OPTIMIZING WIRELESS DATA TRANSFER OF RAILWAY TRACTION SYSTEMS BY DEFINING CONDITIONS

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ABSTRACT

Because of the high availability and reliability requirements of the railway traction systems, online data acquisition and analysis is very crucial. In order to provide uninterrupted passenger operation, data collected from the traction systems should be recorded and transmitted periodically to the maintenance engineer. Data size increases considerably due to the high number of data recorded at high frequency and this leads to a problem of long transmission time and excess uncategorized data.

In this paper, we propose a method for optimizing wireless data transfer of railway traction systems by defining conditions such as warnings, errors and events. Using automated real time data analysis, these predefined conditions are checked and if there is a match, only data packets between pre & post trigger times will be transmitted. Thus, data packet is limited and only categorized data is transferred. Also, thanks to the bidirectional data transfer, conditions can be updated at any desired time.

KEYWORDS

Data Acquisition, Data Transfer, Telemetry, Conditional Data Logging, Long Term Data Logging, Data Mining

INTRODUCTION

Railway traction systems include sub-units such as traction transformer, traction converter, auxiliary power unit, battery charger, gearbox and motors. The traction converter can access the data of other sub-units via sensor and communication interfaces and transmit this data as well as its own data through another communication interface. Thus, hundreds of data such as current, voltage, torque, speed, temperature and I/O (Input/Output) signals can be accessed from a common interface. This data is critical in terms of high safety, operational efficiency and rapid response in emergencies. Even if the data is checked automatically in real time, recording data is important because if a problem occurs, it may be necessary to analyze the data starting from a specific period before the problem to determine the reason. Also, it is not possible to monitor short term changes in the real time data. Therefore, while the data is monitored, it is also recorded with the data logger simultaneously.

To ensure uninterrupted passenger operations, it is necessary to collect and record data from traction systems and check it periodically by maintenance engineers.

Some difficulties arise when maintenance engineers try to collect data from data loggers placed in locked electrical cabinets. In cases where vehicles are located in different cities, access to data is seriously delayed and project costs increase. Such logistical challenges emphasize the inefficiencies of traditional data transfer methods that rely on physical connections. However, developments in internet-based data transfer offer an effective solution. This approach not only simplifies data transfer processes by eliminating the need for physical access, but also reduces unnecessary project expenses.

Transferring long-term data logs over the internet takes a long time and unfiltered data needs to be re-analyzed. By defining conditions, categorized data in lower sizes can be transferred and thus, analyzed data can be accessed in a shorter time.

This article explores the advantages of internet-based data transfer in optimizing operational efficiency and reducing costs.

LOGGING AND TRANSFERRING DATA IN TRACTION SYSTEMS

The data used by units within the traction system can be recorded via different communication protocols such as RS485, Ethernet, CAN (Controller Area Network) and MVB (Multifunction Vehicle Bus). Data is recorded at high frequency to obtain sinusoidal signals. The size of recorded data significantly increases due to the variety of data and high sampling frequency. Therefore, the time required for data analysis and transfer to the test computer is excessive. To shorten data transfer and analysis times, the data logger is programmed to create categorized data logging blocks in addition to long-term data logging. By defining the operating scenarios of the traction system to the data logger, it can be triggered in case of an unexpected scenario. A small-sized data logging block that includes pre-trigger and post-trigger times defined for the data logger can be created. Data logging block are created as specified in Figure 1.

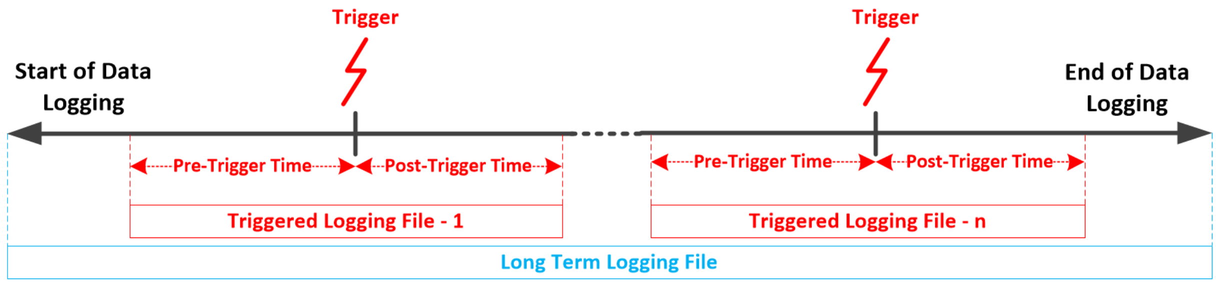

Figure 1 – Data Logging System

Thanks to filtered logs, the analysis of days-long data is done automatically and simultaneously. Long-term logging files that can be used if needed are also kept in memory while obtaining categorized data. By transferring the filtered logs to the test computer, both analyzed data is obtained with reduced data transfer time. This allows direct access of maintenance personnel to the out of scenario event without re-analyzing the transferred data. Periodic triggers can be also created, apart from scenario errors, to check the functionality of the logging and traction system routinely.

In addition to digital data, data logger records events with date and time information in a text file, automatically classifies these events and produces a summary report including statistical analysis. In this way, the frequency of the realized specified conditions can be obtained without examining any data on the graphic screen.

Internet-Based Data Transfer

The transfer between the data logger and the test computer is bidirectional. While transferring data from the logger's memory to the test computer, the current software configuration is scanned, and if there is a new configuration, the data logger's software is updated. When updates such as changing the type of log file to be transferred, modifying control scenarios or changing pre/post-trigger periods are needed, the data logger's software can be updated via remote data exchange. The block diagram of the remote data transfer infrastructure is shown in Figure 2.

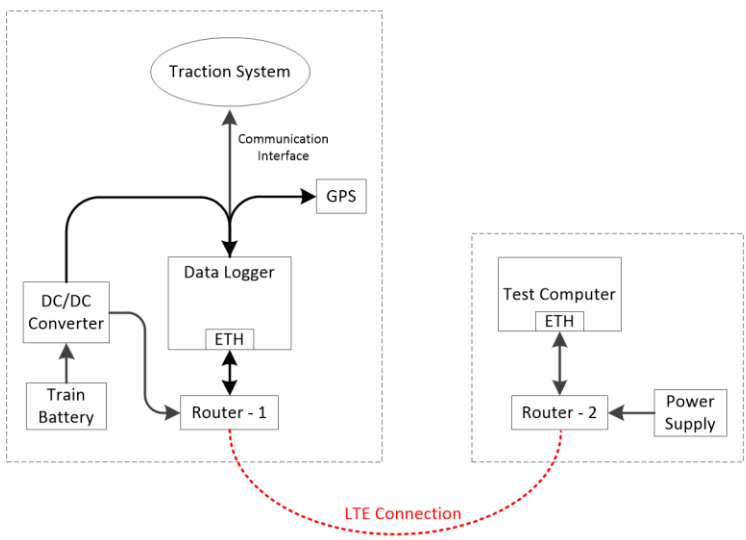

Figure 2 - Remote Data Transfer Infrastructure Block Diagram

During data transfer over the internet, the logger continues recording in the background, ensuring no data loss during the transfer. Generally, filtered logs and the summary report text file are preferred for transfer over the internet. This provides faster access to processed data. The text files created by the data logger are shown in Figure 3.

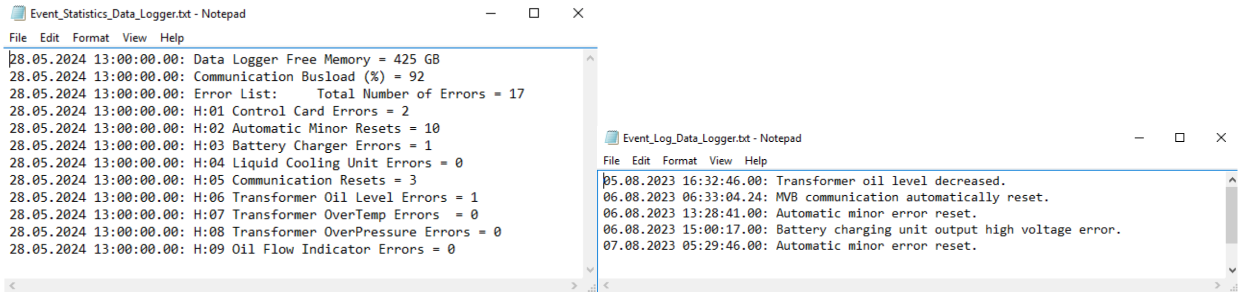

Figure 3 - Text Files Created by Data Logger

In cases where long-term data is needed, the data logger can be remotely programmed to update the type of data to be transferred, allowing long-term logs to be transferred. The block diagram of the data logging and data transfer system is shown in Figure 4.

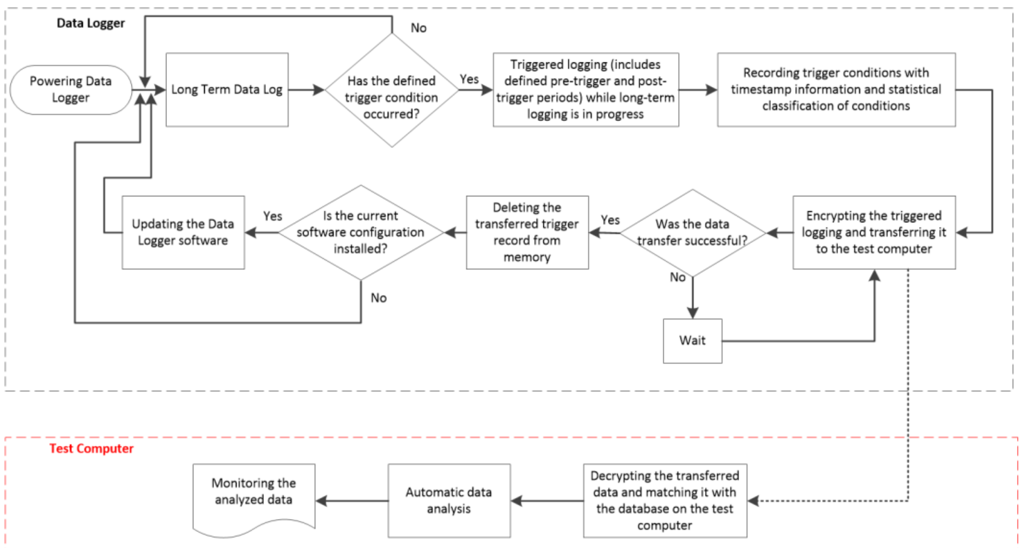

Figure 4 - Data Logging and Data Transfer System Block Diagram

Internet-Based Microcontroller Programming

While the data logger is recording data, it can also send control, request or status messages via the communication interface. Thanks to the bidirectional data exchange with the data logger, the device's software configuration can be updated remotely. The communication interface of the data logger also provides indirect internet access to the microcontrollers in the traction system. The microcontroller software loading algorithm can be developed by programming the data logger. The software file to be loaded into the microcontroller can be converted to an appropriate format and written into the logger's memory. Thus, the data logger waits for a trigger to program the microcontroller. The reason for starting programming with a trigger is to avoid potential safety issues such as the vehicle being in motion, preparing for movement, or high voltage. When the system is ready for programming, maintenance personnel can trigger to start the software loading process.

Security of Data Transferred Over Internet

Data is sent to the logger via a pre-defined static IP address with encryption. The encrypted data is decrypted on the test computer connected to this IP address. After decryption, the transferred data is matched with the database.

Advantages of Internet-Based Data Transfer

Data loggers are located in electrical cabinets inaccessible to passengers. Therefore, making a physical connection to the data logger is not always possible. In cases where data is needed to be transferred from the logger via a physical connection, challenges such as the vehicle being about to depart for an intercity journey or being in a different city can arise. These challenges cause to spend a long time on a short-term task and increase project costs.

Internet-based data transfer overcomes the difficulty of physical connection and reduces unnecessary labor, intercity travel, and accommodation costs. An example filtered data packet transferred over the internet is shown in Figure 5.

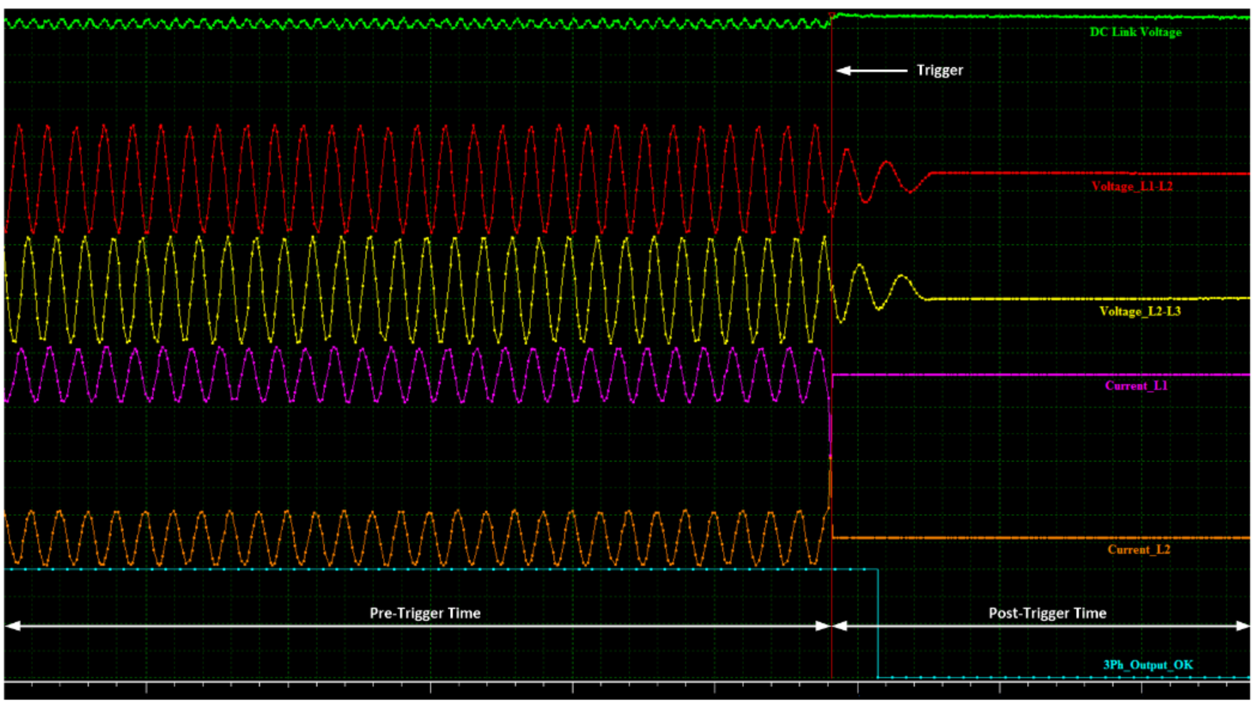

Figure 5 - Monitoring Filtered Logs Transferred to Test Computer

Data Mining

When unexpected conditions other than predefined ones are occurred, a detailed analysis is needed. To determine the start time of these detected conditions, long-term data from the past is analyzed. In this case, days or even weeks of data logs need to be analyzed. Manual analysis can take days. An increase in the number of scenarios to be scanned also prolongs this period.

Using data mining, scanning scenarios within weeks-long data logs can be completed in minutes. After the scan, the moments when relevant conditions occurred are identified and marked on the graphical screen, and the data is automatically analyzed. Additionally, new scenarios can be added to the predefined scenarios when needed. A long-term data record used data mining is shown in Figure 6.

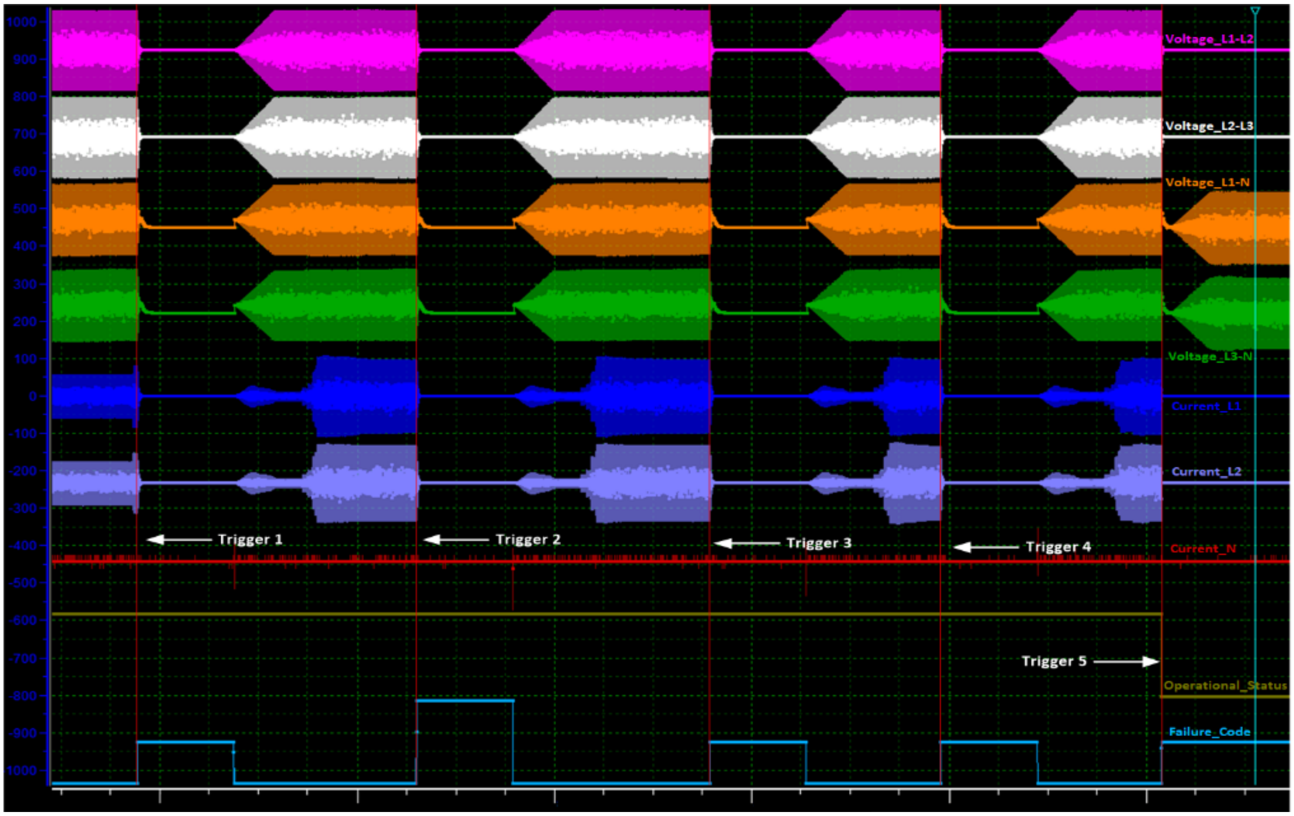

Figure 6 - Data Mining in Long-Term Data Log

CONCLUSIONS

In this study, we introduced a method for optimizing wireless data transfer in railway traction systems through the definition of specific conditions such as warnings, errors, and events. This approach leverages automated real-time data analysis to detect these predefined conditions and selectively transmit data packets only when relevant triggers occur. By focusing on the periods immediately before and after these triggers, we effectively reduce the size of the data that needs to be transferred.

The implementation of this method has demonstrated several significant benefits. First, it minimizes the size of data transmitted, thereby accelerating data transfer processes and ensuring timely access to critical information. This is crucial for maintenance engineers to maintain uninterrupted passenger operations. Second, the bidirectional data transfer capability allows for remote updates to the condition definitions and logging configurations, enhancing the flexibility and responsiveness of the system.

Furthermore, the use of internet-based data transfer eliminates the logistical challenges associated with physical connections to data loggers, such as intercity travel and the accessibility of data logger locations. This method not only reduces project costs related to labor and travel but also ensures continuous data logging and monitoring without interruptions.

Future research should aim to enhance the algorithms used for condition definition and explore machine learning techniques for more sophisticated data analysis.

In conclusion, the proposed method for condition-based data transfer offers a practical and efficient solution for managing large datasets in railway traction systems. By enabling faster and more reliable data transfer, it supports the maintenance and operational efficiency of these critical transportation systems.