Brilliance
Research of Artificial Intelligence

E-ISSN : 2807-9035
Volume 3, **Number** 2, November 2023
https://doi.org/10.47709/brilliance.v3i2.2966

Fiber Optical Network Damage Detection Passive Splitter 1:8 in ODC uses IOT Technology as a means of Real Time Reporting

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Article History:
Submitted: 17-10-2023
Accepted: 20-10-2023
Published: 03-11-2023

Keywords:
AUC; Confusion Matrix; Decision Tree; KNN; zakat

ABSTRACT

Fiber optic networks currently have a lot of interest, so a network monitoring system is needed that guarantees quality and speed of repair if mass disruption occurs. in research [1] regarding fiber network damage detection using IoT with the use of a 1:4 splitter and the use of a detector that can work at a wavelength of 650nm so that it can detect damaged cables with output in the software. So in connection with this, the author wants to develop the results of this research by using a 1:8 splitter and carrying out detection using the LDR sensor and NodeMCU ESP32 using IoT (Internet of Things) technology. The ESP32 NodeMCU will receive data in the form of light intensity values at each ODC from the LDR sensor. And then sent to a database that is connected directly to the Android application. The cable identification process occurs in three states: normal, warning, and error. The test and analysis results show that the hardware device can work well, with attenuation in the passive splitter cable of 10.28 dB and a light source with a wavelength of 650 nm. Cable detected as damaged is indicated by an output in the software with a delay of 4.56 s.

INTRODUCTION

Optical fiber is a type of cable made of glass fiber or fine plastic that can transmit light signals from one place to another [1]. As the name suggests, the transmission medium is optical fiber which uses optical waves as a carrier medium which operates at optical or light frequencies. The fiber optic structure consists of three parts, namely the core, which is a part made of thin glass fiber and is used as a path for light to transmit information. The second is the wrap (cladding) which is a coating for the core and reflects light back into the core, and the third is the jacket (coating) which protects the core and cladding from physical pressure [2].

Fiber optic networks currently have a lot of interest, which has made many telecommunications service provider companies increasingly aggressive in developing their services. To produce quality fiber optic network services, good planning is needed, good materials in accordance with standards, correct installation procedures, as well as good SOPs (System Operation Procedures) and SMPs (System Maintenance Procedures). Based on this, a network monitoring system is needed that guarantees the quality and speed of repairs if mass disruption occurs. This interference can be caused by damage to the active device or a break in a physical network with a large capacity, for example a feeder cable. This damage can be caused by various factors such as natural factors, humans and technical damage. A fault detection system in fiber optics is the most effective method, because it can analyze various faults in fiber optic cables and messages will be sent automatically to the person monitoring.

Therefore, based on research [1] regarding fiber network damage detection using IoT with the use of a 1:4 splitter and the use of a detector that can work at a wavelength of 650 nm so that it can detect damaged cables with output in the software. So in connection with this, the author wants to develop the results of this research by using a 1:8 splitter using an LDR sensor and also using an ESP32 NodeMCU using IoT (Internet of Things) technology. IoT (Internet of Things) is a sensor and accuator embedded in physical objects connected via wired and wireless networks. Internet of Things can also be interpreted as a concept that combines computers and networks to control devices. So by implementing IoT technology you can increase convenience, security and efficiency in various other aspects. Therefore, the author raised the title: Passive Spitter 1:8 Fiber Optic Network Damage Detector in ODC Using IoT Technology as a Means of Real Time Reporting.

LITERATURE REVIEW

Optical Fiber

Optical fiber is a transmission medium or cylindrical light wave guide, which was developed in the late 1960s as a response to the development of communication systems which increasingly required large bandwidth with high transmission rates [3]. The light source used is usually a laser or LED because it has a very narrow spectrum, so the light in the optical fiber does not come out because the refractive index of glass is greater than the refractive index of

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Research of Artificial Intelligence
E-ISSN : 2807-9035
Volume 3, **Number** 2, November 2023
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air. It is in this fiber that the light energy generated by the light source is channeled so that it can be received by the receiver. Optical fiber consists of two types, namely cable optical fiber and plastic optical fiber (Fiber Optic Plastic/FOP). Fiber optic cables are widely used for long distance transmission while FOP is only used for short distance communication.

Fiber optic structure

In general, the structure of a fiber optic cable is divided into several parts, namely:

1. Core (core)
   The core is the main part of a fiber optic cable which is located right in the middle of the cable, is shaped like a cylindrical rod and is made of high quality fine glass fiber and is used as a path for light to transmit information.
2. Sheathing (cladding)
   Cladding is a layer that covers the core of a fiber optic cable and is made of glass fiber. The cladding functions as a protector for the core and as a mirror that reflects light so that it can propagate into the core.
3. Protective (Coating)
   Coating is the outer part after cladding which is made of elastic plastic material (PVC) to protect optical fibers from external pressure. Coating functions as a mechanical protector that protects optical fibers from damage that can occur due to cable bending or other disturbances such as air humidity.
4. Strengthening fiber (Strength member)
   Strength members are made from a type of fabric fiber which is a type of thread which is very abundant and has very good resistance which strengthens the core of the cable so that it does not break easily.
5. Outer jacket
   The outer jacket is the outermost part of the fiber optic cable which is made of PVC. Functions as a protector for the entire inside of the fiber optic cable from external interference

Types of Optical Fiber

Optical fiber can be divided into two types, namely singlemode and multimode.

1. Single mode
   Singlemode fiber cable is a type of fiber that has a core with a very small diameter of around 4-10 µm and a cladding diameter of 125 µm [4]. Singlemode fiber can only transmit signals in one mode with a wavelength of 1310 nm or 1550 nm. so as to prevent chromatic dispersion. Chromatic dispersion is one of the factors that reduces the performance of optical fiber communications caused by changes in the propagation of certain frequency components contained in an optical pulse which causes widening of the optical pulse. Therefore singlemode fiber cables are suitable for large capacities and are usually used for long distance transmission with laser diode based fiber optic transmission equipment.
2. Multimode
   Multimode fiber is the opposite of singlemode fiber, namely it has a large core with a diameter of around 50-70 µm and a cladding diameter of around 100-200 µm [4]. These multimode fibers transmit signals in multiple modes, at specific operating wavelengths. This type of multimode fiber usually has poor transmission, limited capacity, and small transmission capacity.

Internet of Things (IoT)

Internet of Things (IoT) is a concept that aims to expand the benefits of continuously connected internet connectivity. IoT allows users to manage and optimize electronics and electrical equipment using the internet [8]. Internet of Thing (IoT) is a technology that uses the internet to control everything, anywhere and at any time. In its application, the Internet of Thing can identify, track and monitor objects automatically and in real time.
The way IoT works is by utilizing a programming argument where each argument command produces interaction between machines that are connected automatically without human intervention and at any distance. The internet serves as a connector and humans as regulators and supervisors.

NodeMCU ESP32

ESP32 is a microcontroller introduced by Espressif systems which is the successor to the ESP8266 microcontroller. The advantage of the ESP32 is that it has a built-in WiFi module with a microcontroller chip and dual mode Bluetooth and is energy efficient, making it easier to create IoT systems that require a wireless connection [8]. This microcontroller can be used as a complete standalone system or as a supporting device for a host microcontroller. Some of the software used to program the ESP32 is Arduino Pro Mini, Arduino IDE, ESP-IDF Visual Studio Code Extension, and Espressif IoT Development Framework. Figure 1 is an image of the ESP32 with specifications as can be seen in table 1.

Brilliance
Research of Artificial Intelligence

E-ISSN : 2807-9035
Volume 3, **Number** 2, November 2023
https://doi.org/10.47709/brilliance.v3i2.2966

Table 1. ESP32 Specifications

No	A	D
1	Voltage	3.3 Volt
2	Processor	Tensilica L108 32 bit
3	Processor speed	Dual 160 MHz
4	RAM	520K
5	GPIO	34
6	ADC	7
7	802.11 support	11b/g/n/e/i
8	Bluetooth	BLE (Bluetooth Low
9	SPI	3
10	12C	2
11	UART	3

Source : electronicshub.org

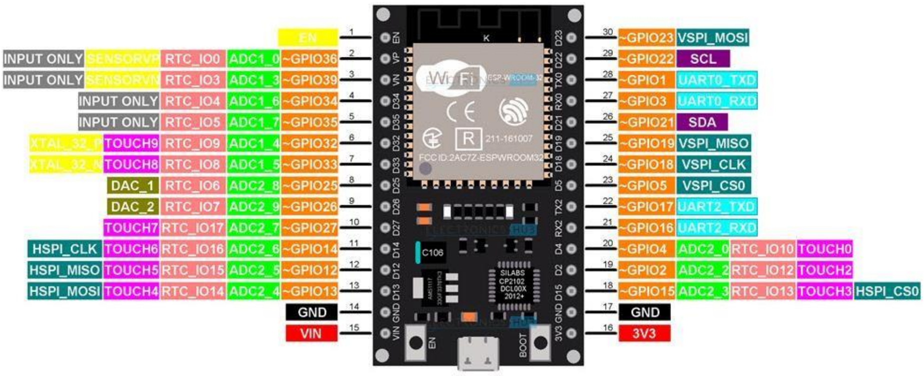
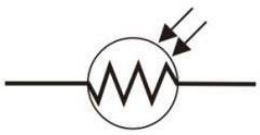


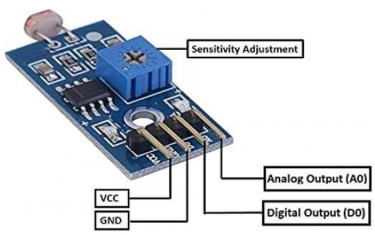
Figure 1. NodeMCU ESP32

LDR sensor

Light Dependent Resistor (LDR) is a type of resistor that is sensitive to light. LDR is a type of resistor that is usually used as a light detector or light conversion meter. The resistance of the LDR changes with changes in the intensity of light hitting it [9]. The LDR resistance value will change according to the intensity of the light it receives. Fig 2 shows the LDR symbol.



Source : samrasyid.com
Figure 2. LDR symbol



Source : techdelivers.com
Figure 3. LDR module

Figure 3. shows the LDR sensor module which is a digital and analog sensor module that is capable of measuring and detecting light intensity. Equipped with 4 terminals, the LDR sensor module has a voltage that operates

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E-ISSN : 2807-9035
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at 3.3V-5V and produces analog and digital signals with an analog output type -A0, as well as a digital switching output (0 and 1)-D0 [10]. This LDR sensor module consists of an LDR, LM393 Comparator, Variable Resistor (Trim pot) which is used to adjust the sensitivity of the LDR sensor, as well as a Power LED and output LED.

MIT App Inventor

MIT App Inventor is an open source web application provided by Google, which is managed by the Massachusetts Institute of Technology (MIT) to create Android applications in the form of visual programming that allows everyone to build applications on smartphones. MIT App Inventor has 2 important parts, namely the design used to create the interface display and block code to create or pour logic into the interface display. MIT Inventor is also supported by an emulator that can run applications created in real time and export project data in SAIA file format [11].

Firebase

Firebase is a database tool from Google that makes it easier for developers to develop applications. Firebase is a platform for real-time applications and has complete libraries for most web and mobile platforms and can be combined with several other frameworks such as node, java, javascript, and so on. Firebase is a non-relational or noSQL database because it does not use tables in its implementation and does not store data locally on the device but in the cloud. Firebase Realtime Database is an online database for storing data from applications. Data is stored in JSON format and can be synchronized in real time for each connected client. Firebase Realtime Database can be accessed directly from a mobile device or web browser, and does not require an application server. Data security and validation can be accessed through Firebase realtime database security rules which are a collection of expression-based rules and are executed when data is read or written [12].

METHOD

System Block Diagram

Block diagram of the Passive Spitter 1:8 Fiber Optic Network Damage Detection system at ODC Using IoT Technology as a Means of Real Time Reporting as can be seen in figure 4.

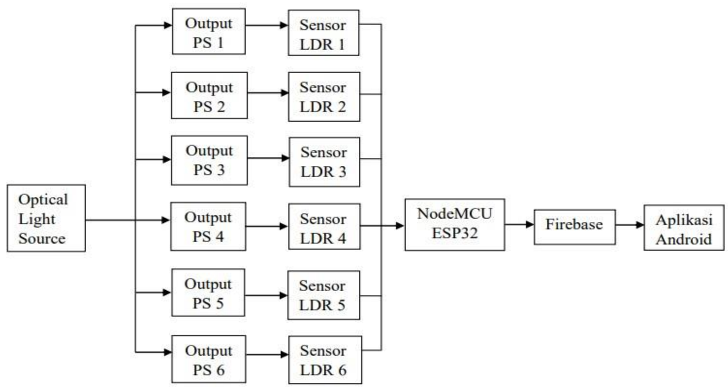


Figure 4. System Design Block Diagram

Based on the system design block diagram, there are several components, each of which has a function and role, namely as follows:

1. Optical Light Source (OLS), functions as a tool used as an energy source in a fiber optic network that emits light into the optical fiber.
2. Fiber Optic Cable, used as a fiber optic network that functions as an ODC using pigtail type fiber optic cable and passive splitter.
3. LDR sensor, LDR sensor as a damage detector in fiber optic cables,which works by identifying the intensity value of the light flowing in the fiber optic network system.
4. NodeMCU ESP32, functions to receive information from the LDR sensor and then send it to the database, namely Firebase and also as a connector for using WiFi.
5. Firebase, which is a database that functions as a place to store information from sensors.
6. MIT App Inventor, which is a platform for creating detection applications, where this damage detection application will later receive information about the condition of the fiber optic cable.

Electronic Design

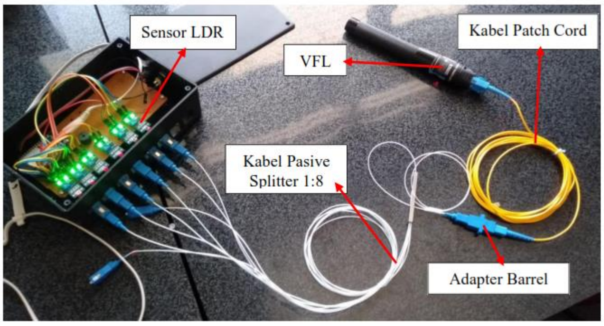
After completing the box design, the next step is to make the electronic device which will later be placed in the box that has been made. Inside the box contains components such as an LDR sensor which is connected to the NodeMCU ESP32 and also a buzzer. In making this tool, eight LDR sensors were used. VFL functions as a light source

E-ISSN : 2807-9035
Volume 3, Number 2, November 2023
https://doi.org/10.47709/brilliance.v3i2.2966

that is transmitted to the fiber optic network. In table 2 there are components of tools and materials needed for overall hardware design and manufacture. And figure 5 is the final view of the overall hardware design.

Table 2. Hardware Tools and Materials

Tools and materials	Amount
Passive Splitter 1:8	1
Patch Cord SC (3m)	1
Visual Fault Locator (VFL)	1
NodeMCU ESP32	1
LDR sensor	6
Adaptor Barrel	7
Buzzer	1
Box (18×11×6 cm)	1
Button	1



Fug. 5. Tampilan Keseluruhan Hardware

Software Design and Creation (Software)

Software has the function of controlling a hardware or hardware working system. The first thing that must be considered in making software is creating a program algorithm that can be expressed in the form of a flowchart. The flowchart of the system is divided into two, namely the flowchart on the NodeMCU ESP32 and the flowchart for displaying Android application data. Before displaying data on an Android application, you first need to create a program on the NodeMCU ESP32. Figure 6 is an image of the NodeMCU ESP32 flowchart, the program will start with the initialization process for each sensor. Then the ESP32 will connect to Wifi so that data can be sent to the database. If the ESP32 fails to connect to Wifi, it will try to connect again, but if the ESP32 successfully connects to Wifi, the ESP32 will continue reading data from the LDR sensor and then the results of reading the data will be sent to database server and data will appear and be stored in the database.

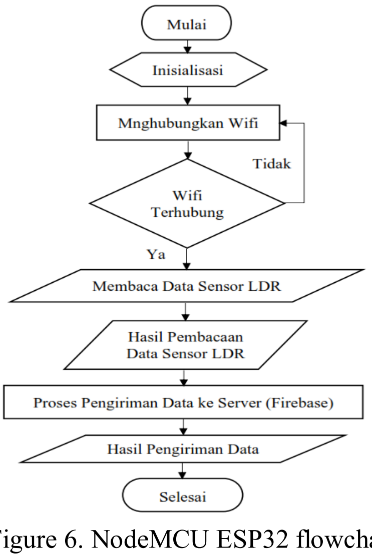


Figure 6. NodeMCU ESP32 flowchart

The second flowchart is a data display flowchart in the Android application. When the application is opened, the

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first step that must be carried out is to carry out the registration process first by entering the username and password. Then, after the username and password have been created, the next step is to log in by entering the username and password that have been created. After successfully logging in you will arrive at the main menu page where the process of receiving data from the database server takes place. When the LDR resistance value received by the database is less than 70 ohms, it is assumed that the cable is in good condition so that the Android application will display a normal display in blue. However, when the database receives an LDR resistance value ranging from 70 ohms to 150 ohms, it is assumed that the cable is not working properly with a yellow warning display. And if the LDR resistance value received by the database is greater than 150 ohms, it is assumed that the cable is broken with a red error display. Android application flowchart
shown in Figure 7.

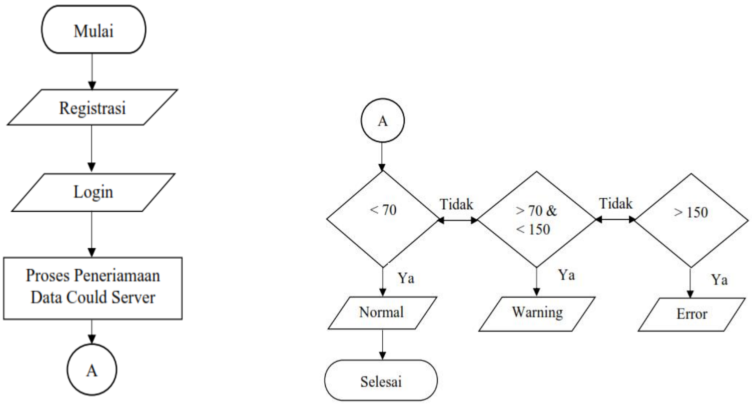
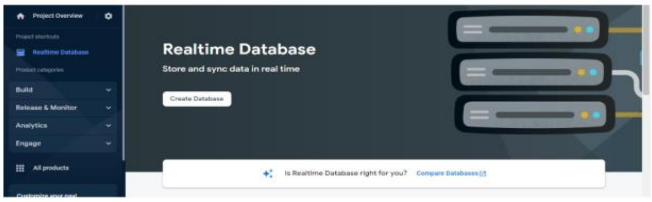


Figure 7. Android Application Flowchart

Realtime Database Creation Using Firebase

Creating a real-time database using Google Firebase is useful for storing LDR sensor reading data and sending it to the Android application. The process of creating a realtime database on Google Firebase is as follows:

1. Create a real-time database to accommodate data from sensors and send it to the application by clicking Create Database, as shown in Figure 8.



Fugure 8. Database Creation View in Firebase

2. The process of retrieving HOST and AUTH on Firebase as in Figure 9 and Figure 10 which functions to connect ESP32 with Firebase

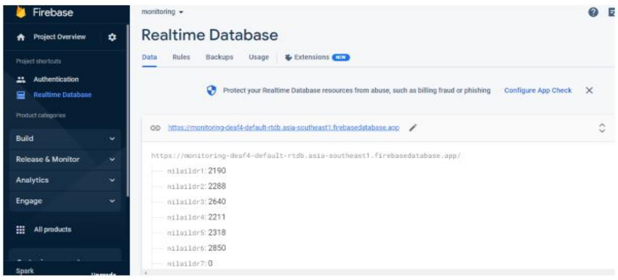


Figure 9. HOST Retrieval

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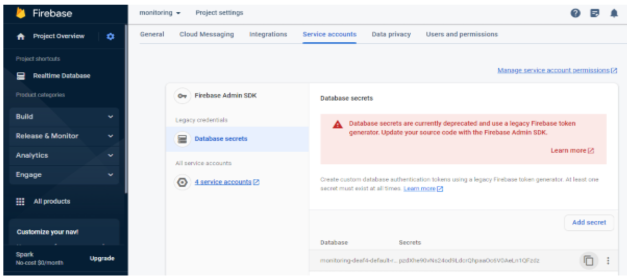

Figure 10. AUTH retrieval

3. Display of data entered into the realtime database after HOST and AUTH are entered into the NodeMCU ESP32 program, as seen in Figure 11.

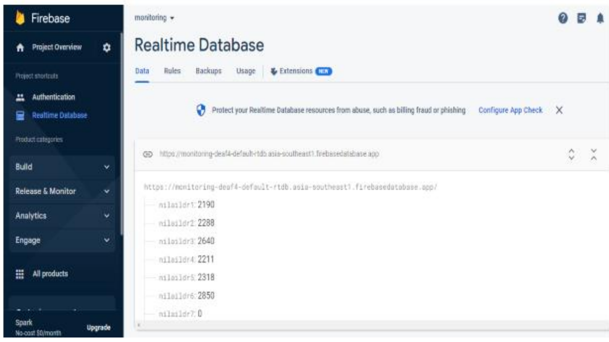

Figure 11. Realtime Database View

Android Application Creation

Android applications are created and designed using MIT App Inventor, which is an open source web application provided by Google. Figure 12 shows the login page for the application and Figure 13 shows the registration page for the application and Figure 14 shows the main page for the fiber optic network damage detection application.

Figure 12. Login Page Display

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Figure 13. Registration page display

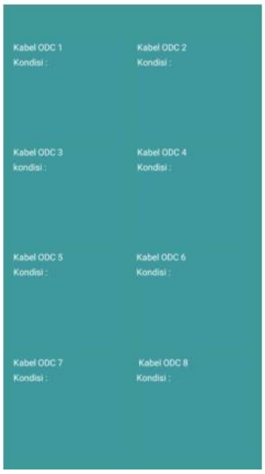

Figure 14. Main page display

RESULT AND DISCUSSION

Testing Connecting NodeMCU ESP32 Wifi

Connecting the NodeMCU ESP32 with Wifi must be done because this system uses the internet to connect the device to the database. The process of connecting the NodeMCU ESP32 is done by entering the SSID and password of the WiFi to be connected. The test results connecting the NodeMCU ESP32 with WiFi can be seen in Figure 15.

Figure 15. Successful Connection

When the ESP32 NodeMCU is successfully connected to WiFi, the serial port will display "Connected to Wifi". The buzzer connected to the NodeMCU will also sound as a sign that the NodeMCU has successfully connected to WiFi.

Device Connection Testing with Database (Firebase)

Software testing begins with the success of the NodeMCU ESP32 sending data to the database. When the LDR

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E-ISSN : 2807-9035
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sensor detects light that is transmitted to the fiber optic cable, the sensor will read the intensity value of the light that is transmitted, which will then be read by the NodeMCU and then sent to the database.

When carrying out the test, the results obtained are as shown in Figure 16. The values sent to the database are analog values with a range of values ranging from 0 to hundreds. This value is obtained when the fiber cable is unloaded or in good condition. As long as the NodeMCU is connected to WiFi, data will be sent repeatedly and continuously to the database.

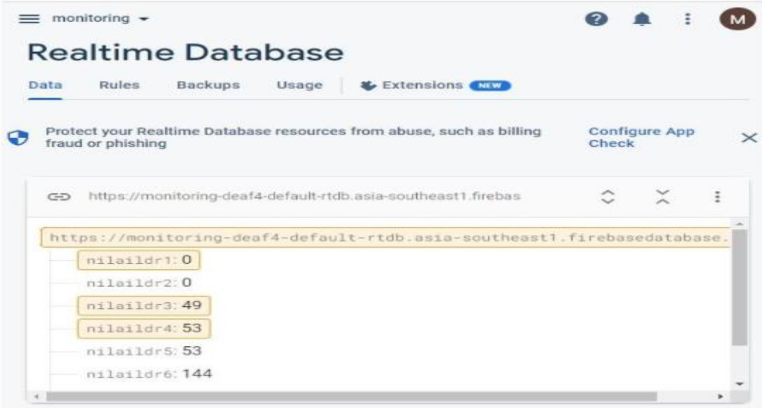

Figure 16. Results of Reading Values in Realtime Database

Application Performance Testing

Application performance testing to determine Android application performance when carrying out real-time reporting. After the LDR sensor successfully detects the light intensity value from the fiber optic cable network and is read by the NodeMCU ESP32 and successfully sent to the database, the data will be used by the Android application to display notifications regarding the condition of the cable. The data sent to the database will be displayed on the Android application in the form of normal notifications, warnings and errors. This situation will be assumed to be the analog value read by the LDR sensor, where the normal situation is when the NodeMCU ESP32 succeeds in reading a small LDR resistance value of 70 ohms, and a warning when the NodeMCU ESP32 reads an LDR resistance value ranging from 70 ohms to 150 ohms. Then the error is when the LDR resistance value read by the NodeMCU ESP32 is greater than 150 ohms.

When testing is carried out in several circumstances. The first situation is when all the ODC cables are installed without any bending or breaks as seen in Figure 17.

Figure 17. Condition of All ODC Cables Installed

In this first state, the NodeMCU ESP32 successfully reads a small LDR resistance value of 70 ohms and sends it directly to the database, as shown in figure 17. Data sent to the database will be connected directly to the Android application. The application will be updated automatically according to the data sent by NodeMCU to the database. Figure 18 is a picture of the application display for the first cable state.

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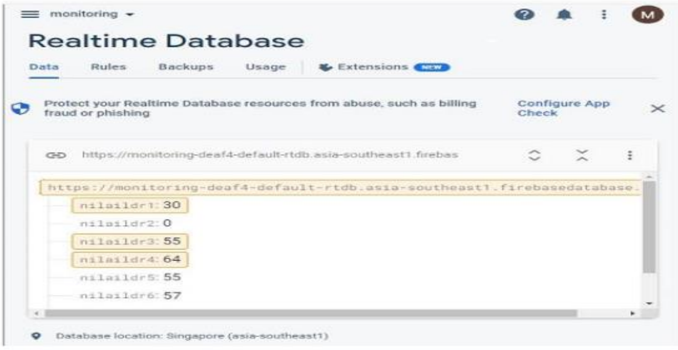

Figure 18. Realtime Display

Figure 19. . Application Display After Data Uploaded in Realtime

The second situation is a situation where one of the ODC cables is broken as shown in Figure 20. In this second situation, the NodeMCU ESP32 reads a large LDR resistance value of 150 ohms. This means the cable is not working properly.

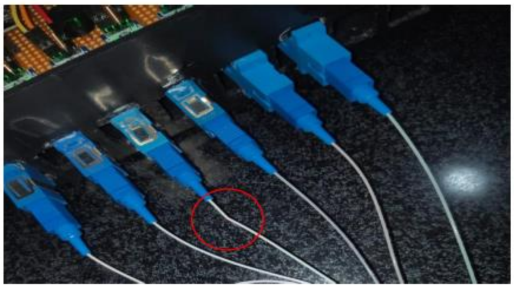

Figure 20. The situation where one of the cables is broken

The data sent to the database is shown in figure 21 and for display in the real-time monitoring application the condition of one of the cables experiencing a fault is shown in figure 22.

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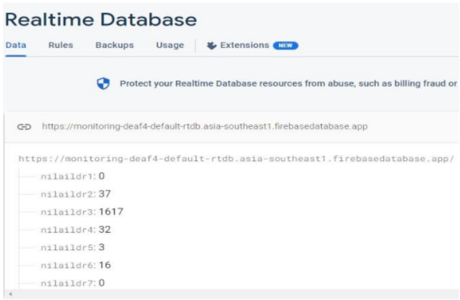

Figure 21. Realtime Database Display When One of the Cables is Broken

Figure 22. Android Application Display When One of the Cables is Broken

Analysis

Passive Splitter 1:8 Fiber Optic Network Damage Detector in ODC Using IoT Technology as a Means of Real Time Reporting requires several components to work as planned. A Wifi connection is also really needed to be able to connect to the internet for sending data from the NodeMCU ESP32 to the database and the database to the Android application.

Based on the test results, the NodeMCU ESP32 can only read LDR sensor values for a maximum of 6 sensors. This is because only the ADC1 pin can be used to read sensors, while the ADC2 pin cannot be used because using the ADC2 pin can cause interference with WiFi. The values read by the sensor and read by the NodeMCU are analog values ranging from 0-4095 so that the values sent to the database are not fixed. Therefore, it is assumed that if the NodeMCU reads an LDR resistance value greater than 70 ohms then the cable is in normal condition, and when the NodeMCU reads an LDR resistance value ranging from 70 ohms to 150 ohms then the cable is in a warning state. If the NodeMCU reads an LDR resistance value greater than 150 ohms then the cable is in error.

The test results show that when all the ODC cables are installed and without any bending, the monitoring application provides notification that all ODC cables are in normal condition with a blue display and the resistance value of each LDR sensor sent to the database is below 70 ohms, so it can be said that the cables are working. in good condition. Then, when one of the ODC cables breaks, the monitoring application displays that one of the cables is in error with a red display and the LDR sensor resistance value sent to the database is above 150 ohms and even reaches a value of 1617 ohms. When one of the ODC cables is not connected to the device, the result is that the cable is in an error state with the value in the database touching 2301 ohms. It can be said that the cable is not working properly**.**

Furthermore, when the cable is bent for 5 cm, the monitoring application displays that There are two ODC cables in a warning state with a yellow display. Then, when the cable is bent 10 cm long, the monitoring application displays that there are four cables in a warning state with a yellow display. The resistance value of the LDR sensor sent to Firebase for the ODC cable with this warning condition is between 70-150 ohms. This can mean that the cable experiences significant attenuation or experiences power losses so that the signal power emitted is reduced.

The application will monitor in real time the condition of the cable based on the values that have been set. The application will be updated automatically according to the LDR sensor resistance value sent from the NodeMCU to the database and the database to the application. The delay obtained when testing was 4.56 s, but this delay can change according to the quality of the internet network and data transmission speed.

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Research of Artificial Intelligence

E-ISSN : 2807-9035
Volume 3, **Number** 2, November 2023
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CONCLUSION

Based on the results of testing and analysis of 1:8 Passive Splitter Fiber Optic Network Damage Detection at ODC Using IoT Technology as a Real Time Reporting Means which has been carried out, it can be concluded that:

1. Sensors or IoT devices used to detect damage to the fiber optic network at ODC are the LDR sensor and NodeMCU ESP32 which are connected directly to Google Firebase and Mit App Inventor as an Android application.
2. The hardware device can work well, with attenuation on the passive splitter cable of 10.28 dB and a light source with a wavelength of 650 nm. The cable detected as damaged is indicated by an output in the software.
3. Data sent from NodeMCU ESP32 to the database can be displayed on the Android application in the form of notifications with three states, namely normal, warning and error with a delay of 4.56 s.

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