Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 6, No.3, July 2024, pp. 02403021-01 ~ 02403021-11
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v6i3.813

Design of IIOT Device Based on LoRa for Parsing Data Directly to SCADA System

Rini Puji Astutik*, Julmy Lesmana Putra, Rahmad Maulana

Faculty of Engineering, Universitas Muhammadiyah Gresik, Jl. Sumatera No 1 GKB, Gresik 61121, Central Java, Indonesia

*astutik_rpa@umg.ac.id

Abstract. As the revolution industry 4.0 was started as well as the productivity increases, the need for data analysis increases. Some industries have wide production area and they need long wire to connected between office for transferring data. A wireless system is one of solution to overcome this issue so that the technique of parsing data to expand coverage area for both local and remote systems. In this research, a device that supports IIOT (Industry on Internet of Things) will be designed by utilizing LoRa technology connected to a SCADA (Supervisory Control and Data Acquisition) system for direct parsing data. By using a SCADA system concept and incorporating wireless system as well as connecting to internet so the industrial system can be monitoring from anywhere so productivity can be increased. To test the proposed design, the two scenarios of performance test have been done, they are communicating distance test and the parsing data between two nodes LoRa as well as connecting to SCADA system. The first scenario results in the maximum communication distance that can still carried out reaching 400m. Meanwhile, the experience of second scenario on the IIOT device prototype produces accurate data so that it can be implemented in the wider industry.

Keywords: IIOT, wireless, LoRa, Node, SCADA

(Received XXX, Accepted XXX, Available Online by XXX)

1. Introduction

The industrial world is developing very rapidly with the industrial revolution 4.0 which is supported by the development of Internet of Things technology. Many industrial devices are starting to change from manual control by humans to machines that can even be controlled automatically. With so many machines that have to be controlled and control points being spread out, it is necessary to have a system that is connected to both long and short distance control. The combination of sensors and actuators in the SCADA system is carried out to advance flexible manufacturing migration towards the concept of industry 4.0[1]. The Industry 4.0 concept approach is also carried out by developing automatic configuration of the bottling process in small to medium scale industries using PLC and SCADA [2]. With the increasingly complex machines to be controlled and the placement of sensors or devices, a system is needed that can accommodate these problems. In this research, a LoRa-based IIOT device system is designed to be able to analyze data directly by connecting to a SCADA system consisting of

a PLC and HMI which is expected to be able to answer future challenges in industry 4.0.

Several studies have been carried out previously, such as:[3] where a wireless sensor network communication system was studied by combining Raspberry Pi and Arduino for monitoring air pollution. In this research, a Raspberry Pi was used as communication between the node and the data collector and here the distance and delivery time delay between the two devices were obtained. Next research began to examine LoRa communication devices in [4] regarding feasibility and performance testing of LoRa devices in wireless sensor networks. From this research it is known that the LoRa device used can communicate a distance of approximately 1 km with a strength level of up to -98dB. From this LoRa capability, the research continues, namely the implementation of LoRa communication to monitor patient heartbeats [5]. Discussions about SCADA are carried out by carrying out services as in [6]–[10] namely SCADA module training for vocational school students where a learning module about SCADA is designed which can simulate machine control activities such as in manufacturing processes. The implementation of SCADA and HMI has also been researched in [11] and [12] namely a parking slot availability system using Arduino nano based on Outseal Studio and Haiwell Cloud SCADA. This SCADA system is used for communication between Microgrids and control room as remotely [13] and [14].

This research proposes the design of device which supporting Industry on Internet of Things by using LoRa for parsing data directly to SCADA system. The design of IIOT device uses simple input output and LoRa module as controlling data incorporated transceiver and laptop for displaying SCADA system. To know the performance of device, the testing of each of device will be done including LoRa module as well as some scenario performance test. The test result shows that the IIOT device can operate as the target of its design and also communication between LoRa module.

The next following part of this article will discuss the methodology of this research and it will be continued to the result and discussing of the proposed design. In this discussion, it will focus on each device and how it can be operated especially the communication between the LoRa node. The end part of this article will be closed by the conclusion of the work that has been done on this research.

2. Methods

The methodology of this research is started by making design plan of hardware and software as IIOT devices for supporting industry revolution 4.0. The design plan of hardware focus on the communication system designed to connect a LoRa node as a slave to others LoRa node as master or sink node. This sink node acts as data collector and directly parsing into SCADA system. The diagram block of this design can be seen on Figure 1.

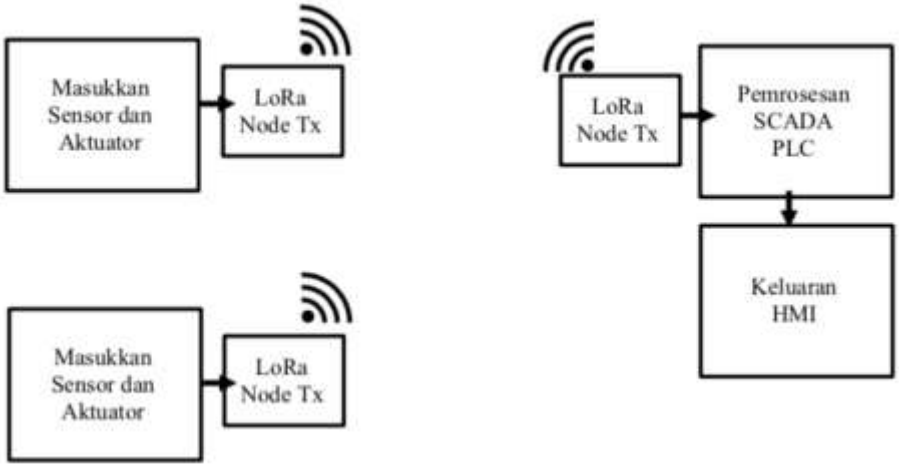

Figure 1. Diagram block IIOT system design based on LoRa

The design of IIOT device uses a temperature sensor as an input device and the fan as an output device. To communicate as well as control between input and output, it uses LoRa device with type SXX1278 LORA UART MODULE. This type of LoRa has maximum distance for communication as 15 KM with 127 dB for RSSI dynamic range [15]. Using its distance, hopefully it can be implemented on the wider area factory. The implementation of LoRa also was used in [16] for communication terrestrial using multi nodes. The SCADA system on this prototype used laptop with Haiwell software for displaying and controlling the system as HMI on this system. The protocol used between LoRa and the other device is Modbus as for communicating between data processing and the output. To test the performance of this design system, it is needed to test each device and combined all of them for identifying the overall work of all devices. The parsing data that relating to SCADA system is explained in [17] using physical layer of LoRa. The LoRa technology often used to for metering device [18]. The reason on why the LoRa technology used in many implementation is due low cost and open source [19]. One of design of IIOT device for Lorawan has been discussed [20] and focused on protocol. Some factory have been implementation smart device for multiband Industrial IoT Communication for efficiency [21].

2.1. IIOT Device design using LoRa node

The design of two LoRa nodes combined with SCADA can be seen in Figure 2. Each LoRa node uses an Arduino for the controller and temperature sensor as well as a LoRa UART module to communicate between the LoRa nodes. The LoRa node which is the sink node uses ESP32 as a PLC in the SCADA system to control and parse data. For output from the sink node, HMI is used by connecting it to a laptop as a data display using Haiwell.

Figure 2. IIOT Design with Two LoRa Nodes and One Sink Node Connected to HMI

Each LoRa node contains an Arduino uno, DHT11 sensor, LoRa module equipped with an antenna and a power bank as an energy source. Meanwhile, the Sink node contains an ESP32, a LoRa module equipped with an antenna and a laptop installed with the Haiwell program which functions as an HMI and RS485 as a modbus connector between the module and the HMI.

2.2. Report Display Design

To be able to display the results of sensing from each LoRa node, a fairly attractive Haiwell HMI display design is needed. The overall design of the Haiwell HMI display can be seen as in Figure 3. Some features of HMI Haiwell display which is used such as real time graph and report data. Both display design can be seen in Figure 4 and Figure 5.

Figure 3. Design of HMI Display of Two LoRa Nodes and One Sink

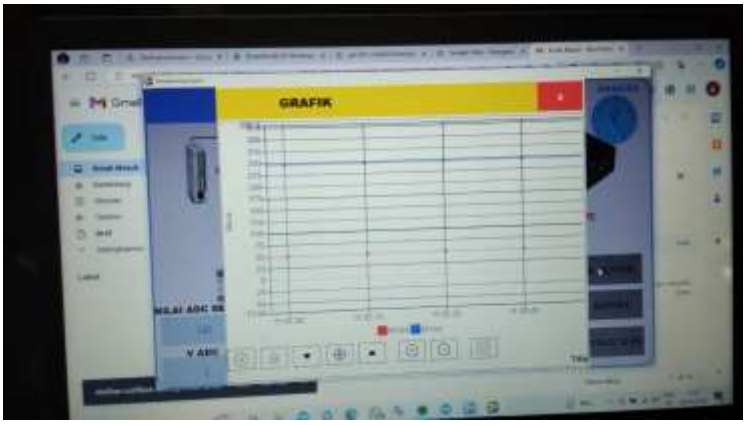

Figure 4. Design of Temperature Display Graph as Real Time

Figure 5. Temperature Tabel Display as Real Time

2.3. Design Software

Beside designing hardware, the designing software also be done for on how the program can be run as the determined hardware. The designing software on this system can be shown in Figure 6.

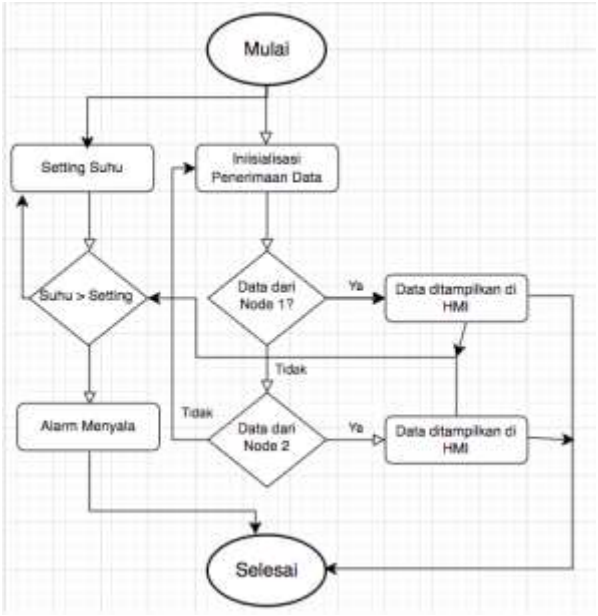

Figure 6. Flowchart of IIOT SCADA System Integrated with LoRa Node

There are two flows such as data reception and setting temperature. The first flow is when the LoRa sink received from LoRa node 1 dan 2 thus they will be displayed on HMI. The second flow is started by setting temperature and when the temperature is upper than the setting data then the alarm displayed on HMI will be colored by red. This indicator is needed so that if something happened then HMI will display the alarm.

The design will be carried out after adding several scripts, the function of each script will be explained including the libraries used.

Figure 7. Script of Module LoRa Sink

In figure 7, it contained the script of Modul LoRa Sink, this module works as data collector from both module LoRa nodes. Using Modbus protocol, the sensing data from both module LoRa node 1 and node 2 received by the module LoRa sink will be displayed on the HMI Haiwell via modbus protocol.

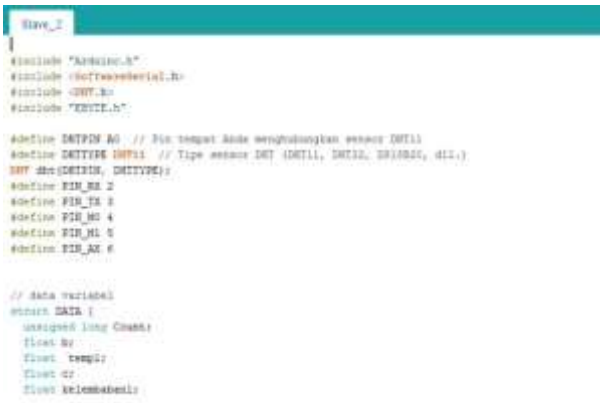

Figure 8. Script of Module LoRa Node 1

Figure 9. Script of Module LoRa Node 2

The script for module LoRa node, either node 1 or node 2 can be seen on Figure 8 and Figure 9. This script has two different name of input analog data at each device so that the LoRa sink can define the both nodes.

2.4. Performance Test Scenario

To know the performance of IIOT device is needed the performance test scenario in this case it was done on two testing, they are communication distance testing between LoRa nodes and Integration SCADA system testing upon connected to LoRa node.

The first test, communication distance testing between LoRa nodes, is by taking the LoRa node with certain distance and used power bank as a sourced energy. This testing is done by adding the distance until no data can be sent between both node and it shows no data on sensing result data.

The second test is the testing of SCADA which connected to two LoRa nodes that were placed in two difference places. Sink node as data collector is used ESP32 and connected to LoRa for communication with both LoRa node as well as modbus. This data collector has two communication protocols, they are LoRa for communicating with LoRa node and modbus for communicating with HMI.

The position of each device is Sink node will be placed at electric circuit laboratory in the 3rd floor, one LoRa node will be placed at energy conversion laboratory in the first floor and the other LoRa node will be placed at lecture room, the same floor as the first LoRa node. After all of nodes placed at their place thus the data collector takes the sensing data via LoRa communication alternately between both LoRa node and displays them on HMI via modbus protocol. The sensing result is shown on HMI as real time both in graph and table form.

3. Results and Discussion

From the previous part, the design has been explained and done some experiences which yield the result as follow. The first test is communicating distance test, in this case, it used two LoRa nodes, one is as receiver which received the sensing data and the other is sensing data and transmitting it. By taking the sensing node in certain distance and recorded the sending data as well as its distance. After that it continues to record both the sensing data and distance after adding some distances until there is no the sensing data could be recorded. From this experiment, it obtained the furthest distance between both nodes as 400 m. The map of the distance data can be seen in Figure 10.

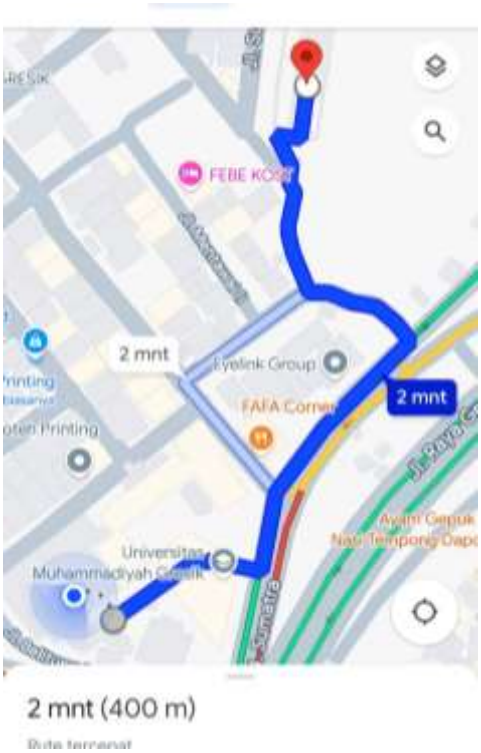

Figure 10. The Furthest Distance of Communication LoRa Node

The result of this test is further than the previous experiment using Dragiano LoRa [4] which could communicate up to 200 m, meanwhile this Ebyte SX1278 E32 LoRa can communicate up to 400 m. Beside do the real time measurement, it is also simulated signal strength versus distance based on data in [15] and the result of simulation and measurement can be seen on the graph in Figure 11.

The second test is SCADA system which connected to LoRa node that placed in different room. It yields some measurement data and the Sink LoRa will display data as seen on Figure 12. Beside HMI shows the real time data, it also displays this data in graph and table form. They can be seen on Figure 13 and 14. Some data from previous measurement are also displayed.

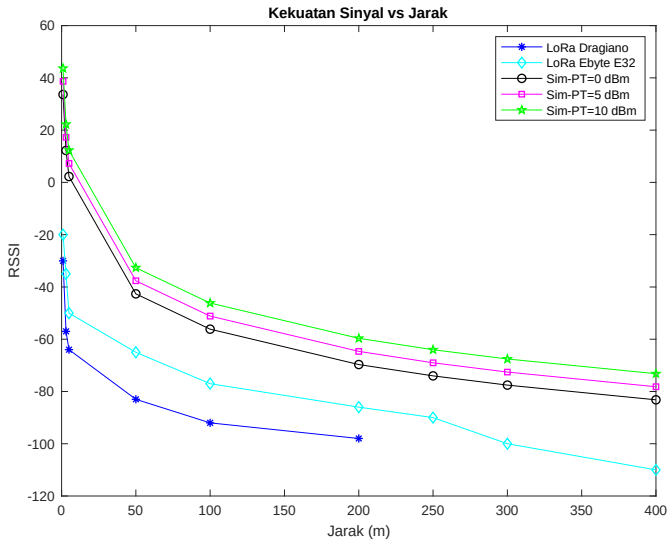

Figure 11. The Measurement and Simulation of Signal Strength VS Distance

Figure12. The HMI Display upon Two LoRa Node Placed in Two Different Room

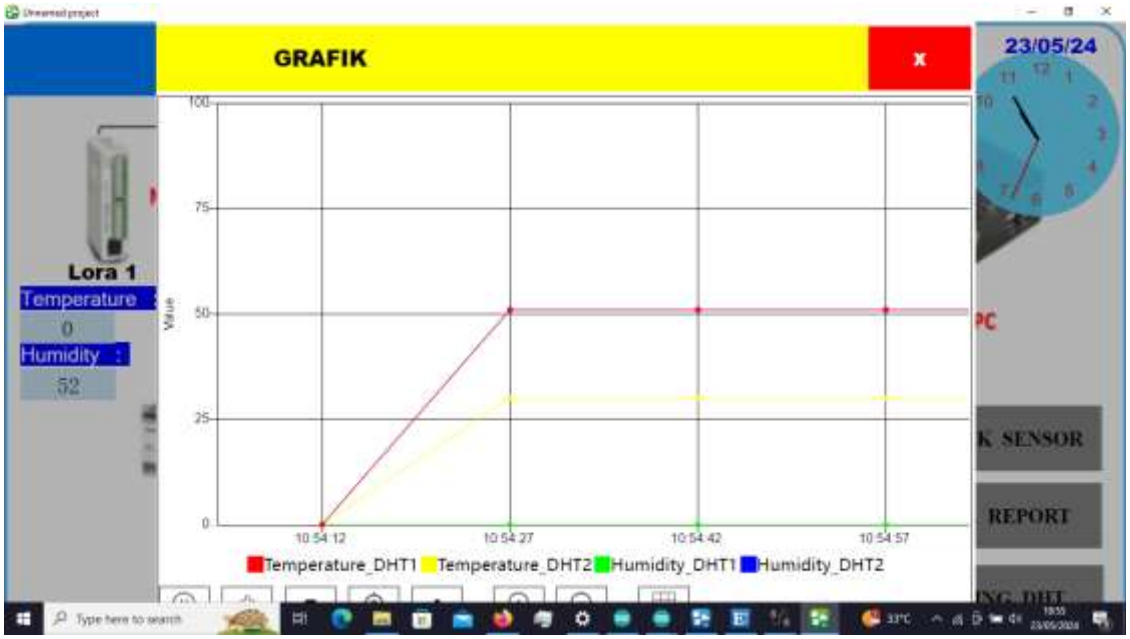

Figure 13. The Graph of Sensing Data from Both LoRa Node

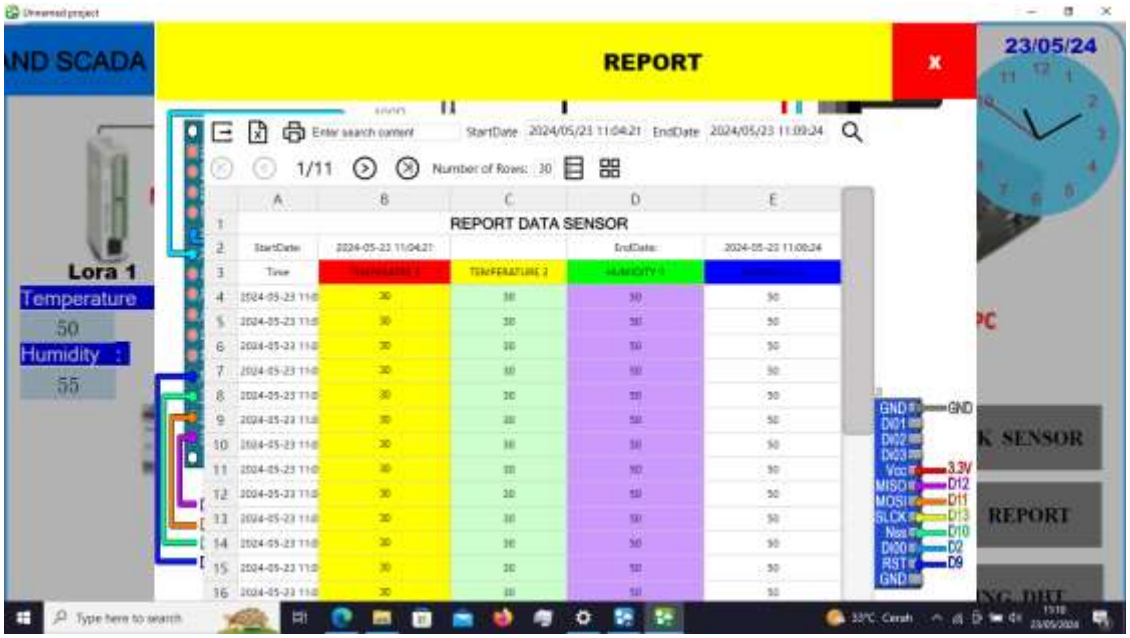

Figure 14. The Tabel of Sensing Data Report as Real Time

Comparing this design to the exiting design at industry which only used SCADA for their system and need long cable for connecting between their office so, this design is very effective and need short time to monitoring the system. This design has no cable for communicating between node so that some benefit can be received for implementing the proposed design and it will improve the productivity. However, for future research, it can be developed the industrial system can be controlled by three different devices or application.

4. Conclusion

In this paper, we have developed the proposed IIOT device design and tested with two different scenarios. The two scenarios are the communication distance test and the monitoring data incorporated with three different display such as table, graph and real time data. The results of the communication distance test show that the communication distance test has increased compared to the previous research. The furthest distance can reach 400m while sensing data still can be recorded, whereas the previous experiment could only reach 200m. With this distance it can be implemented on Industry which had a wide area production. The second scenario test, the collaboration between SCADA system and wireless node using LoRa technology, shows that the system can be run as the design and it can be implemented in the wider industry due to effective system. Comparing to the current system, the proposed design can cut the long cable and also will improve the productivity since the information data can be accessed easily.

Acknowledgements

This research was carried out with financial aid support from the directorate research and community service of Universitas Muhammadiyah Gresik. Thanks to all of friend and student where have helped us to finish this research.

References

[1] A. J. Calderón Godoy and I. G. Pérez, "Integration of sensor and actuator networks and the SCADA system to promote the migration of the legacy flexible manufacturing system towards the industry 4.0 concept," *J. Sens. Actuator Networks*, vol. 7, no. 23, pp. 1–21, 2018, doi: 10.3390/jsan7020023.

[2] K. S. Kiangala and Z. Wang, "An Industry 4.0 approach to develop auto parameter configuration of a bottling process in a small to medium scale industry using PLC and SCADA," *Procedia Manuf.*, vol. 35, pp. 725–730, 2019, doi: 10.1016/j.promfg.2019.06.015.

[3] Misbah, R. P. Astutik, Eliyani, H. A. Winarno, A. Muklish, and D. Andesta, "Communication System on Wireless Sensor Networks using Raspberry Pi and Arduino for Monitoring Gas of Air Pollution," *Proceeding - 2018 Int. Semin. Intell. Technol. Its Appl. ISITIA 2018*, pp. 27–32, 2018, doi: 10.1109/ISITIA.2018.8711371.

[4] R. P. Astutik and H. A. Winarno, "Feasibility test on the performance of LoRa technology incorporated in the wireless sensor network," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 821, no. 1, pp. 1–7, 2020, doi: 10.1088/1757-899X/821/1/012020.

[5] R. P. Astutik and R. F. Bakti, "SISTEM MONITORING DETAK JANTUNG BERBASIS LoRa," *E-Link J. Tek. Elektro dan Inform.*, vol. 15, no. 1, pp. 19–25, 2020, doi: 10.30587/e-link.v15i1.1606.

[6] A. T. H. P. Rini Puji Astutik, Hendra Ari Winarno, Eliyani, Denny Irawan, Raafi' Yanuar Purnama Arifian, Muhammad Febri Prasetyo Utomo, "The arduino SCADA training at the Mambaul Ulum Vocational High School, Gresik," *COMMUNITY EMPOWERMENT*, 2021. https://journal.unimma.ac.id/index.php/ce/article/view/5827/2740 (accessed Mar. 08, 2022).

[7] R. P. Astutik, H. A. Winarno, D. Irawan, W. Triyoga, K. Fibiani, and T. Elektro, "Pembelajaran Modul SCADA Menggunakan Arduino untuk SMK Muhammadiyah 1 Gresik," *J. Abdi Masy. Indones.*, vol. 2, no. 4, pp. 1377–1384, Aug. 2022, doi: 10.54082/JAMSI.434.

[8] D. Irawan, H. A. Winarno, R. P. Astutik, Z. A. Kinanti, E. P. Prastya, and A. Hidayah, "PELATIHAN OUTSEAL-HAIWELL PADA SMK MAMBAUL ULUM, GRESIK," *DedikasiMU J. Community Serv.*, vol. 4, no. 3, pp. 290–296, Sep. 2022, doi: 10.30587/DEDIKASIMU.V4I3.4190.

[9] R. P. Astutik, H. A. Winarno, and E. P. Prastya, "PELATIHAN OUTSEAL HAIWELL PADA SMK SEMEN GRESIK," *J-ADIMAS (Jurnal Pengabdi. Kpd. Masyarakat)epada Masyarakat)*, vol. 11, no. 1, pp. 14–18, 2023, [Online]. Available: https://jurnal.stkippgritulungagung.ac.id/index.php/jadimas/article/view/3626/pdf

[10] Denny Irawan, Rini Puji Astutik, Eka Putra Prastya, and Alief Hidayah, "Pelatihan Outseal-Haiwell for PLC and SCADA di SMKN 1 Singosari, Malang," *Nusant. J. Pengabdi. Kpd. Masy.*, vol. 3, no. 2, pp. 240–248, 2023, doi: 10.55606/nusantara.v3i2.1675.

[11] Y. Ristanto and R. P. Astutik, "Sistem Ketersedian Slot Parkir Dengan Arduino Nano Berbasis Outseal Studio Dan Haiwell Cloud Scada," *Techno.Com*, vol. 22, no. 4, pp. 937–948, 2023, doi: 10.33633/tc.v22i4.9011.

[12] H. Sulistiawan, R. P. Astutik, and Y. Ristanto, "Based on Outseal Studio and Haiwell Cloud Scada to Check Parking System Availability using Arduino Nano on The Miniature Parking Lot," *J. Ris. Rekayasa Elektro*, vol. 5, no. 2, p. 103, 2023, doi: 10.30595/jrre.v5i2.19647.

[13] A. Iqbal and M. T. Iqbal, "Low-cost and secure communication system for SCADA system of remote microgrids," *J. Electr. Comput. Eng.*, vol. 2019, pp. 1–13, 2019, doi: 10.1155/2019/1986325.

[14] P. R. C. de Araújo, R. H. Filho, J. J. P. C. Rodrigues, J. P. C. M. Oliveira, and S. A. Braga, "Infrastructure for integration of legacy electrical equipment into a smart-grid using wireless sensor networks," *Sensors (Switzerland)*, vol. 18, no. 5, 2018, doi: 10.3390/s18051312.

[15] Elecrow, "Sx1278 Lora Module 433M 10Km Ra-02 Wireless Spread Spectrum Transmission Socket for Smart Home Diy," *Elecrow.com*, 202AD. https://www.elecrow.com/sx1278-lora-module-433m-10km-ra-02-wireless-spread-spectrum-transmission-socket-for-smart-home-diy.html

[16] S. Mahmud, "Analysis of Listen Before Talk Protocol Implementation in Terrestrial Network Using Multi-Node LoRa Communication," *Adv. Sustain. Sci. Eng. Technol.*, vol. 5, no. 3, p. 0230301, 2023, doi: 10.26877/asset.v5i3.16520.

[17] R. Maharaj, V. Balyan, and M. T. Kahn, "Design of IIoT device to parse data directly to scada systems using LoRa physical layer," *Int. J. Smart Sens. Intell. Syst.*, vol. 15, no. 1, 2022, doi: 10.21307/IJSSIS-2021-023.

[18] Y. Cheng, H. Saputra, L. M. Goh, and Y. Wu, "Secure smart metering based on LoRa technology," *2018 IEEE 4th Int. Conf. Identity, Secur. Behav. Anal. ISBA 2018*, vol. 2018-Janua, pp. 1–8, 2018, doi: 10.1109/ISBA.2018.8311466.

[19] C. Ndukwe, M. T. Iqbal, and J. Khan, "An Open Source LoRa Based, Low-Cost IoT Platform for Renewable Energy Generation Unit Monitoring and Supervisory Control," *J. Energy Power Technol.*, vol. 4, no. 1, pp. 1–1, 2021, doi: 10.21926/jept.2201007.

[20] A. G. Silva and H. C. C. Michel, "IIoT architecture using Lora technology, Lorawan and OPC UA protocols," *Proc. Int. Conf. Ind. Eng. Oper. Manag.*, no. Compology 2017, pp. 1177–1188, 2021, doi: 10.46254/sa02.20210548.

[21] O. Rholam, M. Tabaa, F. Monteiro, and A. Dandache, "Smart device for multi-band industrial IoT communications," *Procedia Comput. Sci.*, vol. 155, pp. 660–665, 2019, doi: 10.1016/j.procs.2019.08.094.