Research Article

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Research on railroad locomotive driving safety assistance technology based on electromechanical coupling analysis

Abstract: The reliability and effectiveness of a high-speed train’s operation depend heavily on the traction drive system. The purpose of this project was to construct an electromechanical connection model for a bullet train. The model contains the gear-to-gear connection, the differential output of the transmission, which circuits similar to those found in motors, and indirect power management. The purpose of this research is to investigate how modern railroad systems have implemented locomotive driving safety assistance technologies in order to get a deeper understanding of the effects that technological progress has on train operators. The purpose of this study is to learn how technological developments have altered the job of train operators. We will investigate the feasibility, compatibility, and potential consequences of introducing innovative technologies into established workflows. We will look at how it works with current technologies, too. The current investigation has the authority to look at these issues. The ultimate goal of this project is to improve railway operations by providing essential insights for guaranteeing a balance between technological progress and human skill. The ultimate purpose of the project is to enhance the efficiency and security of railway operations. This may be achieved by strengthening the effectiveness and security of railway operations. In addition, the high-speed train model is simulated numerically to maintain that steady rate of travel, and grip, while slowing. The study determined that the stator current is the result of the interaction between the fundamental frequency and the higher harmonics of the rotational frequency. Furthermore, both frequencies can be detected even when traveling at a constant speed. Despite this, unless the rotation frequency is increased, they are often not visible. During traction, the root-mean-square (RMS) values of the rotor and stator currents are lower than that during braking. There is a significant rise in current when the wheels and brakes are first applied. The RMS value of the current lowers dramatically as grip and braking improve. As a result, it is essential to carefully consider how the change may influence the reliability of the system.

Keywords: electromechanical coupling, safety, railroad locomotive, trains

1 Introduction

The introduction of locomotive driving aid devices necessitates a careful evaluation of their legal and moral implications. As new innovations automate critical safety choices, it becomes increasingly important to consider issues of transparency, human monitoring, and possible biases. Furthermore, maintaining conformity to current train rules and emerging legislative frameworks is critical for striking a balance between technology and the safety of travelers, staff, and members of the public.

Here we look at why it is crucial to investigate the propulsion system for fast railways drive system’s changing properties in adverse situations. A traction drive system is a sophisticated electronic system comprising a power converter for regulating the electric motor, an electromotive force (EMF) for generating energy, and a geared mechanism for transmitting power to the wheels argued by Cámara-Molina et al. [1]. This research summarizes the various studies that have been undertaken over the previous several decades based upon this fluid interplay among infrastructure for wheels along with rails. This sheds light on why and how gear transmissions are increasingly being used in research outside of the traditional mechanical framework.

According to Fantechi et al. [2], studies of the lateral and vertical dynamics of the vehicle, the dynamics of wheel–rail interaction, and the use of complex dynamics in reference to the mechanisms on some trains are all examples of areas

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where this line of investigation has been fruitful. The study of railway vehicle dynamics has benefited greatly from these findings. The study also examines the dynamic characteristics of train carriages and the impact of traction motors, as well as the significant advancements made in this field. Researchers have looked at how motor harmonic torque affects tire wear, as well as how imbalanced tires might be damaged by power supplies of electrical pressure harmony. This could also have a substantial impact on the smoothness of the ride in any vehicle that is being operated.

There is a good chance that innovations in locomotive driving safety assistance technology will have a major impact on the efficacy and operations of railroads. Potential risks may be identified in real time, and speed management can be optimized, both of which have the potential to increase safety. They permit preemptive servicing, which lessens unanticipated downtime and boosts operational dependability. Operators and technology work together to make the best decisions for optimal response strategies. Simplifying the procedure for complying with rules aids in boosting safety measures. Passengers and other stakeholders may have faith in the railway system thanks to the improvements in reliability, safety, and efficiency made possible by these technological advancements.

One step toward this end, essential for the train’s safe operation, is to analyze the changing properties of the pulley network system under severe operating circumstances. In the last several decades, researchers have made great strides in understanding the impact of gear transmission systems on vehicle dynamics and the constantly changing relationship between automobiles and track systems. Significant progress has also been made in studying the potential effect of traction engines on the movement characteristics of railroad cars. Enhancing dynamic performance index numbers and ensuring maintenance-free running for bullet railways requires the theoretical guidance provided by this research. While much progress has been made in the areas of optimizing parameters and fault diagnosis, there is still much work to be done to account for all the variables that affect this ever-changing nature of fast connectivity locomotive propulsion machinery designed by Wu et al. [3].

Both the safety of the passengers and the success of the company’s bottom line depend on the efficient operation of the railroad’s locomotives. Over a long period of time, numerous types of safety methods have been created and put into effect to guarantee the complete absence of risk during train operations. One potential use of this technology that might improve road safety is electromechanical coupling analysis researched by Liu et al. [4]. An instance of the overarching technical trend we are examining is the advancement of systems that integrate mechanical and electrical components to deliver prompt input to the driver. In the long run, this technology should help make the roads safer. The system analyzes a wide range of data, such as the velocity of trains, the state of the tracks, and the weather, to create early warnings and alarms. The driver may then take necessary measures to avoid an accident on the road.

Mo et al. [5] reported in his research that this technology not only keeps passengers safe but also lowers the price of keeping locomotives and tracks in working order. As a result of these developments in technology, the electromechanical coupling analysis-based safety assistance system is now more precise and efficient than ever before. This has led to a far quicker pace of adoption of this technology by railways throughout the globe. The technology is still in its infancy, and researchers are continually looking for methods to make it more effective for safeguarding train conductors. This work is organized as follows: Background, objectives and scope are discussed in Section 1, while literature on topics such as train safety, mental workload, stress relief, and advances in technology have been investigated in Section 2. Detailed approaches and parameters analysis are discussed in Section 3 while limitations, experiments and implications of results are reviewed in Section 4. Finally, the findings and challenges are given in Section 5.

2 Literature review

2.1 Determination technology for propelling trains issues

Because of the breadth of this study, we are obligated to conduct a comprehensive analysis of cutting-edge technology that attempt to reduce the emotional strain experienced by train operators. The scope of this investigation is extensive. Locomotive safety relies heavily on human factors such as mental effort and emotional stability. Finding and implementing solutions that effectively counteract the aforementioned dangers to train operations is the driving force for this study’s investigation. Solutions that reduce cognitive load and stress might considerably improve railway operators’ safety by facilitating the improvement of decision-making processes crucial to the proper operating of locomotives. Both anxiety and cognitive load impair one’s ability to make sound judgments when timeliness is of the importance.
According to Romero et al. [6], this traction system’s relative rapidity trains may be used to create traction power. It consists primarily of the energy source supporting the propulsion motor, usually called a propulsion converter (including an inverter, DC-to-AC converter, with rectifiers) and similarly an electromotive force. The high-speed train’s engine is its lifeblood. A variety of unavoidable causes contribute to the early failure of traction systems, like this loss of deterioration between electrical and insulator windings electrical elements argued by Song [7]. Because of this, the security provided by trains is compromised. In order to treat these problems as soon as possible, knowledge of their major diagnostic techniques is crucially designed by Wang et al. [8].

Engine driver support gadgets have the capability to significantly reduce train collisions through the identification and prevention of crashes, control of acceleration, detection of monitor deviations, addressing driver fatigue, adaptation to changing environmental conditions, enhancement of traversing security, and implementation of data-driven security improvements. This comprehensive approach reduces accidents brought on by negligence by people, track problems, and adverse conditions outside, and thus improves overall railroading safety.

According to Weng et al. [9], the traction systems of high-speed trains wear down after repeated uses and break down in a variety of ways. Serious harm might result from these oversights if they are not recognized quickly. We employed a method based on Kullback–Leibler divergence and components assessment (also known as the individual variables) to spot emerging issues in the traction system before they become catastrophic. There were several preliminary power unit failures detected using this technology, proving its better computational efficiency in tests. To detect emerging problems in train traction systems rapidly and precisely, using a Bayesian structure, we improved upon the relevant machine learning technique and demonstrated its usefulness in practice argued by Wu et al. [10]. We devised a technique based on interfering isolation with an unidentified input observer to increase the accuracy of issue assessments for train traction engines under real-world settings. Understanding his key factors that influence locomotives operating security is the first stage in creating effective security support technology. The ability to reduce the likelihood of disasters is significantly increased by carefully tackling these crucial aspects. As a result, the use of these advancements could result in a significantly better operating environment for railroads.

To improve the precision with which early problems in a train’s traction system may be recognized, a strategy founded upon an increased summation of measurable fault data (ToMFIR) residuals has been designed and verified using simulation models. Insulated-gate bipolar transistors (IGBTs) are a crucial part of high-speed train powertrain systems’ electrical infrastructure. According to Yang et al. [11], improved IGBT fault detection accuracy has been achieved via the use of wavelet transform and support vector machines (SVMs). A technique based on statistical indicators and fuzzy clustering has been successfully proposed using both simulation-driven methodologies and data-driven methods. The traction control system of a train was used in experiments to further this technology. The approach was developed with the specific goal of identifying typical problems in traction systems. The authors provide a state-observation-based strategy for fault-tolerant control. A nonlinear failure dynamics model of high-speed trains was developed for this method by Yang et al. [12]. Effective deployment calls for a number of factors to come together, including the incorporation of state-of-the-art cameras, handling of live information employing advanced algorithms, creation of trustworthy internet connections, creation of intuitive interactions, automating of rescue structures, assurance of redundant operation, execution of security regulations, maintenance of connection in current equipment, delivery of comprehensive education, and so on. If this comprehensive strategy was implemented, the effectiveness and security of the railway industry, which are now excellent, would increase much more. All of those indicators are strong right now.

According to Yang et al. [13], devices and tanks for braking, and other brake-related elements, make up the bulk of a train’s braking system. Long-distance travel coupled with the high-speed train industry’s notoriously complex service environment inevitably leads to a wide variety of unexpected malfunctions. Zhang et al. [14] in his research stated that if these malfunction indicators are not repaired on time, accidents compromising safety may occur. Therefore, Zhang et al. [15] argued that studying the train braking system and its primary problem detection techniques are crucial for fault diagnostic study.

Zhang et al. [16] suggested a defect detection approach using refined inter-variate variance and stage monitoring indicators. This approach has the potential to enhance the precision of preliminary defect diagnostics in train brake systems. The authors accomplished this by fusing the concepts of inter-variate variance with four-stage categorization. Experimental evidence confirmed the enhanced performance of the technique described by Zhou et al. [17], who introduced an SVM-based diagnostic framework. This framework enhanced the efficacy of brushing characteristic selection, function computation, and simulation.
decision generating. The purpose behind this alteration was to rectify the information disparity in identifying issues with my brakes. The method relies on the development of an information space and the restriction of control variables created by Zhou et al. [18]. This method effectively reduces the number of false alarms while detecting three different types of initial defeats in advanced stopping technology for fast trains. They created a novel convex packet vertex-based solution for the issue, with the aim of accurate detection of many faults in the train’s braking system.

It is vital to do a thorough cost-benefit analysis in order to have an understanding of the financial consequences of employing new technology to improve the safety of locomotive drivers. This may be done by looking at both the costs and the potential benefits. Decision-makers may be able to gather the knowledge necessary to gain an in-depth understanding of the required financial commitment by conducting an extensive study of the nature of the financial costs. These costs include the purchase of new technology, its integration into current systems, and ongoing maintenance. This inquiry is of equal importance given the potential advantages that these technologies may provide, such as a decrease in the number of collisions, an increase in productivity, and a reduction in the costs associated with maintenance. By putting a dollar amount on these advantages, we become more prepared to compare them with the costs that go along with them and arrive at more informed judgments that strike an appropriate equilibrium between cost-effectiveness and keeping safety first. This allows us to come to the conclusion that striking an appropriate equilibrium between affordability and placing safety first is important.

3 Methodology

3.1 Using computerized management techniques for fault identification and detection in high-speed trains

3.1.1 Identifying the cause of the electrical problems

Overload, unplanned disturbances, and extreme environmental changes are just a few of the many unpredictable events that may cause performance deterioration and early component failure in high-speed train electrical systems. The trains’ ability to operate safely might be jeopardized if these minor issues are not addressed immediately. Therefore, early diagnosis of electrical system issues on trains is crucial. Figure 1 summarizes the most frequent diagnostic approaches.

Elevating the security of train operations through the use of electromagnetic connection research sticks out as a potential and cutting-edge strategy. However, further study is required to fully utilize its potential and optimize its influence on improving safety. Its functions should be thoroughly investigated in this study, as well as different scenarios for operation and how to best integrate it using engine equipment.

Since high-speed trains are designed to operate for extended periods of time in a variety of harsh environments, the electrical system’s actuators and sensors will inevitably degrade and fail over time. When seemingly minor issues are ignored for too long, disaster may strike. An innovative approach utilizing a solitary squirrel-cage induction generator operating within the d-q reference frame has been devised to facilitate the prompt detection of malfunctions in AC motors employed in high-speed trains, regardless of the type of gearbox employed. A very sensitive and accurate model was developed thanks to the utilization of a squirrel cage. As a solution to the very difficult issue of locating electrical circuits with several problems subjected to sulfuric acid, an identification approach that allots various issues with linked signs delineating distinct regions. This method has the potential to dramatically improve diagnostic accuracy. Suspension chain networks with slanted support lines may be quickly checked for problems using a machine-learning-based detecting system. A quick methodology utilizing YOLO V2 and Faster R-CNN 101 is suggested. This method is reliable and accurate enough to pinpoint the origin and nature of an issue. Using YOLO V3, a deep learning-based approach was created for object recognition in photos. When the benefits of migration learning are combined with those of data augmentation, the resulting system is not only simpler for train but also better at identifying foreign items in train electrical systems. In order to remove the inefficiencies of the current human inspection procedure, we propose an autonomous machine vision-based assessment technique to assess trained electrical systems. Damage is identified using a convolutional neural network (CNN), and its location is pinpointed using a speedy method. Powerful weighting approach (complete weighting algorithm; CWA) combines maximum entropy, maximum absolute weighted leftovers, and conventional hierarchical analysis. The study took into account all three of these advantages, showing that the approach is practical. The utilization of the Dempster–Shafer theory-based category combination technique can enhance the early
The detection of faulty capacitors in train electrical systems, hence enhancing the accuracy of fault detection. The goal of this method is to identify aging train capacitors in advance of their full failure. The diagnostic accuracy of trained electrical systems might benefit from a discrete Hidden Markov approach using $k$-means clustering. Using Lloyd’s approach to evaluate the generated sample vector set, this technique has the ability to unearth six different classes of errors, clustering using $k$-means, which uses Lloyd’s technique to statistically recognize six types of error in the amassed sample vector set.

The wide range of environmental conditions that may exist has a significant impact on the effectiveness of locomotive driving hazard assistance devices. Climate factors such as rainfall, snowstorms, and mist, as well as features of the terrain, such as curves and slopes, might impact the reliability of readings from sensors and the ability to identify obstacles. Day-to-night illumination shifts along with outside forces (for e.g., vibration, and roughness) that might impair a system’s stability. Inconsistencies in how various areas share data might be problematic. Adapting to different contexts is necessary for consistent and dependable performance in a variety of settings. Possible approaches to achieving this aim include integrating data from several sensors, analyzing the collected data thoroughly, developing prediction models, and conducting extensive tests.

Therefore, pattern recognition plays a crucial role in the process of recognizing faults for train electrical systems. ResNet, CNN, and YOLO are just a few examples of variations on the classic discrete hidden Markov model.

### 3.1.2 Fixing the problems with the train’s data and command system

Information control systems on high-speed trains consist primarily of a number of modules, including a device for communicating units for identification, management, inputs and output, a showcase unit, and various base structures. Over time, the occurrence of component failures within the car’s information control structure may pose a risk to the train’s stability, particularly if the components are not engineered for prolonged usage. The consistent functioning of high-speed trains relies on the ability to identify and fix problems with their information control systems. The most common way of diagnosis is shown in Figure 2.

Hadoop, MySQL, and HDFS provide the backbone of a big data-driven approach to realistic user-oriented fault diagnostics and failure prediction. The objective was to increase the rate at which faulty electrical control systems in trains could be identified. In order to enhance the Petri net and its ability to detect and isolate defects in the
information control system, a technique based on principal component analysis was developed. By doing so, we intended to improve the reliability of defect detection and localization. Using a multi-layer sensor, train data center, and ground data center in combination with a train safety sensor network (TSSN) allows for rapid identification of earlier warning signs about problems with computerized management networks. To accomplish this, both a typical on-the-ground data center and one built within a train were employed, incorporating a novel technique based on the Kalman filter (KF) and support vector regression (SVR). The information control system’s state prediction accuracy was enhanced, and computational time was saved, thanks to this technology. A study shown that employing a deep belief network (DBN) technique on a vehicle-mounted system outperformed alternative approaches in swiftly identifying train malfunctions. The study utilized actual defect data obtained from the Wuhan-Guangzhou high-

Figure 2: Fault diagnosis strategies for industrial control system include (b) TSSN and (c) DBN along with (a) SVR/KFs.
speed railway. The methodology was designed to improve their information control system’s dependability by making it easier to spot issues. A technique that is a statistical assessment with a very detailed issue network is the basis for this diagnosis. Defects fast speeds rail communication management network in a greater comprehensive manner. The efficacy of the method that was provided was tested by tests, and it was found that the approach was successful. Experiments demonstrated that the technique, which is constructed using D-S proof flexible reasoning plants, with failure networks, is successful for fault prediction and diagnosis. The approach employs a streamlined theory of mind to integrate data from several sensors. This approach, which increase the accuracy of problem detection in information control systems, was tested experimentally.

4 Results and discussion

Resistance is an inescapable part of the environment that the train must overcome as it passes over the track. A high-speed railway frictional barrier is made up of mostly the basic resistance plus the additional resistance. By “basic resistance” we mean the resistance that exists in every scenario in which the train operates; in contrast, by “addi-
tional resistance” we mean the resistance that the train itself creates in the slope, the curve, the tunnel, and so on. Therefore, the model used in this article only considers the effect of the fundamental resistance, and its formulation is as follows in accordance with the theory governing the computation of train traction:

\[ \omega = a + bv + cv^2, \]

where \( \omega \) is the rolling resistance coefficient, 8.6 N, \( b \) is the resistance to one trembling sway, 0.07294 N/t, and \( c \) represents the estimated percentage of wind friction, 0.00111 h/t. The base resistance is measured in Newtons per gram or N/t. A quarter traction drive system’s electromechanical connection design is shown in Figure 3. In this section, we will discuss about wiring and controls used to link the vehicle’s mechanical and electrical systems. The impact-based vehicle dynamic model can establish communication with the Simulink-based traction motor model through the utilization of third-party interfaces, enabling co-simulation. Effectively integrating locomotive driver helping hands methods with continuing railroad networks requires thorough preparation, assessment of harmony, initial testing, combining information, worker instruction, slow execution, adhering to restrictions, ongoing surveillance, and collaboration with a wide range of participants. Installation will be completed in phases with the highest possible standards of worker security and efficiency and with little disruption to existing activities.

With the aid of the impact function module, the SIMAT interface was finally put into action. To begin using the dynamic model of the car in Simulink, its input and output must be defined, and the model must be packaged. This is necessary for the dynamic model to function as intended. In direct torque management, the traction motor’s output torque is fed directly into the dynamic model. The dynamic

![Figure 3: A model of a quarter drive subsystem that is connected electromechanically.](image-url)
model's output is sent into the traction motor model, which calculates the rotor's angular velocity in real-time. Changes in radial motion value created modeling of dynamical systems is then compared to the input angular velocity value by the traction motor in order to formulate a reaction that controls the motor's torque output. In addition, the fundamental resistance is computed at the vehicle model's running speed and fed into the dynamic model. This article examines the role that internal and external friction plays in the development of fast-rail thrust. Because our model does not take into account factors like slopes, curves, and tunnels, it correctly reproduces only the most fundamental kind of resistance; nevertheless, this does not guarantee that it is an accurate representation of real-world scenarios. The results of our simulation also give some insight into the way the vehicle will behave in a variety of different situations. Due to the removal of rail abnormalities, external impacts, and ever-changing operational dynamics, the generalizability of the research may have been affected. Our study gives insight on the dynamic behavior of the traction drive system in particular situations and underlines the need for additional research that includes the whole spectrum of operational concerns. Keeping these limits in mind, we were able to conduct this study, which explains how it works.

4.1 Variable-parameter numerical simulation experiments

In this section, we will dive into the details of the simulation parameters. In addition, the simulation results in this article do not take into consideration the effect of rail irregularity using the vehicle model provided here. Starting from a standstill, the vehicle picks up speed as it obtains traction. The motor rotor may spin as fast as 152 times/s during traction, and top speeds can approach 100 km/h. When the car has been going 100 km/h for half a minute, the engine will take over and begin applying the brakes automatically. Several crucial variables must be evaluated when evaluating different locomotive driving safety support systems to identify the most efficient and feasible solutions for enhancing safety.

4.1.1 Budget investigation

The total cost of each technology, including the original purchase, installation, integration, training, continuing maintenance are determined, and any updates that may be necessary. The best options for boosting safety may be found with the use of a cost-benefit analysis.

4.1.2 Simplicity of execution

The difficulty and possible interruptions of incorporating each technology into existing rail networks are evaluated. The installation of a solution is more likely to go smoothly if it is compatible with the existing system architecture and operational procedures.

4.1.3 Efficiency in hazard justification

Each technology's history of avoiding mishaps, reducing collisions, and lowering danger levels is evaluated. Key

Figure 4: The plot shows how engine force with travel velocity changes over a moment.
Figure 5: Three-phase current in the motor stator over time.

Figure 6: An examination of the stator current attraction. (a) 100 km/h constant speed, (b) 40 km/h constant speed, (c) during a braking run, and (d) during a sudden stop.
markers of efficacy include reliability in real-world circumstances and the observed decrease in mishaps.

### 4.1.4 Correctness and exactness

The technologies’ ability to detect threats while minimizing false positives is compared. A delicate balancing act must be performed between accuracy and intervention to ensure that operational efficiency is not compromised by too sensitive systems.

### 4.1.5 Flexibility

Assess each technology’s ability to adapt to a variety of train types, terrains, and operating circumstances. Solutions that are versatile enough to adjust to different circumstances are the best bet for a preventative safety plan.

After that is completed, the motor is slowed to 60 revolutions/s, and the vehicle reaches a speed of around 40 km/h. Once the rotor speed has stabilized, the next step is to maintain 40.00 km/h for one full minute. Figure 4 shows how motor output torque and vehicle speed varied under different conditions. This propulsion engine’s power generation is around 2500.00 Nm during accelerating (as shown in Figure 4) and roughly 2,500 Nm during braking (as shown in Figure 4). However, even when running at a constant speed, the motor’s output torque will fluctuate between 0 and 150 Nm, with a mean value somewhere in the middle. The rotor speed of the traction motor increases from 0 to 132 revolutions/s during traction acceleration. This causes the vehicle to go from 0 to 100 km/h in 29.2 s. The car will remain stationary for a duration of 50.00 seconds. From that point on, the brake torque will be generated by the motor. This automobile achieves constant steady condition of operation after 62 s during high engine velocity of around 60.00 revolutions/s (the vehicle’s speed is about 40 km/h).

Figure 5 shows that the braking and traction actions cause a significant increase in the amplitude of this three-phase voltage in this generator in the electromotive force, which is minimal when this speed is constant. Transitioning between different speeds by utilizing friction velocities and braking leads to little disturbance to the existing flow.

It can be seen from Figure 6a, that the power plant for vehicles’ use motors suffers a surge in current just before it gets going. About 1400.00 A is the maximum amplitude it reaches. Precautions must be made to protect the motor from the high beginning current. When the vehicle’s brakes are applied, a sudden shift happens in the three-phase current that is flowing through the motor stator, as shown in Figure 6c. This shift happens every time the vehicle’s brakes are applied.

### 5 Conclusion

The authors conclude that they compose, “the efficacy of locomotive systems that assist drivers is of the utmost importance when trying to make certain that these advancements achieve their explicit objective of improving overall railroad safety.” Future research, development, and implementation of these technologies should be guided by the results of in-depth analyses and evaluations of their potential to mitigate risk and improve operational efficiency. The purpose of this is to learn whether these technologies are helpful. More than ever, it is crucial to have foolproof safety procedures in place for everyone who use trains and the support system that allows them to run. Doing so will ensure the reliability of crucial railway systems and the safety of passengers. Making a deliberate effort to improve and enhance every technology that contributes to locomotive safety is one of the few approaches to building a railway ecosystem that is safer and more reliable. This is crucial since there are several ways in which locomotive safety may be enhanced.

The goal of this study was to develop an electromechanical connection model that is compatible with current vehicle and traction control models. Traction, consistent velocity, and braking are all part of the co-simulation’s requirements. In addition, the dynamic parameters of the rotor and stator current are revealed by numerical study when the vehicle is in motion. In this case, the following generalizations are true.

In order to prevent damage to the stator and rotor of a traction motor, precautions must be taken when the vehicle is first started. The current in the stator reaches an amplitude of 1400 A, while the current in the rotor reaches an amplitude of 1250.00 A. As the vehicle’s speed increases during traction, both the stator and rotor currents decrease. Both the stator and rotor currents steadily drop as the vehicle’s speed decreases during braking. The amplitude of the capacitor oscillator is stable because the rotor and stator currents are both stable. The root-mean-square (RMS) value is used to characterize the trend of the traction motor’s current amplitude change under the transient scenario of changing speed and load. This is done to investigate typical fluctuations in current amplitude. An analogous method involved employing the short-time fourier transform (STFT) to identify fast alterations in the frequency spectrum, a concept that you may already be acquainted with.
Knowing whether these advances influence train operators and designers in the function of locomotive operator is crucial in assessing their feasibility and assuring they are easily adopted in current employment paradigms. To ensure adherence with prescribed standards while improving security and efficiency in operation, we must acknowledge the influence the technologies plays on actions, judgements, and obligations. This holistic strategy emphasizes the need of combining human knowledge with technical progress for maximum efficiency.

Analyze the recent pace and frequency of the oscillator’s three-phase current, which has a lower RMS value during braking than during idling or under load. As the vehicle’s speed increases or decreases under traction or braking, the RMS increases toward shrink. Their stator current steadily drops from its highest value of roughly 200 A during traction, and from its peak value of around 205 A during braking. The RMS value changes between 70 and 72 A when the procedure is carried out at constant speeds of 100 and 40 km/h, respectively. High harmonics within their range of motor present might represent the rotation frequency of the driving shaft and the gear meshing frequency. At a speed of 100 km/h, the frequency of voltage above the generator (about 50 Hz) is nearly two times more than the frequency of the rotation of the pinion shaft (approximately 24.56 Hz). At speeds of about 40 km/h, a pattern somewhat dissimilar to the one described above may be seen. These greater order sine waves are both visible and especially audible actual time of whole brakes power grip operation, unlike the rotational frequencies at two constant speeds.

Locomotive operating safety aid technologies need to be tailored to individual rail networks and regions to be effective. These technologies have the potential to efficiently address many challenges that are unique to the area if the requirements are studied, algorithms are modified, sensor sets are changed, and the communication infrastructure is modified. Technology may be made more flexible via the use of user interfaces, regional standards, cultural norms, and specific training programs. Matching the needs of the community with the capabilities of the technology may be achieved through collaboration amongst a wide range of stakeholders, pilot testing, and ensuring that the technology can be scaled. This enables researchers to track the technology’s performance and make adjustments as needed. This strategy implements safety-improving technology throughout the rail network for maximum safety and efficiency. Technology that increases security measures might be used to accomplish this. The plan’s objective is the uniform use of various safety-related technologies.

There has been a rise in the number of measures taken to ensure the safety of current high-speed trains, despite the fact that they provide more convenience and luxury than ever before. High-speed trains are large and complicated, so it stands to reason that the performance of its numerous vital systems would degrade and fail prematurely throughout the course of their operation, putting passengers at risk. As a result, monitoring the condition of critical railway systems and identifying problem areas is an essential but increasingly difficult task.

Previous studies have shown that high-speed trains may employ feature extraction and pattern recognition for fault detection in critical systems. Despite this, the process is often carried out using manual inspection, test benches, and video monitoring – older, less suitable methods. To begin, current defect diagnosis approaches are not scalable enough for wide-scale web implementation. Second, the lack of comprehensive or objective monitoring data prevent thorough troubleshooting of major railway systems. Third, there is room for improvement in the present methodologies’ applicability if we’re going to use them for problem diagnostics on high-speed trains.

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References


