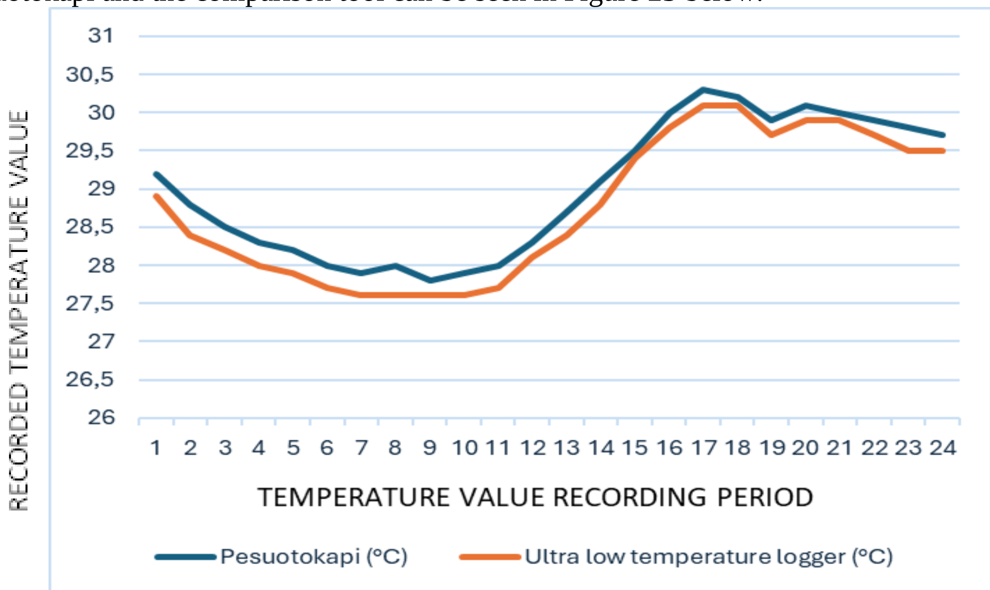


Fig. 11. The results of the recording pattern from the comparative test between pesuotokapi and the comparison device after calibration.

From the graphic pattern recorded in Figure 25 above, it can be concluded that the pesuotokapi and comparison tools have the same recording pattern with the highest measurement difference of 0.4 °C. However, to find out whether there is a real difference in value between pesuotokapi and ultra-low temperature logger, a statistical test, namely the T-test, must be performed.

Table 9 - T-test results on pesuotokapi and comparison device after calibration at room temperature.

Independent Samples Test								
			t-test for Equality of Means					
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference

									Lower	Upper
TEMPERATURE VALUE	Equal variances assumed	.240	.626	.943	46	.350	.2500	.2650	-.2835	.7835
	Equal variances not assumed			.943	45.843	.350	.2500	.2650	-.2835	.7835

From Table 9 above, a sig (2-tailed) value of 0.35 was obtained, so it can be concluded that there is no noticeable difference between the average temperature value recorded by the pesuotokapi and the comparison device (ultra-low temperature logger) with a confidence interval of 95%, so it is continued for testing in the freezer.

The comparative test between the calibrated pesuotokapi and the comparison device (ultra-low temperature logger) in the freezer was carried out for 355 (three hundred and fifty-five) hours with an average temperature difference of 1.2 °C. Visualization of temperature recording patterns in calibrated pesuotokapi and comparison tools can be seen in Figure 24 below.

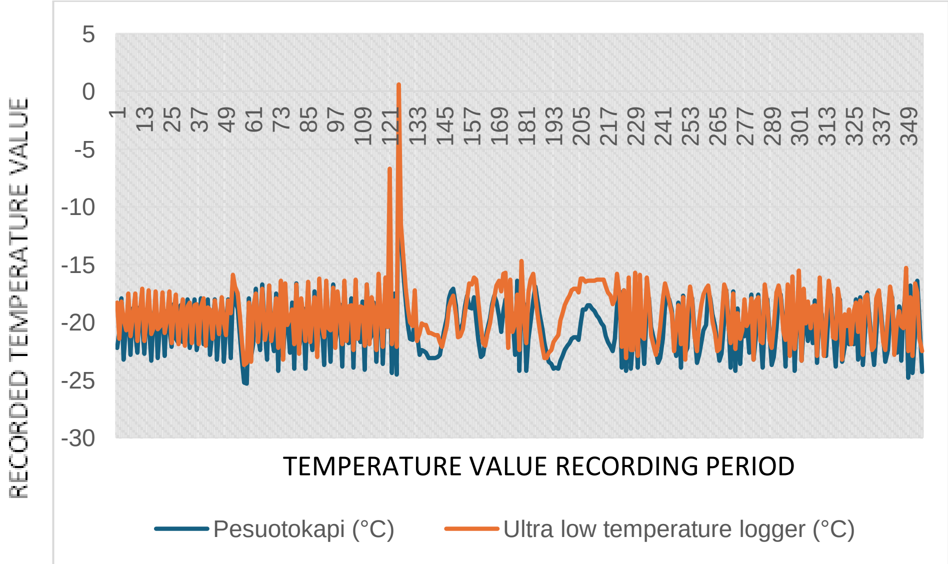


Fig. 12. Comparison Of Temperature Value Recording Patterns Between Calibrated Devices And Temperature Recorders Sold Commercially.

Figure 26 above shows that the pesuotokapi and the comparison device still have the same temperature value recording pattern but with a more significant difference in value compared to the difference in comparative tests before calibration. The most significant difference in temperature values in the comparative test between calibrated pesuotokapi is 8.8 °C. Statistical tests were conducted to clarify the temperature values recorded by calibrated pesuotokapi and comparison tools. The T-test determines if there is a noticeable difference between the temperature values recorded by the calibrated pesuotokapi and the comparison device. The results of statistical tests on calibrated pesuotokapi temperature values and comparison tools are presented in Table 10 below.

Table10 - Statistical test results between temperature values recorded by pesuotokapi and comparison tools.

Independent Samples Test										
				t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TEMPERATURE VALUE	Equal variances assumed	.338	.561	-3.733	374	.000	-1.0473	0.2805	-1.5990	-.4957
	Equal variances not			-3.733	373.790	.000	-1.0473	0.2805	-1.5990	-.4957

assumed

From Table 10 above, a sig (2-tailed) value of 0.000 is obtained, so it can be concluded that there is a significant difference between the temperature value recorded by the calibrated pesuotokapi and the comparison device at a 95% confidence interval.

Each tool's average recorded temperature and standard deviation are calculated to determine the average recorded temperature and standard deviation of both the pesuotokapi and the comparison device after calibration. The calculation was carried out using the SPSS Ver.26 program, so the average value for pesuotokapi was -20.5 C° and a standard deviation of 2.45. As for the comparison tool, the average temperature recorded was -19.3 C ° and a standard deviation of 2.56. The results of calculating the average recorded temperature and standard deviation of both pesuotokapi and comparison tools are presented in Table 11 below.

Table 11 - The calculation of the average temperature recorded and standard deviation both on pesuotokapi and comparison tools.

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
PESUOTOKAPI	355	-25.3	-2.4	-20.493	2.4996
Valid N (listwise)	355				
COMPARISON TOOL	355	-23.7	.6	-19.282	2.5565
Valid N (listwise)	355				

The design of an automatic temperature recording device for fishing vessels has been done and can work well. This automatic temperature recording device for fishing vessels is named PESUOTOKAPI. The process of using the Pesuotokapi tool can be monitored by accessing the website that has been provided or by LAN (Local Area Network) if there is no internet network. The website provided to access Pesuotokapi is www.pesuotokapi.net. While the link to monitor via LAN can be accessed at http://192.168.1.102:8123/. The export of temperature log data or coordinate data can be downloaded through grafana or an editor file in Excel / CSV format. Several factors, including sensor sensitivity, can cause temperature value measurement results differences. The difference in temperature accuracy results can be influenced by the sensor sensitivity used in a study. However, the stability level of the measurement is also a consideration for the desired results (Ivory et al., 2021). Materials that generate power from temperature differential are thermoelectric. Stable operation and longevity are benefits. They are the finest clean energy sources employing fuels or waste heat. Since it has attracted great attention and research, various high-performance thermoelectric materials have been discovered and created. This study examined the maximum service temperature sensitivity of thermocouples, thermoelectric thin films, and Pt/In2O3 TFTCs (Z. Liu et al., 2020). Flexible TFTCs have ultra-high sensitivity compared to traditional thermocouples placed onto flexible substrates. While some materials, such as indium tin oxide (Gregory et al., 2012), La0.8Sr0.2CrO3 (D. Liu et al., 2018), Be2Ti3 (Kurokawa et al., 2020), and SnSe (Heo et al., 2019), have higher test sensitivity, such as the Seebeck coefficient, However, the flexible substrate's treatment temperature limit considerably impacts the material's preparation and post-treatment, making it difficult to obtain the ideal usage condition.

The cooling machine used in this research uses a thermostat that works automatically when the temperature in the cooling machine has reached the optimal temperature. The purpose of the thermostat in the freezer is to control the temperature in the freezing room, optimize the ice machine's workload, conserve energy, maintain a consistent temperature, and reduce strain on the machine. The ultra-low temperature data logger product obtained from the market has a measuring range of -100°C to 80°C and an accuracy level of ± 0.5°C, as specified in its specifications. The temperature sensor utilized in this study is the PT 100 thermocouple temperature sensor, which boasts an extensive recording range of -50°C to Nevertheless, after computing the standard deviation of the temperature data that was captured, it becomes evident that the data distribution from the photographer aligns more closely with the average temperature number.

A comparative test was conducted in this study to verify the functionality of the pesuotokapi tool that had been developed by assessing its ability to accurately measure temperature values. Based on the results of the comparative test, it is evident that the temperature recording pattern of pesuotokapi consistently shows higher values compared to the comparison tool, with an average temperature difference of -0.8 °C. This indicates that the dependability of pesuotokapi is confirmed. In order to assess the validity of the pesuotokapi tool, it is imperative to compute the confidence interval for both the pesuotokapi tool and the comparison tool. The confidence interval for the pesuotokapi tool without calibration was calculated to be -18.9±0.18 C °, whereas the confidence interval for the comparison tool was -19.7±0.25 C °. The confidence interval for the pesuotokapi tool after calibration was determined to be -20.5±0.26 C°, while for the comparison tool it was -19.3±0.27 C°. In order to assess the degree of variability in the average values of the pesuotokapi tool and comparison tool, the coefficient of variation was computed for the temperature recording data obtained in this study. The calculation findings indicate that the coefficient of variance for the pesuotokapi tool, prior to calibration, was 9.39%, whereas the variance coefficient for the comparison tool was 12.09%. Following the calibration process, the coefficient of variation for the pesuotokapi tool was determined to be 11.96%, while the coefficient of variance for the comparison tool was found to be 13.28%. The coefficient of variance obtained from the pesuotokapi tool consistently exhibits a lesser value compared to the coefficient of variance obtained from the comparison tool. This demonstrates that the data generated by the pesuotokapi tool has a reduced divergence compared to the comparison tool when compared to the average recorded temperature value. The temperature reading generated by the pesuotokapi device prior to calibration consistently exceeds that of the comparator device, resulting in a more favorable effect on the quality of fish held in the hold.

5. Conclusion

A experiment was conducted to assess automatic temperature recording systems on fishing vessels. The trial involved comparing temperature values recorded on pesuotokapi devices with those recorded on comparator devices. Statistically significant findings were obtained from the comparative test before and after calibrating. However, upon examining the temperature recording pattern of pesuotokapi and comparison devices, it is evident that they exhibit the same recording pattern. This similarity is particularly noticeable in pesuotokapi before calibration is performed. This indicates that the PT 100 temperature sensor, which is utilised in this study, can function effectively even without calibration. The coefficient of variation for the comparison tool was 12.09%. After completing the calibration process, the pesuotokapi tool had a coefficient of variation of 11.96%, while the comparison tool had a coefficient of variance of 13.28%. The coefficient of variance received from the pesuotokapi tool consistently shows a lower value compared to the coefficient of variance obtained from the comparison tool. This illustrates that the data produced by the pesuotokapi tool exhibits less variation in contrast to the comparison tool when compared to the average recorded temperature value. The temperature reading produced by the pesuotokapi device consistently surpasses that of the comparator device before calibration, leading to a more beneficial impact on the quality of fish stored in the hold..

A recommendation for this research is to utilise a more streamlined battery design, such as a thin shape, in order to reduce the overall thickness and weight of the installed tool in the grip. Furthermore, it is important to conduct direct equipment trials on seafaring vessels engaged in fishing activities in order to facilitate additional study. It is necessary to utilise this particular form of temperature sensor in future research, particularly temperature sensors that possess exceptional precision at low temperatures.

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References

Abdullah, A., Saad, F. S. A., Ahmad, Z. A., Sudin, S., Kamaruddin, K., Bakar, M. A. A., Ajit, M. I. M., & Ghazali, F. (2018). Development of ESP32-based Wi-Fi Electronic Nose System for Monitoring LPG Leakage at Gas Cylinder Refurbish Plant. In *2018 International Conference on Computational Approach in Smart Systems Design and Applications, ICASSDA 2018*. https://doi.org/10.1109/ICASSDA.2018.8477594

Akbari, N., Failler, P., Pan, H., & Drakeford, B. (2023). *The Impact of Fisheries on the Economy : A Systematic Review on the Application of General Equilibrium and Input – Output Methods*. https://doi.org/https://doi.org/10.3390/ su15076089

Akhmetzhanov, B. K., Gazizuly, O. A., Nurlan, Z., & Zhakiyev, N. (2023). *Integration of a Video Surveillance System Into a Smart Home Using the Home Assistant Platform*. *April 2022*. https://doi.org/10.1109/SIST54437.2022.9945718

Alam, U. I. M., & Rahmani, R. (2021). Federated semi-supervised multi-task learning to detect covid-19 and lungs segmentation marking using chest radiography images and raspberry pi devices: An internet of medical things application. *Sensors*, *21*(15). https://doi.org/10.3390/s21155025

Astagia, A., Nurani, T. W. , & Kurniawati, V. R. (2022). Persyaratan Ekspor Tuna Tujuan Uni Eropa, Amerika Serikat,dan Jepang. *Albacore*, *6*(1), 57–66.

Astawan, M. (2019). Penanganan dan pengolahan hasil Perikanan di atas Kapal. *Basic Principles of Fishery Product Processing Technology*, 1–338.

Azhary, M. A. ., & Lorenza, A. (2021). Analisis Sistem Kerja UPS (Uninterruptible Power Supply) Power Scale 200 kVA Terminal Bandara PT. Angkasa Pura II (Persero). *IJEERE: Indonesian Journal of Electrical Engineering and Renewable Energy*, *1*(1), 13–20. https://doi.org/10.57152/ijeere.v1i1.70

Bestari, D., Ma'ruf, W. F., & Anggo, A. D. (2013). Perbandingan Mutu Udang Windu (*Penaeus monodon*) yang Diproses dari Berbagai Jenis Metode Pembekuan Berbeda. *Jurnal Pengolahan Dan Bioteknologi Hasil Perikanan*, *2*(2), 116–125.

Cao, S., Yu, S., & Zhang, Z. (2020). GPS relative positioning strategies for the fishery Internet of Things. *Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering*, *36*(10), 158–165. https://doi.org/10.11975/j.issn.1002-6819.2020.10.019

Desnanjaya, I. G. M. N., & Arsana, I. N. A. (2021). Home security monitoring system with IoT-based Raspberry Pi. *Indonesian Journal of Electrical Engineering and Computer Science*, *22*(3), 1295–1302. https://doi.org/10.11591/ijeecs.v22.i3.pp1295-1302

Ding, X., Chen, L., Liu, M., & Hu, S. (2022). Design of intelligent fishery monitoring system based on Internet of Things technology. In *IMCEC 2022 - IEEE 5th Advanced Information Management, Communicates, Electronic and Automation Control Conference* (pp. 126–129). https://doi.org/10.1109/IMCEC55388.2022.10019930

Ega, A. V, Ginanjar, G., Azzumar, M., & Achmadi, A. (2023). *Internet of things (IoT) based automatic room temperature monitoring and control Internet of Things (IoT) based Automatic Room Temperature Monitoring and Control with EGS-PWS 2 . 0. 030001*(February), 0–12.

FAO. (2015). Nuestro futuro: Un mundo sin hambre. *FAO Publications*, 83. www.fao.org/publications

Gatial, E., Balogh, Z., & Hluchy, L. (2020). Concept of Energy Efficient ESP32 Chip for Industrial Wireless Sensor Network. In *INES 2020 - IEEE 24th International Conference on Intelligent Engineering Systems, Proceedings* (pp. 179–183). https://doi.org/10.1109/INES49302.2020.9147189

Gregory, O. J., Amani, M., Tougas, I. M., & Drehman, A. J. (2012). Stability and microstructure of indium tin oxynitride thin films. *Journal of the American Ceramic Society*, *95*(2), 705–710. https://doi.org/10.1111/j.1551-2916.2011.04845.x

Haldar, S., Sain, A., Suman, S., Biswas, L., & Biswas, K. (2022). Internet of Things for Fishery. In *Lecture Notes in Electrical Engineering* (Vol. 815, pp. 505–513). https://doi.org/10.1007/978-981-16-7011-4_48

Haya, S., & Restuwati, I. (2022). Teknik Pembekuan Ikan Tongkol Bentuk Utuh dengan

Metode Air Blast Freezer. *Jurnal Penyuluhan Perikanan Dan Kelautan*, *16*(1), 45–63. https://doi.org/10.33378/jppik.v16i1.283

Hayashi, M., Shibata, K., & Nobukawa, S. (2021). Advantage of graft architecture with a flexible main chain for implantation of ductile nature into brittle amorphous acrylic glass. *Polymer*, *236*. https://doi.org/10.1016/j.polymer.2021.124316

Hejazi, P., & Ferrari, G. (2018). *Energy and Memory Efficient Data Loss Prevention in Wireless Sensor Networks*. *July*. https://doi.org/10.20944/preprints201807.0206.v1

Heo, S. H., Jo, S., Kim, H. S., Choi, G., Song, J. Y., Kang, J. Y., Park, N. J., Ban, H. W., Kim, F., Jeong, H., Jung, J., Jang, J., Lee, W. B., Shin, H., & Son, J. S. (2019). Composition change-driven texturing and doping in solution-processed SnSe thermoelectric thin films. *Nature Communications*, *10*(1). https://doi.org/10.1038/s41467-019-08883-x

Hidayat, R. N., Sabri, L. M., & Awaluddin, M. (2019). Analisis Desain Jaring Gnss Berdasarkan Fungsi Presisi (Studi Kasus : Titik Geoid Geometri Kota Semarang). *Jurnal Geodesi Undip*, *8*(1), 48–55. https://ejournal3.undip.ac.id/index.php/geodesi/article/view/22451

Hosny, K. M., Darwish, M. M., Li, K., & Salah, A. (2021). *COVID-19 diagnosis from CT scans and chest X-ray images using low-cost Raspberry Pi*. 1–18. https://doi.org/10.1371/journal.pone.0250688

Hutapea, R. Y. F., Khikmawati, L. T., & Gusfirmansyah, W. (2020). Studi Penanganan Hasil Tangkapan Purse Seine Di Km Bina Maju Kota Sibolga. *Jurnal Teknologi Perikanan Dan Kelautan*, *10*(2), 183–190. https://doi.org/10.24319/jtpk.10.183-190

Indrotristanto, N., Andarwulan, N., Fardiaz, D., & Dewanti-Hariyadi, R. (2022). Prioritization of food – pathogen pairs in export refusals of fishery commodities from Indonesia. *Food Control*, *131*. https://doi.org/10.1016/j.foodcont.2021.108476

Ivory, R. A., Kholis, N., Nurhayati, & Baskoro, F. (2021). Review Penggunaan Sensor Suhu Terhadap Respon Pembacaan Skala Pada Inkubator Bayi. *Jurnal Teknik Elektro*, *10*(01), 185–194.

Izquierdo-Monge, O., Redondo-Plaza, A., Peña-Carro, P., Zorita-Lamadrid, Á., Alonso-Gómez, V., & Hernández-Callejo, L. (2023). Open Source Monitoring and Alarm System for Smart Microgrids Operation and Maintenance Management. *Electronics (Switzerland)*, *12*(11). https://doi.org/10.3390/electronics12112471

Kamarozaman, N. B., & Awang, A. H. (2021). IOT COVID-19 Portable Health Monitoring System Using Raspberry Pi, Node-Red and ThingSpeak. In *IEEE Symposium on Wireless Technology and Applications, ISWTA* (Vol. 2021, pp. 107–112). https://doi.org/10.1109/ISWTA52208.2021.9587444

Kang, K., Xu, L., Wang, W., Wu, G., Wei, J., & ... (2020). A Hierarchical Automata Based Approach for Anomaly Detection in Smart Home Devices. *... on Internet of Things …*. https://ieeexplore.ieee.org/abstract/document/9291572/

Karthika, K., Dhanalakshmi, S., Murthy, S. M., Mishra, N., Sasikala, S., & Murugan, S. (2023). Raspberry Pi-Enabled Wearable Sensors for Personal Health Tracking and Analysis. In *International Conference on Self Sustainable Artificial Intelligence Systems, ICSSAS 2023 - Proceedings* (pp. 1254–1259). https://doi.org/10.1109/ICSSAS57918.2023.10331909

Kondaveeti, H. K., Kumaravelu, N. K., Vanambathina, S. D., Mathe, S. E., & Vappangi, S. (2021). A systematic literature review on prototyping with Arduino : Applications , challenges , advantages , and limitations. *Computer Science Review*, *40*, 100364. https://doi.org/10.1016/j.cosrev.2021.100364

Kuliabin, K., Belov, A. V, Sergeev, T. V, & Suvorov, N. B. (2018). The digital recorder of the human's body fast temperature oscillations. In *Proceedings of the 2018 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering, ElConRus 2018* (Vol. 2018, pp. 1205–1208). https://doi.org/10.1109/EIConRus.2018.8317308

Kurokawa, T., Mori, R., Norimasa, O., Chiba, T., Eguchi, R., & Takashiri, M. (2020). Influences of substrate types and heat treatment conditions on structural and thermoelectric properties of nanocrystalline Bi2Te3 thin films formed by DC magnetron sputtering. *Vacuum*, *179*(June), 109535. https://doi.org/10.1016/j.vacuum.2020.109535

Kushnir, V., Koman, B., & Yuzevych, V. (2019). IoT Image Recognition System Implementation for Blind Peoples Using esp32, Mobile Phone and Convolutional Neural Network. In *2019 11th International Scientific and Practical Conference on Electronics and Information Technologies, ELIT 2019 - Proceedings* (pp. 183–187). https://doi.org/10.1109/ELIT.2019.8892289

Le, V. C., & Yoo, M. (2021). Application for Managing YAML Template for Kubernetes. *Journal of Korean Institute of Communications and Information Sciences*, *46*(11), 1950–1957. https://doi.org/10.7840/kics.2021.46.11.1950

Li, J. (2020). Design and Development of Marine Temperature Data Recorder System Based on Single-Chip Microcomputer. *Journal of Coastal Research*, *106*, 571–575. https://doi.org/10.2112/SI106-129.1

Li, Y., Zhan, J., Xu, W., Qi, C., & Zhu, C. (2020). Design and analysis of high-power thermostatic control system based on TEC. In *Proceedings of SPIE - The International Society for Optical Engineering* (Vol. 11455). https://doi.org/10.1117/12.2565215

Litaay, C., Wisudo, S. H., Haluan, J. H., & Harianto, B. (2018). the Effects of Different Chilling Method and Storage Time on the Organoleptic Quality of Fresh Skipjack Tuna. *Jurnal Ilmu Dan Teknologi Kelautan Tropis*, *9*(2), 717–726. https://doi.org/10.29244/jitkt.v9i2.19304

Liu, D., Shi, P., Ren, W., Liu, Y., Liu, M., Zhang, Y., Lin, Q., Tian, B., Jiang, Z., & Ye, Z. G. (2018). Investigation on thermoelectric properties of screen-printed La1-xSrxCrO3-In2O3 thermocouples for high temperature sensing. *Journal of the European Ceramic Society*, *38*(15), 5030–5035. https://doi.org/10.1016/j.jeurceramsoc.2018.07.025

Liu, Z., Tian, B., Fan, X., Liu, J., Zhang, Z., Luo, Y., Zhao, L., Lin, Q., Han, F., & Jiang, Z. (2020). A temperature sensor based on flexible substrate with ultra-high sensitivity for low temperature measurement. *Sensors and Actuators, A: Physical*, *315*, 112341. https://doi.org/10.1016/j.sna.2020.112341

Lokollo, E., & Mailoa, M. N. (2020). Handling techniques and Microbial Contamination on Fresh Scads Fish (Decapterus sp) in Traditional Markets, Ambon City. *Jurnal Pengolahan Hasil Perikanan Indonesia*, *23*(1), 103–111. https://doi.org/10.17844/jphpi.v23i1.30923

Metusalach, Kasmiati, Fahrul, & Jaya, I. (2014). Effect of fishing techniques, handling facilities and methods On quality of the fish. *Jurnal IPTEKS PSP*, *1*(1), 40–52.

Mondragon, A. E. C., Mondragon, C. E., & Coronado, E. S. (2020). Feasibility of Internet of Things and Agnostic Blockchain Technology Solutions: A Case in the Fisheries Supply Chain. In *2020 IEEE 7th International Conference on Industrial Engineering and Applications, ICIEA 2020* (pp. 504–508). https://doi.org/10.1109/ICIEA49774.2020.9102080

Mubarak, R., Budiyanto, S., & Wulandari, P. (2020). Techno-economic analysis of satellite implementation as a broadband internet provider in Indonesia. *Journal of Physics: Conference Series*, *1517*(1). https://doi.org/10.1088/1742-6596/1517/1/012082

Ningtyas, R., Jayarachman, M. N., Imam, S., & Muryeti. (2023). The Use of Colour Indicator as a Smart Packaging for Monitoring Spoilage Fillet Catin Fish (Pangasius Sp.) In Room Temperature. *IOP Conference Series: Earth and Environmental Science*, *1177*(1). https://doi.org/10.1088/1755-1315/1177/1/012048

Nizam, M. N., Haris Yuana, & Zunita Wulansari. (2022). Mikrokontroler Esp 32 Sebagai Alat Monitoring Pintu Berbasis Web. *JATI (Jurnal Mahasiswa Teknik Informatika)*, *6*(2), 767–772. https://doi.org/10.36040/jati.v6i2.5713

Nurzaman, A. F. (2023). Development of Internet of Things System for Smart Fishery in Ornamental Fish Farming. In *Proceedings of 2023 International Conference on Information Management and Technology, ICIMTech 2023* (pp. 667–672). https://doi.org/10.1109/ICIMTech59029.2023.10277831

Pauly, D. (2017). A vision for marine fi sheries in a global blue economy. *Marine Policy*, *October*, 0–1. https://doi.org/10.1016/j.marpol.2017.11.010

Prabowo, I. P. H., Nugroho, S., & Utomo, D. (2014). Penggunaan Raspberry Pi Sebagai Web Server Pada Rumah Untuk Sistem Pengendali Lampu Jarak Jauh Dan Pemantauan Suhu.

Techne : Jurnal Ilmiah Elektroteknika, *01*, 111–124.

Prafanto, A., Budiman, E., Widagdo, P. P., Putra, G. M., & Wardhana, R. (2021). Pendeteksi Kehadiran menggunakan ESP32 untuk Sistem Pengunci Pintu Otomatis. *JTT (Jurnal Teknologi Terapan)*, *7*(1), 37. https://doi.org/10.31884/jtt.v7i1.318

Prihatmoko, D. (2017). Pemanfaatan Raspberry Pi Sebagai Server Web Untuk Penjadwalan Kontrol Lampu Jarak Jauh. *Jurnal Infotel*, *9*(1), 84. https://doi.org/10.20895/infotel.v9i1.159

Purwanto, H., Alauddin, M. H. R., & Ramli, M. S. (2024). Analisis Penanganan Ikan Yang Baik Di Pps Nizam Zachman Jakarta Dengan Metode Design Thinking. *Jurnal Teknologi Perikanan Dan Kelautan*, *15*(1), 33–46. https://doi.org/10.24319/jtpk.15.33-46

Rai, P., & Rehman, M. (2019). ESP32 based smart surveillance system. In *2019 2nd International Conference on Computing, Mathematics and Engineering Technologies, iCoMET 2019*. https://doi.org/10.1109/ICOMET.2019.8673463

Rizal, I. F., Arimbawa, I. W. A., & Afwani, R. (2018). Rancang Bangun Digital Home Assistant dengan Perintah Suara Menggunakan Raspberry Pi dan Smartphone (Design and Built Digital Home Assistant with Voice Commands Using Raspberry Pi and Smartphone). *J-Cosine*, *2*(2), 127–134. http://jcosine.if.unram.ac.id/

Rosman N., A. (2018). Perancangan Termokopel Berbahan Besi (Fe) dan Tembaga (Cu) Untuk Sensor Temperatur. *Indonesian Journal of Fundamental Sciences*, *4*(2), 120. https://doi.org/10.26858/ijfs.v4i2.7640

Sani, M. I., Ibnugraha, P. D., Sari, M. I., Rizal, M. F., Hanifa, F. H., Salasa, S. A., Reksa, A. A., Hartono, A. F., & Utama, N. C. (2023). Non-Invasive Human Body Temperature Detection for Online Event Data Recorder. In *2023 3rd International Conference on Intelligent Cybernetics Technology and Applications, ICICyTA 2023* (pp. 448–453). https://doi.org/10.1109/ICICyTA60173.2023.10428855

Santoso, H., & Ruslim, R. (2019). Pembuatan Termokopel Berbahan Nikel (Ni) dan Tembaga (Cu) Sebagai Sensor Temperatur. *Indonesian Journal of Fundamental Sciences*, *5*(1), 59. https://doi.org/10.26858/ijfs.v5i1.9376

Sanzay, D., Yuliati, & Santosa, H. (2020). Sistem Otomasi Proses Likuifikasi Dalam Pembuatan Setengah Jadi Gula Cair Dari Ubi Singkong. *Scientific Journal Widya Teknik*, *19*(2), 2020.

Saptadi, A. H. (2014). Perbandingan Akurasi Pengukuran Suhu dan Kelembaban Antara Sensor DHT11 dan DHT22. *Jurnal Infotel*, *6*(2), 49–56.

Sarwono, J., & Herlina, B. (2012). *Statistik Terapan : Aplikasi Untuk Riset Skripsi, Tesis dan Disertasi Menggunakan Spss, Amos dan Excel*. Elex Media Komputindo.

Setiawan, N. (2007). Penentuan Ukuran Sampel Memakai Rumus Slovin Dan Tabel Krejcie-Morgan. *Universitas Padjajaran, November*.

Setiawan, R., Anom Besari, A. R., Wibowo, I. K., Rizqullah, M. R., & Agata, D. (2018). Mobile visual programming apps for internet of things applications based on raspberry Pi 3 platform. *International Electronics Symposium on Knowledge Creation and Intelligent Computing, IES-KCIC 2018 - Proceedings*, *October*, 199–204. https://doi.org/10.1109/KCIC.2018.8628483

Škraba, A., Koložvari, A., Kofjač, D., Stojanović, R., Semenkin, E., & Stanovov, V. (2019). Prototype of Group Heart Rate Monitoring with ESP32. In *2019 8th Mediterranean Conference on Embedded Computing, MECO 2019 - Proceedings*. https://doi.org/10.1109/MECO.2019.8760150

Song, Y., & Zhu, K. (2019). Fishery internet of things and big data industry in China. In *Proceedings - 2019 International Conference on Machine Learning, Big Data and Business Intelligence, MLBDBI 2019* (pp. 181–185). https://doi.org/10.1109/MLBDBI48998.2019.00041

Triwibowo, R., & Rachmawati, N. (2021). *Refusal to Export Fishery Products: Biological Contamination, Challenges and Strategies*.

Wahab, M. N. A., Nazir, A., Ren, A. T. Z., Noor, M. H. M., Akbar, M. F., & Mohamed, A. A. S. A. (2021). Efficientnet-Lite and Hybrid CNN-KNN Implementation for Facial Expression Recognition on Raspberry Pi. *IEEE Access*, *9*, 134065–134080.

https://doi.org/10.1109/ACCESS.2021.3113337

Wendri, N., Wayan Supardi, I., Suarbawa, K. N., & Made Yuliantini, N. (2012). Alat Pencatat Temperatur Otomatis Menggunakan Termokopel Berbasis Mikrokontroler At89S51. *Buletin Fisika, Jurusan Fisika, Fakultas Matematika Dan Ilmu Pengetahuan Alam, Universitas Udayana*, *13*(1), 29–33. www.wfunda.com/desingstandards/sensors/

Whittington, R. H., Muessig, D., Reddy, R., Mohammad, A., Mitchell, K., Brumbaugh, J., Mehta, D., & Hayes, D. (2020). Temperature monitoring with an implantable loop recorder in a patient with presumed COVID-19. *HeartRhythm Case Reports*, *6*(8), 477–481. https://doi.org/10.1016/j.hrcr.2020.05.024

Widyatmika, P. A. W., Indrawati, N. P. A. W., Prastya, W. A. A., Darminta, K., Sangka, G. N., & Sapteka, A. A. N. G. (2021). Perbandingan Kinerja Arduino Uno dan ESP32 Terhadap Pengukuran Arus dan Tegangan. *Jurnal Otomasi Kontrol Dan Instrumentasi*, *13*(1), 35–47. https://doi.org/10.5614/joki.2021.13.1.4

Wijaya, I. D., Nurhasan, U., & Barata, M. A. (2017). Implementasi Raspberry pi Untuk Rancang Bangun Sistem Keamanan Pintu Ruang Server dengan Penegenalan Wajah Menggunakan Metode Triangle Face. *Jurnal Informatika Polinema*, *4*(1), 9–16.

Witria. (2021). The Effectiviness of Neem Leaves (Azadirachta indica) to Longtail Tuna Meat Histamine. *Jurnal Pengolahan Hasil Perikanan Indonesia*, *24*(2), 209–217. https://doi.org/10.17844/jphpi.v24i2.33514

Yusni, E. (2019). Analysis of histamin content in tuna fish Thunnus sp. with Elisa method at fishing port of Belawan, North Sumatra, Indonesia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 348, Issue 1). https://doi.org/10.1088/1755-1315/348/1/012034

Zare, A., & Iqbal, M. T. (2020). Low-Cost ESP32, Raspberry Pi, Node-Red, and MQTT protocol based SCADA system. In *IEMTRONICS 2020 - International IOT, Electronics and Mechatronics Conference, Proceedings*. https://doi.org/10.1109/IEMTRONICS51293.2020.9216412

Zhang, H., Srinivasan, R., & Ganesan, V. (2021). Low cost, multi-pollutant sensing system using raspberry pi for indoor air quality monitoring. *Sustainability (Switzerland)*, *13*(1), 1–15. https://doi.org/10.3390/su13010370

Zhou, X., Li, S., Li, X., Yan, X., ZhangXuenan, Wang, F., & Tonglei Cheng. (2020). High-Sensitivity SPR Temperature Sensor Based on Hollow-Core Fiber. *IEEE Transactions on Instrumentation and Measurement*, *69*(10), 8494–8499. https://doi.org/10.1109/TIM.2020.2992828