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EXPERIENCE GAINED DURING EXAMINATION OF ELECTROMAGNETIC COMPATIBILITY BETWEEN ROLLING STOCK AND AXLE COUNTERS

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ДОСЛІДЖЕННЯ ЕЛЕКТРОМАГНІТНОЇ СУМІСНОСТІ РУХОМОГО СКЛАДУ І ЛІЧИЛЬНИКІВ ОСЕЙ

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ИССЛЕДОВАНИЕ ЭЛЕКТРОМАГНИТНОЙ СОВМЕСТИМОСТИ ПОДВИЖНОГО СОСТАВА И СЧЕТЧИКОВ ОСЕЙ

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Axle counters are more and more often applied in train detection systems. The wheel sensor is a main part of each axle counter system. In parallel, more and more complex railway vehicles, especially traction ones, are a potential source of interferences influencing the operation of these train detection systems. It is the reason to verify the electromagnetic compatibility (EMC) between

the signalling equipment, particularly train detection systems and new vehicles in the process of obtaining the permission for their exploitation. The measurement of interfering magnetic fields generated by vehicles is one of tests to be carried out. For the simplification and unification purpose of the applied interference test methods the EN 50238 standard and TS 50238-3 technical specification were developed. The specification defines unified testing procedures. However, it is necessary to verify if it may replace different testing methods used in particular European states. It is the goal of the European research project financed from the TEN-T network resources. This project is part of the larger project of facilitation and speeding up the ERTMS system deployment. One of nine measurement campaigns planned in the frame of this project was conducted in Poland by Railway Research Institute.

Keywords: track vacancy detection, interoperability, railway transport, axle counters, magnetic fields.

Системи підрахунку осей призначені для експлуатації на залізничному транспорті, контролю вільності (зайнятості) ділянок колії на станціях і перегонах при різних видах тяги поїздів. Датчик коліс є основною частиною кожної системи лічильників осей і має стійкість до завад, які генерує рухомий склад, і потрібну чутливість для реєстрації проходження колісної пари, точність для неприйнятності обліку зайвих колісних пар. Для досягнення згаданих властивостей датчик обліку проходження колісних пар механічно закріплюється до рейки і забезпечується розділення його електричного кола й рейки. Зазначається особливість функціонування датчика, зокрема принцип придушення магнітного поля між передавачем і приймачем датчика віссю колісної пари. З появою нових видів рухомого складу з'являються проблеми, які пов'язані з виникненням джерел перешкод і впливають на роботу цих систем. Тому виникає необхідність у перевірці електромагнітної сумісності (ЕМС) між сигнальним обладнанням, зокрема системами виявлення поїздів, і новим рухомих складом, особливо в процесі отримання дозволу на його експлуатацію. Однією з цілей проведених досліджень є вимірювання і оцінювання магнітних полів, які виникають від рухомого складу. Для спрощення та уніфікації методів випробування перешкод були розроблені стандарт EN 50238 і технічна специфікація TS 50238-3. Специфікація визначає уніфіковані методи проведення випробувань. Тому необхідно визначити можливість застосування даних методів випробувань у конкретних експлуатаційних умовах залізничної інфраструктури більшості європейських країн. Це і є метою європейського дослідницького проекту, який фінансується з мережесвих ресурсів TEN-T. Цей проект – частина більшого проекту розгортання системи ERTMS. Один з дев'яти етапів вимірювальних робіт, запланованих у рамках цього проекту, було проведено в Польщі Інститутом досліджень залізниць.

Ключові слова: лічильник осей, магнітне поле, інтероперабельність, залізничний транспорт, вимірювання.

Системы счѐта осей предназначены для эксплуатации на железнодорожном транспорте, контроля свободности (занятости) участков пути на станциях и перегонах при любом виде тяги поездов. Датчик колес является основной частью каждой системы счетчиков осей. С появлением новых видов подвижного состава появляются проблемы, связанные с возникновением источников помех, влияющих на работу этих систем обнаружения поездов. Поэтому возникает необходимость в проверке электромагнитной совместимости (ЭМС) между сигнальным оборудованием, в частности системами обнаружения поездов, и новым подвижным составом, особенно в процессе получения разрешения на его эксплуатацию. Одной из целей проведенных исследований является измерение и оценка магнитных полей, которые возникают от подвижного состава. Для

упрощения и унификации применяемых методов испытания помех были разработаны стандарт EN 50238 и техническая спецификация TS 50238-3. Спецификация определяет унифицированные методы проведения испытаний. Поэтому необходимо определить возможность применения данных методов испытаний в конкретных эксплуатационных условиях железнодорожной инфраструктуры большинства европейских государств. Это является целью европейского исследовательского проекта, финансируемого из сетевых ресурсов TEN-T. Этот проект – часть более крупного проекта развертывания системы ERTMS.

Ключевые слова: счетчик осей, магнитное поле, интероперабельность, железнодорожный транспорт, измерение.

Introduction. One of the basic function performed by the railway signalling devices is track occupancy detection of the specified part of the railway network. It may be a section of main track, station track, junction or any other separated region which needs continuous occupancy detection in order to provide safe and uninterrupted rolling stock movement. In the past, this function was mostly realized by the various types of track circuits which primary operating principle is based on indicating electrical (galvanic) shunting of each rail with rolling stock axles. Therefore such devices are detecting track occupancy continuously along all track circuit area under condition of preserving proper electrical isolation between rails. In addition as a side effect of above mentioned method diagnostic of rail cracks rail is possible due to the fact that rail continuity is required for track circuits operation. If rail is cracked or broken then automatically track circuit indicates track occupancy permanently. However difficulties in the application of track circuits and need to maintain necessary technical parameters of track and roadbed contributed to the development of alternative methods for track occupancy detection so called axle counters systems.

Axle counters detect passing of a trains between two points of a track via wheel sensors that are installed on each end of a supervised section. Each time train passes over wheel sensor with the first axle counting process starts. The same process takes place in the second counting point and if two counts have the same values the track is indicated as unoccupied and clear for next train. Each

counting head consists of two independent wheel sensors therefore each device is able to detect speed and direction of a train. To improve the reliability axle counting systems are usually designed with redundancy that means at least two independent channels are used to generate information regarding track status.

The aim of the study. Nowadays European railways are more often increasing the number of axle counters systems installations in relation to track circuits devices. Railway infrastructure managers exchanged a lot of track circuits for the axle counter systems, especially on the main lines of fundamental importance for the whole transport system. This is directly linked with the issue of ensuring the proper safe and uninterrupted operation of axle counting systems that are resistant to the interferences generated from the rolling stock. Wheel sensors must comply with requirements for sensitivity in order to reliably detect wheel passage. Moreover this parameter has to be reduced at the same time to avoid undesirable influence of external interferences which can cause for example erroneous counting of redundant axis. Wheel sensor is mechanically attached to rail and its circuit is separated from it. However, the influence of interfering magnetic fields cannot be avoided, since the sensors operate on the principle of coupling or damping magnetic field between the transmitter and receiver of the sensor through the axis of the vehicle. Wheel sensors operate in frequency bands characteristic for a different types of axle counters. The current flowing in the rails with frequency of a sensor

or external magnetic field at this frequency will strongly affect the performance of a sensor. Magnetic field vector for currents in the rails has predictable direction, while the magnetic field vector has a direction depending on the location of interference source in relation to the wheel sensor. The impact of interference will be different for the sensor when there is no nearby axes and another when the axle will be located in the sensing area. Therefore interferences due to their origin can be divided into: currents flowing in the rails (return traction current and resonance currents in catenary), magnetic fields (fixed and variable) generated by elements of the rolling stock (eg rail brakes, eddy current brakes, electric traction motors, converters). Providing the required reliability of axle counting with usage of wheel sensors on acceptable susceptibility level determines need of elaborating electromagnetic field limits generated from a rolling stock. This issue is called EMC Electromagnetic Compatibility of railway vehicles with signalling trackside devices in that case axle counters. There are number of different types of axle counting systems around the Europe and many more of rolling stock that is usually prepared and allowed to operate in a wider area of the rail network, which results in considerable complexity of the compatibility problem. Determining acceptable levels of interference for each frequency band of operation of wheel sensor is a subject of the so-called process of frequency management and it has been defined in the technical specification TS 50238-3.

Validation of the measurement method according to TS 50238-3. Validation of measurement method regarding permitted magnetic fields levels generated from the rolling stock has been made in the scope of European project WP11. Measurement campaign was performed according TS 50238-3 in following countries: Austria, Belgium, Netherlands, France, Germany, Poland, Switzerland, Great Britain and Italy.

Research was conducted on the basis of pre-agreed programs on selected sections of railroads or special test tracks for all traction supply systems, i.e. For 1.5 kV and 3 kV DC and 15 kV and 25 kV AC. Each measurement campaign included: measurements of magnetic fields generated from rolling stock performed in consistent manner in accordance with the technical specifications TS 50238-3, measurements in accordance with applicable national test procedures of axle counter response in case of magnetic field limit exceedances, post processing of collected data in order to compare interferences levels with existing national limits.

Measurement campaign in Poland. Railway Research Institute was responsible for performing Polish measurement campaign and representation of the final results. In regard to abovementioned issues there was a need to set up test system for measuring magnetic field emissions generated by rolling stock. Railway Research Institute acquired all necessary components and build up complete measurement system that provides testing of both sides of vehicle at the same time. It was made according to the technical specification TS 50238-3 and the measurement is performed in three dimensions by specially designed antennas. The examination involves performing of a several test runs by the tested vehicle over the sensors and recording the levels of generated magnetic fields. In accordance to TS 50238-3 requirements measurement has to be conducted independently in three mutually perpendicular dimensions marked with letters: X, Y, Z. Location of each measurement direction is illustrated on Fig. 1.

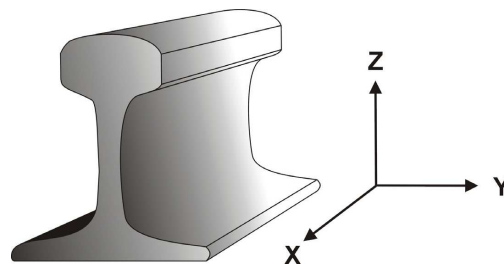


Fig. 1. Measurement directions

In all stages of the Polish campaign measurements were carried out simultaneously using two antennas mounted on the inner side of rails in order to measure maximum level of

disturbances generated from the examined rolling stock regardless of any asymmetry in the position of the interference source on the vehicle (Fig. 2).



Fig. 2. Two measurement antennas mounted to the rails

In the first phase of the project all participants elaborated measurement schedules. Polish campaign was planned to take place first on the Test Ring near Żmigród that belongs to Railway Research Institute and after that on a regular railway line with high density of train movement. The purpose of conducting measurements on the railway line in service was to examine as many types of vehicles as it was possible. Through measurements performed on the Test Ring personnel had opportunity to familiarize with new research equipment, test procedures and processing of collected data according to TS 50238-3. Realization of the measurements on the Test Ring also allowed to extend the range of examined vehicles. Second stage of Polish campaign was conducted on CMK line which is currently one and only line in Poland that allows trains to travel with a speed up to 200 km/h. Thus that fact there was possibility of performing measurements with a speed which was not possible to achieve on any other line in Poland. As it was mentioned before third stage was carried out on line with high density of railway traffic. Regarding project

assumptions it was the most important phase and therefore measurements duration was the longest and number of tested vehicles was the largest. Data acquired during all phases of Polish measurement campaign after digital processing led to some conclusions regarding inferences levels generated from variety of rolling stock on 3 kV railway lines. Accuracy of measuring method and measurement equipment was confirmed on the basis of final results. After examination of the same vehicle within few days of the measurements it was visible that results were very similar to each other every time. Visual presentation of measurement is something like a footprint of particular vehicle and it is a unique like human fingerprints.

Exemplary results of magnetic fields strength measurement are presented on Fig. 3, 4 and 5. Every time measurement was taking place it was automatically compared with the limit values set out in technical specifications for each of the directions. Measured data are marked with blue color, red color represents limit values for each of the three directions.

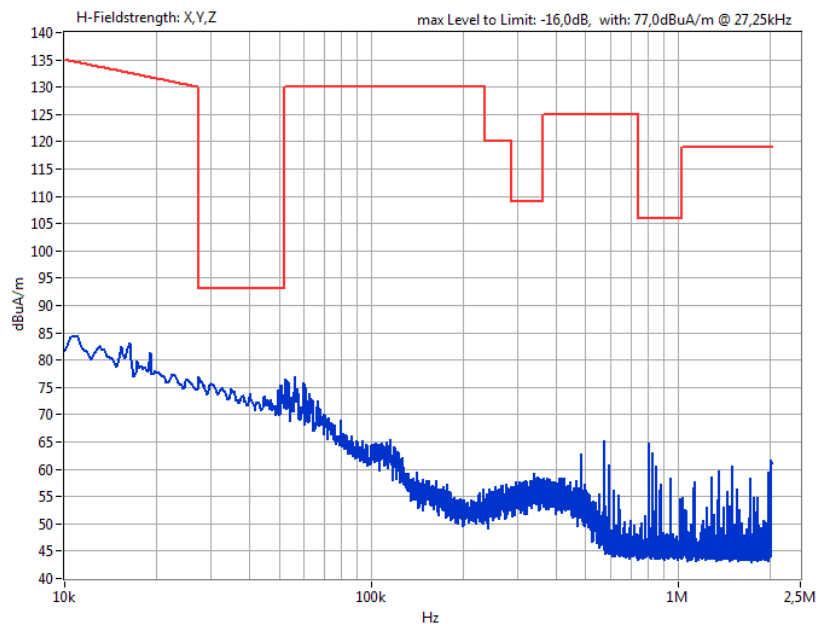


Fig. 3. Exemplary result of measurement in X direction

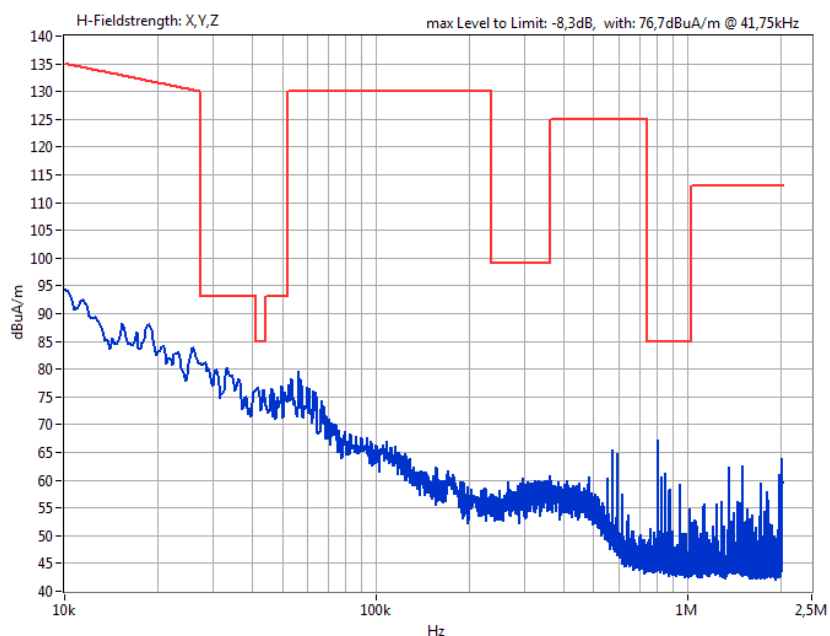


Fig. 4. Exemplary results of measurement in Y direction

Conclusions. Measurement method and used equipment provided repeatability of results on acceptable level what ensured reliability under condition of regular calibration of whole system according to procedures. Further conclusion concerning tests was that it is possible to distinguish some groups of vehicles regarding results types.

First of all electric traction vehicles equipped with electro-mechanical traction converters generated significantly less disturbances than the newer generation vehicles equipped with electronic converters. Interference generated by diesel locomotives, which were even smaller and mostly did not exceed disturbance of a background noise.

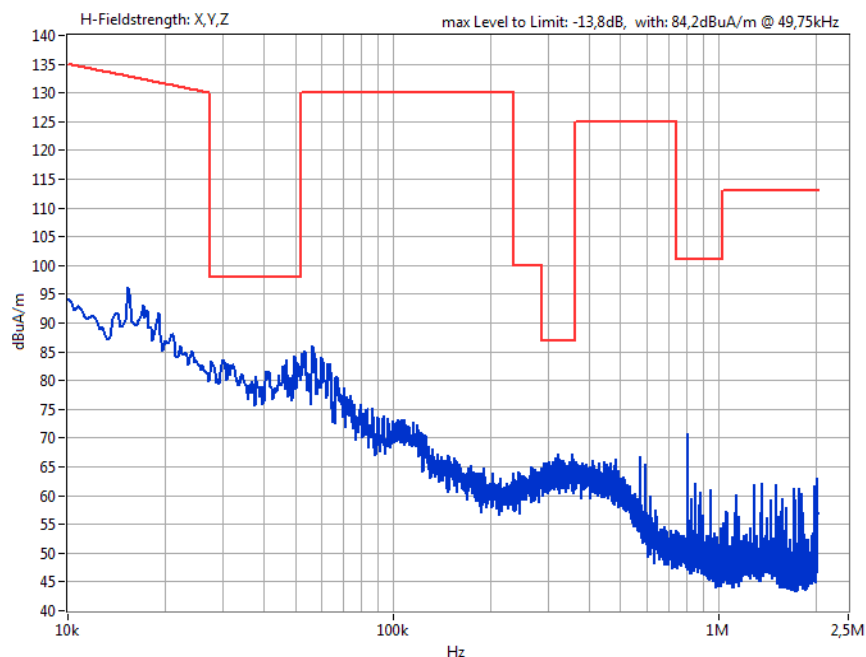


Fig. 5. Exemplary result of measurement in Z direction

Moreover it was noticed that the higher values of magnetic fields were observed in Y and Z directions. Experience gained so far also indicates that the magnetic fields strength exceedances emitted by rolling stock generally concern the measurement plane Y. This is due to the mutual influence of magnetic fields generated from rail currents and from rolling stock in this direction. Results gathered during campaign in all countries that participated in the project may contribute to elaboration of uniform European measurement method of disturbances from rolling stock. This step will give opportunity to eliminate all sources of exceeded interferences on the stage of approval tests. Facing the general trend of introducing axle counters on new railway lines

and replacing track circuits with them on modernized ones, the issue of testing the impact of magnetic fields on axle counters is essential and it should be carried out for the entire range of rolling stock that is operating on a rail network. Presented method of measuring magnetic field strength meets the requirements of the technical specifications of the TS 50238-3 and allows clear determination of whether the tested vehicle may affect the operation of the wheel sensors and consequently the axle counters. Such action would eliminate rolling stock that may affect the operation of axle counters, and thus will reduce disturbances in train movements allowing easier traffic management.

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