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Analysis of Damage to the Axle Counter of the ZP D 43 Module at the Maros Station Crossing

Ghozy Akram Mujahid[1], Mohamad Lukman Hakim[2], Nathanael Tegar Putra Nugraha[3], Arief Darmawan[4].
[1]Politeknik Perkeretaapian Indonesia, Madiun, Indonesia, ghozy.tep2220341@taruna.ppi.ac.id
[2]PT Celebes Railway Indonesia, Makassar, Indonesia, lukman.h@pt-cri.com
[3]PT Celebes Railway Indonesia, Makassar, Indonesia, nathan.erpcri@gmail.com
[4]Politeknik Perkeretaapian Indonesia, Madiun, Indonesia, darmawan@ppi.ac.id

Corresponding Author: ghozy.tep2220341@taruna.ppi.ac.id[1]

Abstract: This study analyzed the damage to the Axle Counter Module ZP D 43 at the Maros Station crossing. The ZP D 43 module functions to detect the presence of the train, but it was found to be disrupted due to lightning strikes and a poor grounding system, which caused fatal damage to the module and counting head. The research method uses a qualitative approach through observation, technician interviews, as well as SWOT and TWOS analysis. The results of the SWOT and TOWS analyses show the need to improve system protection and grounding improvements to improve operational reliability. These findings provide strategic recommendations to improve the safety and efficiency of train travel in the Makassar–Parepare Railway Project.

Keyword: Axle Counter,Modul ZP D 43, SWOT, Grounding, Lightning Strikes

INTRODUCTION

Trains are one of the most efficient and effective modes of transportation in transporting passengers and goods. A railway system consists of various components, including rails, locomotives, and signaling systems that function to regulate the movement of trains. One of the important components in this system is the axle counter, which serves to detect the presence of trains on the rail tracks. Axle counters work by counting the number of axles that pass through a certain point, so that it can determine whether the path is safe to travel or not (Fatkhan et al., 2021) The existence of a reliable railway system is essential to ensure the safety and comfort of passengers. With the increasing number of train users, especially in urban areas, the need for an efficient and safe system has become more and more urgent. Well-functioning trains can reduce congestion on the highway and provide a more environmentally friendly transportation alternative (Yudhistira et al., 2022).

Currently, many countries, including Indonesia, are investing in the development of railway infrastructure. However, despite the progress, there are still challenges to be faced, such as damage to system components, including the axle counter. This damage can cause significant operational disruption, including delays and the risk of accidents (Rozi, 2023).

The issue of axle counter reliability is very crucial, because failure to detect the presence of a train can result in dangerous situations, such as collisions or accidents at the crossing. Research shows that the reliability of axle counters is directly related to safety patterns and smooth train operations, where any error in axle calculation can lead to incorrect decisions in train traffic regulation (Widi et al., 2023). Axle Counter is a railway detection equipment that generates wave frequencies to calculate the number of axles passing through the rails. Axle counter is one of the detectors for the presence of trains that has the ability to calculate and evaluate the number of axles entering and exiting a certain railway detection area. Determination of the match between the number of inbound and outgoing axles usually allows the track to return to normal without being occupied (Sunardi et al., 2023). Axle counters are a vital component in the railway signaling system, functioning to detect the presence and number of train wheels passing on a track. The reliability of these devices is essential to ensure the safety and smooth operation of the railway. However, various reports indicate that the axle counter module, particularly the ZP D 43 type, often experiences interference that can result in a "failed detection" condition. This kind of disruption has the potential to hamper train operations and reduce the level of travel safety**.**

Damage to the axle counter can result in various risks, such as errors in detecting the presence of trains, which in turn can lead to collisions or accidents at the crossing. Additionally, failure of this system can disrupt train travel schedules, impacting passenger satisfaction and operational efficiency. Research by Nugraha et al. (2023) emphasizing that protection against overcurrent is essential to prevent damage to the counter axle system. The operation pattern of the train relies heavily on the reliability of detection systems such as axle counters. When the axle counter is functioning properly, the signaling system can provide the operator with accurate information regarding the track conditions. However, in the event of a breakdown, misinformation can lead to dangerous decisions, such as allowing trains to enter already filled lines (Sebidang, 2020). The reliability of the axle counter affects not only safety, but also operational efficiency, as delays caused by detection errors can disrupt the entire train travel schedule.

Several studies have been conducted to analyze damage to the axle counter and its impact on train operations. Research by Fatkhan et al. (2021) Indicates that a better detection system can reduce errors in axle calculations. In addition, research by Yudhistira et al. (2022) examine the impact of electromagnetic interference on axle counters in the LRT, highlighting the importance of fault management to maintain system reliability. This research focuses on "Analysis of Damage to the Axle Counter of the ZP D 43 Module at Maros Station crossing". With the increasing frequency of train travel, it is important to understand and analyze the damage that occurs to the axle counter, as well as its impact on the train's operating pattern. This study aims to provide recommendations for repair and maintenance that can improve the reliability of the system. In the context of PT KAI (Persero), Resort Sintel 1.16 Karawang, damage to the axle counter is often caused by external factors such as bad weather and electromagnetic interference. Therefore, this study will analyze the factors that cause the damage and how it affects the operation of the train. The methodology used in this study includes data collection from fault reports, direct observation in the field, and analysis of the existing axle counter system. Based on research from Rozi (2023) on the use of Circuit Breakers and axle counters on Commuter Line Electric Rail Trains, The significance of this study lies in its ability to provide deeper insights into the damage to the axle counter and its impact on the safety and operational efficiency of trains. By understanding this issue, PT KAI can take proactive steps to prevent future damage. The results of this study are expected to contribute to the development of railway system maintenance and management policies in Indonesia. Overall, this study aims to analyze the damage to the axle counter and its impact on the train operation pattern in the Makassar-Pare-Pare Railway Project, namely at PT

Celebes Railway Indonesia. By focusing on the ZP D 43 Module precisely at Maros Station, it is hoped that this research can make a significant contribution to the development of a safer and more efficient railway system. This is based on the fact that the axle counter system is an important component in the train traffic control system that is used to detect the presence of trains on a rail block. The Axle Counter system experiences various types of interference, such as hardware malfunctions, data transmission failures, and misconfigurations. These disruptions affect system reliability, cause operational delays, and disrupt train travel schedules (Rosyidi & Budhi Santoso, 2023). The presence of an axle counter is very important for the operating pattern of the train which determines the safety of the train journey itself, the ZP D 43 module is an advanced model of the ZP 43 E/V with increased resistance to EMC. Making this model more compatible in terms of functionality and interface. The *Counting Head* is a component attached to the rail as a railway axle counter. The working principle of the *Counting Head* or axle counter on this Axle counter is that if the axle difference = 0 which means that all axles have successfully passed through the counting head, it will be clear / safe status and if the axle difference passes through *the Counting Head* ≠ 0 then the track is said to be occupied or which means the train is still in the 1 section and each road plot has 1 *Counting head* (LRS Training Module:20).

One of the approaches that can be used as an instrument in the selection of a basic strategy is through SWOT analysis, which is the systematic identification of various factors to formulate an organizational strategy. This analysis is based on a logic that can maximize strengths and opportunities, but at the same time can minimize weaknesses and threats (Wiswasta et al., 2018). The SWOT (Strengths, Weaknesses, Opportunities, Threats) method is a strategic analysis tool that aims to identify internal and external factors that affect the performance of a system or organization SWOT analysis is often used by several companies to identify internal and external performance inhibitors and enhancers, analyze these factors based on their estimated contribution to net worth and estimated control, and decide what actions to take that will be taken in the future regarding these factors. In the context of this study, the use of SWOT on the ZP D 43 axle counter damage analysis serves to evaluate the strengths of the existing system, identify technical and operational weaknesses, and formulate improvement opportunities and threats that must be anticipated. SWOT allows for a holistic and systematic approach by bringing together internal factors such as device condition and quality of care, with external factors such as extreme weather or electromagnetic interference. The main advantage of this method is its ability to provide a logical basis for strategic decision-making through the grouping of key issues that affect the success of the system. Thus, SWOT can support the continuous improvement of axle counter by formulating data-based strategies, as well as improving the reliability of railway signaling systems in a sustainable manner (Leigh, 2010).

METHOD

This research method uses a qualitative approach to analyze the damage to the Axle Counter Module ZP D 43. A qualitative approach is used to understand the context and factors that influence damage. This approach can provide a more comprehensive understanding of the phenomenon being studied. Data collection is carried out through several techniques, including interviews, observations, and document analysis. Interviews were conducted with operational officers and technicians responsible for axle counter maintenance, namely the operation facility maintenance officer, PPKA. The data needed is in the form of damage/fault report data, technical data from the ZP component itself, and what causes this disturbance to occur. What needs to be observed here is what factors cause anomalous patterns on the Axle counter, namely in the ZP D 43 module so that the cause and solution can be found. According to Space (2013) Historical data analysis can help in understanding the dynamics of a system and provide insights for future improvements. The data collected will be analyzed using descriptive statistical methods to provide an overview of the frequency and type of damage that occurs. After the data is collected, the analysis is carried out using SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis techniques to evaluate the factors that affect the performance of the axle counter. SWOT analysis is an effective tool for identifying system strengths and weaknesses, as well as existing opportunities and threats. Using this analysis, it is hoped that the right solution can be found to improve the reliability of the axle counter across Maros Station. This research is expected to be the basis for further research on railway detection systems, as well as contribute to the development of railway technology and infrastructure in Indonesia. Thus, the safety and operational efficiency of trains can continue to be improved to meet the increasing crowding of the community.

RESULT AND DISCUSSION

1. Result

This research is focused on the ZP D 43 Module device with the ZP13 device number of the Siemens brand which is located at the Maros station. The data obtained are data from failure findings, historical data in the form of preventive forms, interviews with experts, and datasheets from the ZP D 43 Module itself. Furthermore, the results of the analysis will be compared with the findings of the relevant previous research. Research by Fatkhan et al. (2021) shows that environmental conditions can affect the performance of axle counters and emphasizes the importance of regular maintenance. Furthermore, the results of the analysis will be compared with the findings of the relevant previous research. The frequency of time the axle counter damage occurs here is uncertain, but some cases are found at least every 2-3 months, anomalous patterns of the axle counter are found for several days until follow-up.

2. Discussion

After data collection in the form of interviews, based on the frequency of time damage to the Axle counter is not as frequent as once every few months, but occasionally there is a red track due to fault *errors* in the ZP module, The cause of the red track on the VDU (*Visual Display* Unit) display is often due to a bad cable joint on the track, not good here means connecting but the voltage goes up and down or is not fixed. And the solution to this is none other than to connect the cable using a spare cable. So when there are wires there is nothing good. This means that it is necessary to find and disassemble the joint and then repair it, but one of the latest anomalies that occurred on December 19, 2024 on ZP D 43 was damaged due to lightning strikes that required a total replacement of the ZP D 43 module.

Source: Research Results

Figure 1. Documentation of the Discovery of the Burning ZP D 43 Module

It can be concluded from the picture above, there is an indication of a report from the field officer who reported that the indication of ZP0413 on the ACM is orange which means that there is a problem of damage to the ZP D 43 module, which causes the TCB Module as a counting head to be damaged. The image above shows the ZP Module which is allegedly struck by lightning, Lightning is a flash of light in the atmosphere that consists of thunder and is caused by the release of electricity. Lightning is generated in electrically charged storm systems (Mudhalifana, 2016). According to data from BMKG on lightning strike information on Sulawesi Island during January 2025, the Total CG (*Cloud to* ground) Lightning Strike varies greatly. The total number of CG strikes in January 2025 decreased slightly when compared to December 2024. This strengthens the assumption of a lightning strike that occurred right at the time the Axle counter was suspected of a lightning strike. When a lightning strike occurs in the transmission line, an overvoltage occurs, causing ground disturbance and insulation failure (*back flashover*). This *flashover* phenomenon occurs when the voltage across the insulator line exceeds the critical voltage of *the flashover*, causing a fire crack in the insulator (Pangestu, 2020). The insulating device in this case is the grounding system on the Axle counter. Actually, it did not hit the ZP module directly, but the affected rail then spread to the *counting head*, from the *counting head* it propagated to the ZP D 43 module that was hit by lightning, it was found that the module and counting head were damaged" from the results of interviews from technicians in the field. For the Axel counter module, it can actually be repaired here, but it depends on the damage. For example, a small device attached to the module with this soldering method can still be combed or repaired, while in this case the ZP module which is considered "burned" due to the propagation of lightning strikes must replace all units, especially the TCB module of the ZP module. The following is the technical data of the ZP D 43 device:

Table 1. Technical data of the ZP D 43 device

Operating frequency	43 kHz
Wheel detection equipment supply voltage optional	30 V DC to 72 V DC 26 V AC to 50 V AC
Signal frequency f1	3.60 kHz
Signal frequency f2	6.52 kHz
Test voltage	10 kV DC to rail
Ballast resistance	0 Ω to ∞ Ω
Output impedance	135 Ω
Protective device (optional)	deflector
Power consumption	2.5 kW

Source: Research Results

From the description of the table above, it can be concluded that the input voltage to the module itself is in the form of DC, and there is equipment that functions to protect the counting head in the form of *a defletor* located next to the ZP module. As a physical protector of the counting head, on the other hand the protection of the counting head component from overvoltage, namely the grounding system, in this case *the deflector* which is also an electrical conductor, it can be ensured that the lightning strike that propagates through the rail is passed through *the deflector* which is also made of metal. The standard of good grounding resistance is below 5 ohms according to PUIL, The relationship between resistance (resistance) and current and voltage was discovered by a physicist named George Simon Ohm. Ohm found that the value of current is affected by voltage and resistance (resistance) Insulation must be measured because the insulation value of an object can change due to the influence of outside weather and the structure of the material itself. The external influence is where the Insulation is located, whether in a humid room or in a place with high temperatures, so that as time goes by, it is very possible that the value of the Insulation Resistance will change or decrease. While the structural factor of the insulation material is because the insulator material coats/blocks the conductor that conducts a large enough current so that it generates heat, then the structure of the insulation material automatically decreases its insulation power (Yusniati et al., 2021). This highlights the importance of insulating devices or resistance to incoming voltage even from outside the device. In addition, environmental factors around the Axle Counter are vulnerable to lightning strikes and the absence of lightning rod components around the rails. Moreover, high rainfall occurred around the location of the suspected ZP that burned.

Source: Research Results

Figure 2. Deflector Components

From all the data we collected, it can be concluded that the solution to the case of the ZP D 43 module being struck by lightning is to pay attention to the good grounding aspect, namely each rail and around the axle counter and money order. From the results of the above findings, it can be concluded that several factors can be concluded for the formation of a SWOT analysis of the cases that occurred. Here is the SWOT analysis table we created:

Table 2. SWOT Analysis

Strengths	**Weaknesses**
Technically direct handling	Limited historical data of corruption
Support of experienced technicians in the field	Limited observation time
Availability of technical documentation from officer	Poor Grounding System
Opportunities	**Threats**
Developing a monitoring system and early warning system	Dependence on spare components
Preparation of operational standards for treatment procedures based on field findings	Other areas with the potential for the same case
Improvement of protection components based on damage analysis results	Environmental and inclement weather factors that allow for easier propagation of electricity
	Budget constraints and distribution of technicians in operational areas

Source: Research Results

From the SWOT analysis above, the next TOWS Analysis will be carried out where the TOWS analysis is an extension of the SWOT analysis framework but by looking for ways to match strengths with opportunities and threats with weaknesses, the main objectives of

TOWS Analysis are Reducing threats, Taking advantage of opportunities, Utilizing strengths, and removing weaknesses. The significant difference between SWOT and TOWS analysis is the difference in the relationship between internal and external factors and TOWS analysis is needed to know what threats we will face rather than looking at opportunities first (Tumbuan, 2022). Here is a continuation of the SWOT analysis, namely TOWS:

Table 3. TOWS Analysis

TOWS ANALYSIS	**STRENGTH** Support of experienced technicians in the field	**WEAKNESS** Poor Grounding System
OPPORTUNITIES Developing a monitoring system and early warning system	**S-O** Gather experienced academics and technicians to conduct research and development related to existing systems	**W-O** Taking advantage of opportunities to develop monitoring systems and early warning systems to identify, mitigate, and improve poor grounding systems.
THREAT Dependence on *spare components*	**S-T** Develop alternative procedures or technical modifications that remain safe and compliant with standards under limited spare parts conditions.	**W-T** Audit and upgrade of the grounding system & conduct a thorough evaluation of the grounding system. Increased stock of critical components such as identification of the most vulnerable and critical components

Source: Research Results

From the TOWS analysis above, it can be concluded that the analysis can utilize advantages and reduce weaknesses, which is a more effective breakthrough in overcoming a problem. With this approach, the organization here is PT CRI can increase operational resilience and reduce potential losses due to technical glitches and repair delays. The Axle Counter system is an important component in a train traffic control system that is used to detect the presence of trains on a rail block. The axle counter itself is built from WDE (*Wheel Detection Equipements*) which consists of a counting head and TCB (*Trackside Connection Box*) located next to the rails, as well as an evaluation computer (evaluator) located in the ACR (*Axle Counter Rack*) (Weleri-krengseng et al., 2022). Disturbances in the form of sensor damage, data transmission failures, or other hardware failures. To maintain the optimal performance and reliability of the axle counter equipment, regular regular maintenance is required. Maintenance includes several important steps such as regular monitoring of the performance of the axle counter needs to be carried out to detect potential problems or disturbances from an important step.

Periodic inspections of axle counter components are carried out. In addition, maintenance also includes checking the physical condition of the evaluator modules, connecting cables of indoor equipment, and measuring the frequency parameters, voltage, and indication checks on the evaluator modules of indoor equipment (Rosyidi & Budhi Santoso, 2023). The correlation of the study is also in the form of a lack of maintenance for the component which is also in the case of the Makassar-Parepare Project, the grounding system. Then weather factors and lightning strikes where the area that allegedly struck ZP D 43 at Maros Station has the same number of lightning, Lightning is one of the natural events, which is in the form of the release of an electrical charge with a fairly high current and is transient (brief) that occurs in the atmosphere. One of the damage to the Axle counter here is suspected of causing a disturbance. Interference of the ground wire type that can result in the disconnection of the ground wire, the rise of the ground wire potential followed by *a backflashover* to the phase wire and the rise of the grounding potential of the transmission tower causing a step voltage hazard (Naibaho & Sofiyan, 2021).

Table 4. Correlation Coefficient Between Building Density and Number of Lightning Strikes in Makassar and Surrounding Areas

No	District Name	Number of Lightning	Building Density (Buildings/Km2)
1	Biring Kanaya	78	809.95
2	Bontoala	1	5313.81
3	Makassar	3	6789.29
4	Mamajang	3	5752.89
5	Manggala	29	1041.47

Source: Research Results

It can be seen from the research Susanto (2019), shows that the Biringkananya area and its surroundings have a higher potential for lightning strikes than other areas in the city of Makassar, this shows several correlations such as the greater the value of building density in an area and the smaller the number of lightning strikes. The area around Maros Station also has a small level of building density. It can be concluded from the results of the analysis above that there are several internal and external factors in the damage to the Axle counter that occurs. Internal factors that cause damage to the Axle counter are poor grounding system, lack of protection components in the module. Meanwhile, the external factors that allow damage to the axle counter are environmental and weather factors that have the potential to cause lightning strikes with high intensity, the lack of protection components in the form of lightning rods around the axle counter. The lightning protection system in the form of an internal lightning protection system can be applied to the components of the Axle counter, which aims to protect the structure and its contents from the effects of lightning strikes, such as overvoltage (Mahira et al., 2024).

CONCLUSION

From the results of this study, it can be concluded that fatal damage to the ZP D 43 Axle Counter Module was found as a new phenomenon, namely lightning strikes along with a poor grounding system causing the TCB module and other components to catch fire, the direct strike from lightning called Cloud to ground caused several sparks that spread to the ZP module components. as well as the station environment that is vulnerable to high lightning intensity. And with the SWOT approach and also TOWS, existing problems or weaknesses will be minimized well and take advantage of existing opportunities. This is very useful for companies and the community as consumers/customers, in this case a safe and comfortable train travel system. For the sake of the safety and smooth operation support system of the Makassar-Parepare Train Project, it is hoped that important components in the form of Axle Counter have a good protection and maintenance system, some specifications such as the grounding system need to be improved. There are several suggestions for PT CRI to always monitor the performance of infrastructure equipment periodically, where there are still many components that are always handled by replacing spare components and Tumbalan from other stations. From the results of the SWOT and TOWS analysis above, some suggestions or future developments are gathering experienced academics and technicians to conduct better research and SOPs in the future, Taking advantage of opportunities for the development of monitoring systems and early warning systems, Developing alternative procedures or technical modifications that remain safe and in accordance with standards, and

Auditing and improving the grounding system & conducting a thorough evaluation of the grounding system for the level of better security and safety.

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