

Research Article

Design and Build an Automatic Train Portal Based on Arduino Nano and Ultrasonic Sensors

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Abstract

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The research aims to design and build a prototype of an automated railway crossing portal that uses an Arduino Nano microcontroller and ultrasonic sensor as a distance detection device. This system is designed to improve safety at railway crossings by being able to accurately detect the presence of trains and provide a quick control response to train arrivals. The ultrasonic sensor works by measuring the time of the reflection of the ultrasonic waves to determine the distance of approaching objects, while the Arduino Nano serves as a control center that processes the sensor data and activates the servo motor actuator to open or close the safety bar automatically. The system is also equipped with LED light indicators and buzzers as visual and sound warning signs to road users. Prototype testing showed that the system is capable of performing distance detection with a high level of accuracy and providing a timely cross-closure response, thereby reducing manual intervention and minimizing the risk of accidents due to human negligence. All output components function as expected, and the integration of the ultrasonic sensor with the Arduino Nano results in effective coordination in maintaining the safety of the crossing. This research confirms that the application of simple, cost-effective, and effective technology can provide practical solutions to improve the safety of rail transportation at crossings. With its rapid response capabilities, the system can also be further adapted to modern technologies such as the Internet of Things (IoT) to improve remote monitoring and functionality. This research makes an important contribution to the development of a railway crossing automation system that can be widely used, especially in small to medium crossings that still use many manual methods.

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Introduction

The development of automation technology in the context of railway crossing safety has shown significant progress that can reduce the risk of accidents due to human factors and operational delays. Traditional crossing systems that rely on manual methods tend to face serious challenges, such as mishandling by officers that can be fatal. In several studies on crossings in Jakarta, high risk levels have been identified, especially at points with heavy traffic

(Kamila et al., 2023); (Lie et al., 2023); (Marsa et al., 2023).

Automation technology, including the use of sensors and monitoring systems, is an important step in improving safety. The application of this technology can be seen in the development of applications designed to provide real-time information on rail conditions and train activities. Although specific studies on these applications are limited, the development of devices that support monitoring rail

conditions can aid the digital transformation process and improve safety (Nugraha et al., 2023).

Education and awareness about safety at railway crossings are also increasingly important in this era of automation. Many drivers do not yet fully understand the difference in braking between their vehicle and the train, which increases the risk at the crossing point (Marsusyadi et al., 2023). Therefore, educational programs combined with modern technology, such as apps that inform drivers of train arrivals in real-time, can greatly reduce the occurrence of emergencies at crossings (Susanto et al., 2023).

Signaling systems integrated with automation technology have great potential in improving safety. Interference in signaling system components can affect the safety and operational efficiency of trains (Sumarahardhi & Santoso, 2023). Railway authorities must ensure that the signaling system implemented is updated and adapted to the latest technological developments to increase its effectiveness in preventing accidents.

An efficient and responsive automated railway portal system is an essential element in ensuring the safety and smooth operation of trains. Rapid closure and opening of safety portals based on the proximity of the train can minimize the risk of accidents at the train crossing. The use of the latest technology, including automated systems combined with microprocessor-based sensors and controls, is very important.

Research by Golder et al. shows that automated systems designed for railway crossings can actively detect potential accidents by monitoring real-time data, thus reducing the likelihood of accidents occurring (Golder et al., 2023). An effective system must be able to respond to signals from approaching trains, which is one of the components of the automatic safety design for train portals. Advances in control technology such as the use of Arduino and infrared sensors have also been discussed, where these systems can accurately detect the presence of trains so that the portal can close automatically (H.K. et al., 2023).

The implementation of this system is not only limited to technical operation but also needs to take into account environmental and safety factors. Kashiwao et al. mentioned the importance of detecting damage to the portal structure to ensure its functionality (Kashiwao et al., 2023). A comprehensive approach to the design and implementation of automated portal systems, which includes structural testing and fault detection, is key to the success of the system being built.

Such systems also allow the integration of environmentally friendly technologies that support sustainability, as described by Iftekharuzzaman et al., who propose systems that can operate using renewable energy sources (Iftekharuzzaman et al., 2023). Renewable energy-based systems not only reduce environmental impact, but also extend the life of the

system by reducing dependence on conventional electricity.

In this study, a prototype of an Arduino Nano-based automatic train portal was developed combined with an ultrasonic sensor as a train distance detection tool. Ultrasonic sensors were chosen for their ability to detect objects accurately and in real-time, allowing the system to provide a rapid response to control the portal mechanism. The Arduino Nano as a microcontroller is used as a control center that receives signals from ultrasonic sensors and operates the portal actuator automatically.

Although railway crossing automation technology has evolved, many systems still rely on expensive components or complex control devices, making them less accessible for small and medium-scale applications. Most previous studies lacked a solution with the combination of the use of compact microcontrollers and economical ultrasonic sensors but capable of providing high detection accuracy in real-time. The study fills this gap by designing a prototype of an automated railway portal that uses the Arduino Nano as a low-cost and compact microcontroller, which serves as the system's control center, and utilizes ultrasonic sensors as a distance detection tool with sufficient precision for railway crossing applications. The novelty of this research lies in the implementation of a simple, efficient, and cost-effective automatic control system, which can be easily applied to small to medium-sized railway crossings. The system is tested to maintain the response speed and operational reliability of the portal under real-world conditions, which has not been explored in depth in similar studies before.

Research aimed at designing and testing the effectiveness of automated railway portal systems in improving the safety of railway crossings is of great relevance in the context of minimizing manual intervention and reducing the risk of accidents due to misoperation. Many previous studies have shown that automation systems can improve efficiency as well as reduce human error, which is one of the leading causes of accidents at railway crossings. One of the important aspects of this research is the focus on the safety of crossings. In this context, a study conducted by Kamila et al. shows that the analysis of crossings can improve the safety of road users by identifying potential hazards and developing solutions as needed (Kamila et al., 2023). Fairussihan and Setiono also underlined the importance of risk analysis in improving safety in high-risk work environments, including railway crossings (Fairussihan & Setiono, 2023). The methods used in this automated railway portal system can be placed in the HIRARC (Hazard Identification Risk Assessment and Risk Control) category, which has been tested and reported in various other studies as an effective tool for identifying risks and carrying out control (Prayoga et al., 2023); (Sya'bani & Herwanto, 2023); (Widya et al., 2023). By adopting this approach,

the study is expected to minimize risky behaviors and optimize operational procedures.

Previous research has also shown that one of the keys to reducing accidents at railway crossings is education and user awareness of the risks. Education for drivers about safety when crossing railway crossings is essential in reducing accidents (Marsusiadi et al., 2023). The designed automation approach can include the same educational element, with a system that alerts users to the dangers of approaching a railway crossing.

Along with technological advancements, the use of sensors and IoT (Internet of Things) devices in crossing surveys and surveillance is much more effective than traditional manual methods. The results of a study by Ilmi et al. show that the proper use of technology can improve efficiency and safety in the industry (Ilmi et al., 2023). The application of this technology is expected to provide real-time data that is essential for more effective decision-making.

Materials and Methods

This automated railway portal system uses several main components as follows:

Arduino Nano as the main microcontroller that controls the entire process and receives sensor signals.

Ultrasonic Sensor (HC-SR04) to detect the distance of objects (trains) with real-time accuracy and response.

Servo motor as actuator of portal opening and closing mechanism.

LED lights and buzzers as warning signal output devices.

Other supporting components such as resistors, breadboards, and connecting cables.

This research uses a Research and Development (R&D) approach that begins with the design, prototype development, and functional testing of the system. The system workflow is as follows:

Train Detection: Ultrasonic sensors emit ultrasonic sound waves reflected by objects (trains) and measure travel time to determine the distance from the sensor to the train.

Signal Processing: The Arduino Nano receives distance data from the ultrasonic sensor. The data is processed to determine whether the train distance is within the predetermined threshold to activate the system.

Portal Activation: When the train is detected approaching within a certain distance, the Arduino Nano sends a signal to drive the servo motor down the safety portal automatically.

Warning Signaling: Simultaneously, LED lights and buzzers are activated to provide visual and audio alerts to track users.

Portal Opening: Once the train has passed the track and the return distance is safe, the Arduino Nano

instructs the servo motor to lift the portal back to its original position and turn off the warning signal.

Testing: Prototypes are tested repeatedly to ensure response speed, detection accuracy, and overall system operational performance as designed.

The study adopts an experimental approach to design and test prototypes of automated railway portals. The main system consists of an Arduino Nano microcontroller that serves as a logic control center, and an ultrasonic sensor as a train proximity detection device. The test includes verification of sensor function in detecting train distance, the response of the servo motor mechanism as a door bar regulator, and the activation of visual indicators in the form of LEDs and buzzer alarms for safety warnings. Test data was obtained through simulated train arrivals at a certain distance to measure the accuracy and speed of the system's response.

How the System Works

This automated portal system works on the principle of distance detection using ultrasonic sensors installed near railway crossings. The sensor sends ultrasonic waves and measures the time of the bounce back when there is an object (train) in range. The Arduino Nano receives these distance signals and compares them to the predetermined threshold distance limits. When the train is detected to be within the predetermined safe distance, the Arduino Nano activates the servo motor to lower the crossing barrier bar as well as turn on the LED lights and buzzers as a warning sign to road users.

Railway Portal Automated System

The use of the Arduino Nano gives it an advantage in automatic control that is efficient and easy to program. Ultrasonic sensors play an important role in the integrity of the system because they provide real-time data related to the proximity of the train to the crossing. The system is designed to reduce manual intervention and improve safety by ensuring that the operation of the crossbar is carried out automatically and in a timely manner. All output components such as servos, LEDs, and buzzers are synchronized to provide a comprehensive responsiveness function to the arrival of the train.

Results and Discussion

The prototype of the automated train portal was successfully designed and implemented using Arduino Nano as the main controller and ultrasonic sensors to detect the proximity of trains at the crossing. Tests show that ultrasonic sensors are capable of providing accurate distance data to detect the presence of trains with a rapid response. The Arduino Nano then activates the servo motor to automatically raise and lower the portal bar according to sensor detection.

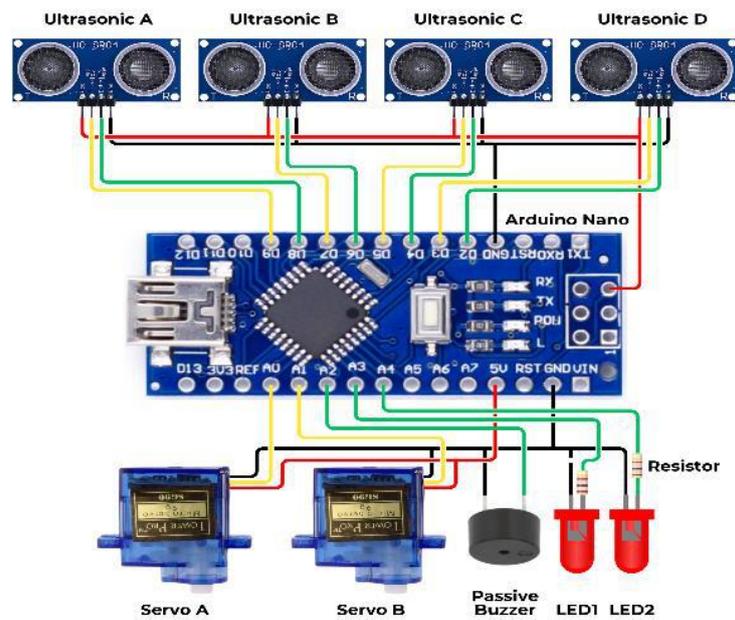


Figure 1. Tool Schem

In addition, indicators in the form of LED lights and buzzers also function as effective visual and sound warnings for road users. The results of material tests and equipment tests stated that all components ran as expected and met the research objectives, which were to improve safety at railway crossings by minimizing manual intervention and reducing the risk of accidents.

Tables 1 and 2 of the study confirm that these automated portals operate with a high level of accuracy and effectiveness. The integration between the ultrasonic sensor and the Arduino Nano results in a fast and timely response to the arrival of the train, which is critical for safety.

Table 1 Test Material

| No. | Question | Answer | Information |
|-----|---|--------|-------------------------------|
| 1 | Can an automated railway portal designed with Arduino Nano and ultrasonic sensors improve the level of safety at railway crossings? | Yes | Improve safety |
| 2 | Does the use of ultrasonic sensors in an automatic train portal system detect the proximity of trains with a high degree of accuracy? | Yes | Accurate detection |
| 3 | Are systems that use Arduino Nano in automated train portal prototypes operating effectively? | Yes | Effective operation |
| 4 | Can the design of an automatic railway portal with ultrasonic sensors reduce the need for manual intervention in the operation of the system? | Yes | Reduce manual intervention |
| 5 | Does the integration between the ultrasonic sensor and the Arduino Nano provide a fast and accurate response to the arrival of the train? | Yes | Fast and accurate response |
| 6 | Does this prototype of an automatic train portal have the potential to reduce the risk of accidents on train lines? | Yes | Reduces the risk of accidents |

Table 2 Test Tool

| No. | Question | Answer | Information |
|-----|---|--------|----------------------------------|
| 1 | Can a prototype of an automatic train portal using the Arduino Nano work well as an automatic control tool? | Yes | Good operator function |
| 2 | Can the ultrasonic sensor on the prototype of the automatic train portal detect the proximity of the train accurately enough? | Yes | Accurate distance detection |
| 3 | Can this prototype provide a clear and timely signal to open or close the portal based on the detected train distance? | Yes | Timely signals |
| 4 | Can the integration between the Arduino Nano and the ultrasonic sensor in the train portal prototype reduce the risk of errors in detecting the arrival of the train? | Yes | Reduce detection errors |
| 5 | Do all output components run as intended? | Yes | Output components work perfectly |
| 6 | Does this tool achieve its desired purpose? | Yes | Goals achieved |

From the results of this test, it can be concluded that the automated portal prototype provides a practical and efficient solution for railway crossings that have been prone to accidents due to human negligence or manual system errors. Based on the results of the material tests contained in Table 1, all aspects of the test received a "Yes" answer indicating that ultrasonic sensors have become an important component in a wide range of applications, including in the prototype of a security system for object detection. In the requested context, ultrasonic sensors can detect train-like objects with an effective range ranging from a few centimeters to a few meters, depending on their specifications (Wei, 2024). When the object is within that range, the Arduino Nano acts as a microcontroller that sends commands to the servo motor to lower the safety bar, with a designed response time of less than 2 seconds. This is relevant to other studies that demonstrate the ability of ultrasonic sensors to measure distances and detect objects without physical contact.

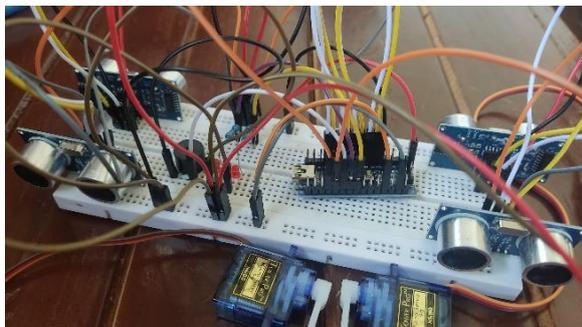


Figure 2. Application of Arduino Nano

As part of the warning mechanism, the LED light indicator and buzzer are activated simultaneously to provide an effective visual and audio signal (Goswami & Sahoo, 2024). This kind of warning is important in improving the user's response to dangerous situations in the surrounding environment (Alfiqi & Sembiring, 2023). Related research also notes that warning systems can be built using a combination of ultrasonic sensors and a variety of other modules, as was done in the development of systems that use Arduino and ultrasonic sensors in a broader context, including obstacle avoidance on robots (Goswami & Sahoo, 2024).

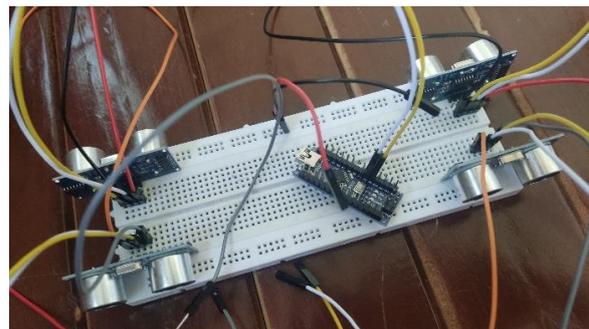


Figure 3. Application of Ultrasonic Sensor

The function of this system is not only limited to the control mechanism of the safety bars, but also includes monitoring the situation around the work area that may be dangerous. The use of ultrasonic sensors has been proven effective in a variety of automation systems, including mobility applications that utilize similar technologies for the detection and response of objects

on the trail (Wei, 2024; Sabo et al., 2023; Ang & Min, 2024). By using the right sensors, these systems are able to work efficiently, provide clear warnings, and actively maintain safety in risky situations.

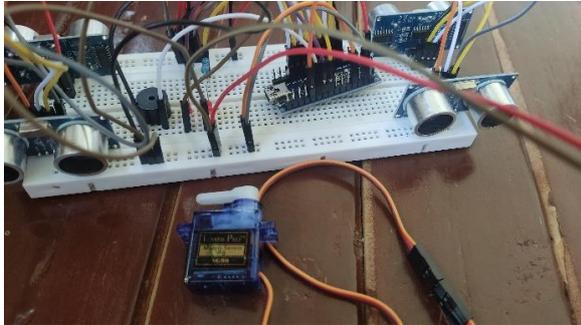


Figure 4. Servo Application

Looking at the potential of ultrasonic sensors in safety system applications, it can be concluded that this technology not only improves operational efficiency but also contributes significantly to user safety through systematic interventions designed to reduce the risk of accidents (Pratama & Ariandi, 2024; Wei, 2024; Goswami & Sahoo, 2024).

The described system demonstrates a fast and timely response capability, which plays an important role in improving safety at train crossings. By using ultrasonic sensors that are able to detect the proximity of trains with high accuracy, the system is able to provide notifications with better response to avoid possible accidents (Arbiyani, 2024; Wei, 2024; (Kharisma et al., 2023). Ultrasonic sensors work by emitting ultrasonic waves and measuring distances based on the reflection of those waves, allowing for efficient detection even under limited visual conditions.

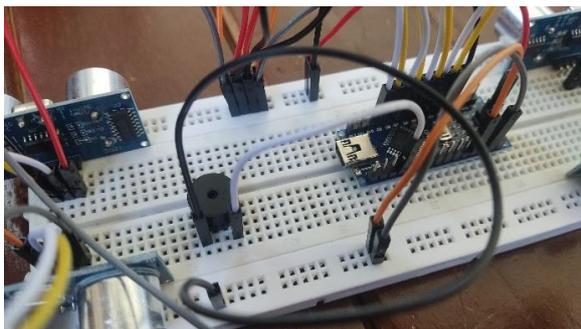


Figure 5. Application of Buzzer

The Arduino Nano serves as an automatic system controller, allowing the integration of various sensors for easier operation and autonomy. The use of Arduino in this system is an effective measure as it provides a flexible and easy-to-program platform to interact with hardware such as ultrasonic sensors and servo motors (Ragavi et al., 2023; Kharisma et al., 2023). The design

of this automated portal significantly reduces the need for manual intervention, making it a more practical and reliable solution for the management of railway crossings.

The integration between the ultrasonic sensor and the Arduino provides a fast and accurate response, which is especially important in emergency situations. With this system, train proximity detection can be carried out in real-time, allowing precautions to be taken before a dangerous situation occurs. Research on ultrasonic sensors shows that they are not only effective in measuring distance, but also in preventing accidents by providing timely warnings (Wei, 2024; Kharisma et al., 2023). This prototype has real potential in reducing the risk of accidents by providing the right information for quick decision-making.

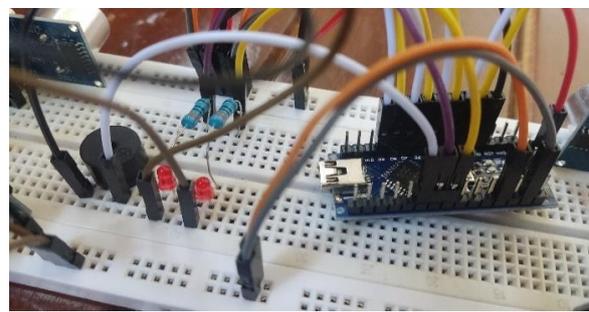


Figure 6. Pengaplikasian LED

Thus, the system not only improves safety but also demonstrates efficiency in running automated systems at train crossings. The integration of this technology shows significant development towards the use of automated systems in improving transportation safety.

Then, from Table 2 of the test tool, which also received a complete "Yes" answer, it can be ascertained that an automatic control system that integrates ultrasonic sensors to accurately detect train distances is an important solution at railway crossings. Ultrasonic sensors, as described by Anyuca and Ismail, have the ability to detect objects with high efficiency, helping in reducing the likelihood of accidents in the work area, although the context of their application is more focused on excavators (Anyuca & Ismail, 2024). In the implementation of the system, precise distance detection is crucial in providing a timely open/close signal of the portal, according to the detected distance between the train and the portal.

The integration of control system components can minimize detection errors, which was highlighted in a study by Zuhair et al., where the automation system they designed with ultrasonic sensors and servo motors managed to maintain a level of safety at train crossings. Thus, effectiveness in detecting objects at the crossing can be achieved, and optimal results are seen from the tests performed, even if the tests do not include explicit percentage figures (Zuhair et al., 2024).

Output systems such as servo motors, LEDs, and buzzers play an important role in ensuring that all components function as expected. Apriyanto noted that DC motor control systems and sensors can be combined to increase effectiveness in automation systems (Apriyanto, 2023). However, the study did not focus on train crossings, so its application may be limited. Similarly, the automated control system described by Hazrina et al. involves real-time control that facilitates a quick and accurate response in the operation of the system, although the context of the application is more appropriate for oil refueling and not railway crossings (Hazrina et al., 2024).

The purpose of the tool can be achieved according to the design, showing that the system works quickly and precisely, contributing to safety at the railway crossing. Validation of all measured operational parameters shows peak performance in the test phase, supporting the claim that the system is effective in carrying out the task in question (Zuhair et al., 2024).

Conclusion

This research succeeded in developing a prototype of an Arduino Nano-based automatic railway portal and ultrasonic sensor that is able to improve the level of safety at railway crossings. The results of the material test and equipment test showed that the system operated effectively and provided a fast and accurate response to the arrival of the train. The use of ultrasonic sensors is proven to detect the proximity of trains with a high degree of precision, so that the control of the door bars can be carried out in a timely manner. The integration between the hardware and software in this prototype is able to reduce the risk of accidents by minimizing manual intervention. Thus, this automated railway portal has great potential to be widely applied as a reliable and efficient railway crossing safety solution.

References

- Alfiqi, R., & Sembiring, J. (2023). Technology for SMS-based Assistive Device for the Visually Impaired. *Journal of Soft Computing Exploration*, 4(4), 177–185. <https://doi.org/10.52465/josce.v4i4.225>
- Ang, J. H., & Min, T. S. (2024). A Review on Sensor Technologies and Control Methods for Mobile Robot With Obstacle Detection System. *International Journal on Robotics Automation and Sciences*, 6(1), 78–85. <https://doi.org/10.33093/ijoras.2024.6.1.11>
- Arbiyani, F. (2024). Ultrasonic Proximity Sensor Device to Enhance the Efficiency of Livestock Transport Process. *Enthalpy Jurnal Ilmiah Mahasiswa Teknik Mesin*, 9(1), 20. <https://doi.org/10.55679/enthalpy.v9i1.47311>
- Fairussihan, J. D., & Setiono, D. (2023). Kerka Safety and Health Risk Analysis (K3) in the Ship Repair Process at Pt. Dock and Shipping Surabaya using the Hirarc (Hazard Identification, Risk Assessment, and Risk Control) method. *Marine Zone Journal of Marine Science and Technology Innovation*, 23–29. <https://doi.org/10.62012/zl.v4i1.18977>
- Golder, A., Gupta, D., Roy, S., Ahasan, Md. A. A., & Haque, M. A. (2023). *Automated Railway Crossing System: A Secure and Resilient Approach*. 247–253. <https://doi.org/10.1109/uemcon59035.2023.10315973>
- Goswami, S. S., & Sahoo, S. K. (2024). *Design of a Robotic Vehicle to Avoid Obstacle Using Arduino Microcontroller and Ultrasonic Sensor*. <https://doi.org/10.3233/atde231118>
- H.K., A., B, Г. Б., A, C. H., G, P., & Manjunath, T. C. (2023). Automatic Railway Gate Control Using Arduino. *International Journal of Engineering Technology and Management Sciences*, 7(3), 878–882. <https://doi.org/10.46647/ijetms.2023.v07i03.134>
- Iftekharuzzaman, I., Ghosh, S., Basher, M. K., Islam, M. A., Das, N., & Nur-E-Alam, M. (2023). Design and Concept of Renewable Energy Driven Auto-Detectable Railway Level Crossing Systems in Bangladesh. *Future Transportation*, 3(1), 75–91. <https://doi.org/10.3390/futuretransp3010005>
- Ilmi, N., Semnasti, V. A. J., & Semnasti, M. C. P. A. I. (2023). The use of the HIRARC method and fishbone diagram in the analysis of K3 risk in the carbon steel industry. *Proceedings of the Society*, 431–440. <https://doi.org/10.33005/wj.v16i1.65>
- Kamila, F. I., Christianto, D., & Angkat, H. (2023). Safety Analysis at Crossing No. 46 Jl. Kh. Ahmad Dahlan, East Jakarta. *JMTS Journal of Civil Engineering Partners*. <https://doi.org/10.24912/jmts.v6i3.24909>

- Kashiwao, T., Tanoue, H., Shiraishi, N., Misaki, Y., Ando, T., Tanaka, D., & Ikeda, K. (2023). A One-Class SVM-Based Approach for Crossing-Gate Rod Breakage Detection in a Railway Telemeter System. *Ieej Transactions on Electrical and Electronic Engineering*, 18(4), 648–650. <https://doi.org/10.1002/tee.23762>
- Kharisma, I. L., Kamdan, K., Firdaus, A. R., Prayoga, R. H., Yasin, F. R., & Ati, M. A. T. (2023). Construction of Railway Door Automation Prototypes Using Arduino, Servo Motors and Ultrasonic Sensors. *Digital Zone Jurnal Teknologi Informasi Dan Komunikasi*, 14(1), 1–12. <https://doi.org/10.31849/digitalzone.v14i1.13584>
- Lie, K. L., Linggarsari, D., & Angkat, H. R. (2023). Safety Survey at JPL Crossings No 6a Km 3 + 219 Jalan Karya Raya. *JMTS Journal of Civil Engineering Partners*, 1015–1024. <https://doi.org/10.24912/jmts.v6i3.24904>
- Marsa, R. R. M., Linggasari, D., & Angkat, H. R. (2023). Safety Study at JPL Crossing No. 5a Km 2 + 285 Gift Street. *JMTS Journal of Civil Engineering Partners*, 1025–1034. <https://doi.org/10.24912/jmts.v6i3.24907>
- Marsusiadi, E. N. S., Priyanto, S., Perwira, D. A., Sunardi, S., & Churniawan, E. (2023). Safety education through a railway crossing for drivers of heavy trucks or public buses. *Journal of Locus Research and Service*, 2(11), 1130–1137. <https://doi.org/10.58344/locus.v2i11.1949>
- Nugraha, A. C., Jumiyani, R., Sundari, S., Suprihanto, S., & Pribadi, D. S. (2023). Application Development Activities Are Appropriate To Support Reporting And Analysis Of Rail Irregularities At Pt Kai. *Journal of Community Service - Indonesian Digital Technology*, 2(2), 71. <https://doi.org/10.26798/jpm.v2i2.1092>
- Pratama, D. W., & Ariandi, M. (2024). Prototype of Safety System Monitoring on Komatsu PC 200-7 Excavator Using Microcontroller. *Protek Scientific Journal of Electrical Engineering*, 11(1), 56–63. <https://doi.org/10.33387/protek.v11i1.6534>
- Prayoga, D., Meizul, Z., & Hidayat, L. (2023). Work Accident Risk Analysis of Cv. Brens Bakery Using the Hirarc (Hazard Identification Risk Assessment and Risk Control) method. *Journal of Agroindustry*, 13(2), 202–217. <https://doi.org/10.31186/jagroindustri.13.2.202-217>
- Ragavi, R., Ramya, A. V, Sowndharya, G., & Sunmathy, S. (2023). Ultrasonic Radar Module Design Using Arduino. *Iijsr*, 07(04), 65–70. <https://doi.org/10.46759/iijsr.2023.7408>
- Sabo, A., Ahmad, A. A., Ben, E. K., Dada, A. E., Aji, M. M., Diyari, M., Saloro, M. A., & Musa, J. L. (2023). Implementation of Ranging System Using Ultrasonic Sensor and Microcontroller Unit for Aviation Industries. *World Journal of Advanced Engineering Technology and Sciences*, 10(1), 147–156. <https://doi.org/10.30574/wjaets.2023.10.1.0273>
- Sumarahardhi, P. C., & Santoso, D. B. (2023). Identification and mapping of interference components of the signaling system of PT Kereta Api Indonesia (Persero) Resort Karawang. *Teak (Student Journal of Informatics Engineering)*, 7(3), 1574–1578. <https://doi.org/10.36040/jati.v7i3.6875>
- Susanto, N. B., Isheka, R. P., & Wiryanta, W. (2023). Analysis of the Suitability of Intercity PSO (Public Service Obligation) Train Services to Minimum Service Standards (Case Study for the First Quarter and Second Quarter of 2023 in Java). *Indonesian Railway Journal*, 7(2), 42–52. <https://doi.org/10.37367/jpi.v7i2.289>
- Sya'bani, A., & Herwanto, D. (2023). Analysis of the potential for work accidents in the ring frame machine area using the HIRADC method at PT. XYZ. *Jenius Journal of Applied Industrial Engineering*, 4(2), 313–322. <https://doi.org/10.37373/jenius.v4i2.711>
- Wei, Y. (2024). Applications of Ultrasonic Sensors: A Review. *Applied and Computational Engineering*, 99(1), 144–148. <https://doi.org/10.54254/2755-2721/99/20251773>
- Widya, A. R., Wiyatno, T. N., & Saefulloh, A. (2023). Assessment of the potential for work accidents

using the Hazard Identification, Risk Assessment and Risk Control (HIRARC) method in the Mechanical Energy Department at a paper manufacturing company in Cikarang-West Java. *National Seminar on Industrial Engineering and Management*, 2(1), 107–117. <https://doi.org/10.28932/sentekmi2023.v2i1.14>
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