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RAILCAR PUBLIC ADDRESS SYSTEMS OPERATION WITH REGARD TO ELECTROMAGNETIC INTERFERENCE

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Summary: In this paper, the issues related to operation of railcar public address systems, which are used in rail transport, were presented. They constitute devices included in the transport telematics systems. Their aim is to ensure an appropriate level of information service for passengers by the voice information messaging. They are operated under different conditions of their present electromagnetic environment. The intended or unintended (static and mobile) electromagnetic interference, which occurs within the vast railway area, can be a cause of their functioning interference. Therefore, the proper functioning of railcar public address systems in the electromagnetic environment, which is included within the railway area, is so essential.
Keywords: operation, railcar public address system, electromagnetic interference

1. INTRODUCTION

In this paper, the basic issues connected with the electromagnetic interference impact on the railcar public address system applied within the railway environment, were presented. It is operated in various conditions of its surrounding electromagnetic environment [4, 11, 13]. The intended or unintended (static and mobile) electromagnetic interference, which occurs within the vast railway area, can be a cause of its functioning interference [12]. Due to the fact that it takes part in the transport process and it is used to provide information for travellers [21, 22], its reliable operation is extremely important [6, 8, 15, 17].

The railcar public address system plays a role of providing information for travellers [9]. It is characterised by one-way functioning, i.e. it transmits information (usually) from one location to many receivers, which are usually speakers. Receiving devices are arranged in particular cars and compartments, so that travellers can receive information.

The railcar public address system applied in the railway transport is used in the particular electromagnetic environment [18]. The natural electromagnetic environment shaped by the phenomena that occur on the Earth is seriously distorted, in particular, within the railway area. It is caused by the occurrence of a large number of electromagnetic field sources radiating in intended or unintended ways. Every electrical or electronic device powered by electricity produces its own electromagnetic field, which is related to its operation. Within the railway area, there are devices and electronic systems which should operate properly irrespective of interference, which have an impact on them (in the permitted range of levels). The systems' mutual coexistence as well as their proper functioning within the railway area in the particular electromagnetic environment, and operation without the implementation of unacceptable distortion to the environment was defined as electromagnetic compatibility.

2. ELECTROMAGNETIC INTERFERENCE PRODUCED WITHIN THE RAILWAY AREA

The concept of the electromagnetic compatibility can be defined as a possibility of the signal and interference coexistence without the loss of information included in the signal. By extending the compatibility concept in the application for railcar public address systems, the definition can be formulated as follows: an element of the electromagnetic public address systems environment is considered compatible, if the mutual coexistence of a given element (e.g. amplifier, speakers, etc.) with other elements of this environment (e.g. rail traffic management systems, railway station lighting system, power supply systems, railway telecommunications systems, etc.) can be mutually tolerated [2]. Figure 1 shows the mutual interaction of the railcar public address system and the electromagnetic environment existing in the vast railway area.

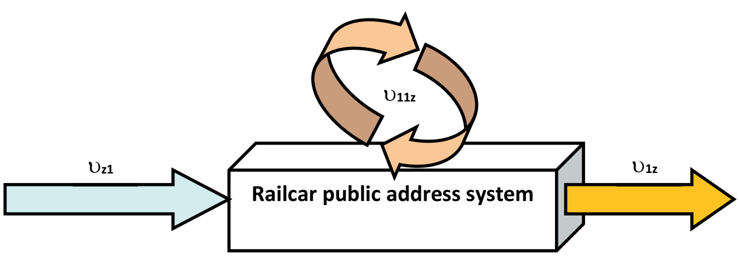

Fig. 1. The mutual interaction of the railcar public address system and the electromagnetic environment existing in the vast railway area, where:

- υ_{1z} – electromagnetic interference produced by the railcar public address system affecting other systems being in the vast railway area,
- υ_{z1} – external electromagnetic interference from other devices and systems (e.g. train traffic control system, railway traction), which are located in the vast railway area,
- υ_{11z} – electromagnetic interference generated by the railcar public address system affecting the system components.

The electromagnetic interference parameters, which occur within the railway area, should be determined in relation to the following circuits:

- current circuits of a high value of the flowing current (traction substations, overhead contact line, return circuit, traction vehicles);
- current circuits of a small value of the flowing current (rail traffic management systems, telecommunications systems, transport surveillance systems, etc.)

The interference generated by substations and traction vehicles are asynchronous interference (direct current overhead contact line), as opposed to the alternating current traction (synchronous interference). In the alternating current traction, there is one-sided power supply (each next traction section is powered by some other phase). The interference (interference spectrum) generated within the overhead contact line and by traction vehicles are synchronised with the fundamental frequency for a traction supply system.

The interference sources, which affect the railcar public address system within the railway area, include:

- traction substations with installed rectifiers (6- and 12-pulse ones),
- pulse-controlled traction vehicles of high power,
- electrical and electronic devices installed in the station building (e.g. computer systems, low-voltage internal power grid, lighting systems, internal and external public address network, commonly used devices located in the facility, etc.),
- external electromagnetic interference (e.g. from radio, TV and cell phone transmitters, internal communication within the railway area, tram power supply traction running near station buildings, high-voltage power supply electromagnetic traction, high- and medium-voltage transformer stations, etc.).

The moving source of radio interference within the railway area includes traction vehicles. The adjustment of voltage applied to the motor terminals is performed by the pulse control or with the use of resistors. The pulse control can be implemented by changing the power impulse width at a fixed frequency of their repetition, or by changing their frequency at a constant impulse width.

While applying the thyristor regulation in the motor power circuit due to commutation, current from the overhead contact line used by a vehicle has the impulsive nature. According to the Fourier theory, the impulse flow can be divided into an infinite sum of harmonics, the amplitudes and frequency of which depend on the amplitude value and the repetition period of impulses generated in the overhead contact line.

If $\omega = 2\pi/T$ means the pulsation of a periodic function f(t), which meets the Dirichlet conditions, then the f(t) function can be presented as the Fourier series:

$$f(t) = \frac{a_0}{2} + \sum_{k=1}^{\infty} (a_k \cos k\omega t + b_k \sin k\omega t) \tag{1}$$

where:

$$a_k = \frac{2}{T} \int_{t_0}^{t_0+T} f(t) \cos k\omega t dt \tag{2a}$$

$$b_k = \frac{2}{T} \int_{t_0}^{t_0+T} f(t) \sin k\omega t dt \tag{2b}$$

In the above expressions t_0 means any time value t. Coefficients a_k, b_k do not depend on the t_0 quantity selection.

The a_0 constant within the formula (1) is calculated from the a_k formula, assuming k = 0. Constant $a_0 = 0$, where:

$$\int_{t_0}^{t_0+T} f(t) dt = 0 \tag{3}$$

After the appropriate transformations, additionally marking $A_0 = a_0/2$, it is possible to present the Fourier series as follows:

$$f(\alpha) = A_0 + \sum_{k=1}^{\infty} \left(A_{mk} \sin(k\alpha + \varphi_k) \right) \tag{4}$$

where: $\alpha = \omega t$.

The expression (4) has a simple physical interpretation: every distorting periodic signal occurred in the supplying overhead contact line can be presented as a sum of $A_0 = a_0/2$ quantity and infinitely many sinusoidal waves, called harmonics. The sinusoidal quantity with the lowest (k = 1) pulsation value is called fundamental harmonics (pulsation $\omega = 2\pi/T$). Sinusoidal quantities with k pulsationω, however $k \geq 2$ are called higher harmonics.

Within the traction line, the following elements have an impact on the value and shape of the confounding variable component:

- values of currents generated by individual receiver sources X_1, X_2,..X_n, - where X_1, X_2,..X_n are traction vehicles,
- confounding variable components generated by substations supplying the traction under loading due to the own signal processing characteristics,
- position point on the railway traction, in which a vehicle is located,
- vehicle transmittance in the traction line in relation to this point.

The amplitude of harmonics generated by the current receiver (traction vehicles) are subject to the amplitudes and phases of the harmonics coming from individual traction substations.

The railcar public address system installed in the large railway area is susceptible to the interference impact. Long distances between the individual devices, which form the system, result in the necessity to use the power supply and signal cables as well as transmission buses of significant lengths. This may be a cause of inducing interfering signals in them.

3. ELECTROMAGNETIC COMPATIBILITY OF RAILCAR PUBLIC ADDRESS SYSTEMS IN THE RAILWAY ENVIRONMENT

The electronic devices applied in the railway transport are required to meet multiple criteria. They include, among others, miniaturization, electricity consumption reduction, high functionality [5], high reliability [3], vibration resistance [1]. The implementation of these requirements results in the fact that a level of useful devices signals can be compared to the level of interference generated e.g. by static and mobile interference sources (e.g. medium- and high-voltage lines, transformer stations, electrical devices). Therefore, the issue of measuring the electric field strength values and magnetic field induction for implemented or used devices of railcar public address systems becomes relevant.

The railcar public address system is mostly built of the pre-amplifier, power amplifier, control system, railcar phone (and/or microtelephone), speakers layout located in the car, power supply system [16, 20], interfaces to other systems [7, 14, 19].

Measurements of the E electric field strength and B magnetic field induction were carried out for two different stereo systems (marked as A and B types). The stereo systems (their names will not be given in order to avoid these products' advertisement) with similar technical parameters (power supply, output power level, non-linear distortion level) were examined. The measurements results constitute the characteristics of the E electric field strength distribution and the B magnetic field induction, which were presented in Figures from 2 to 5.

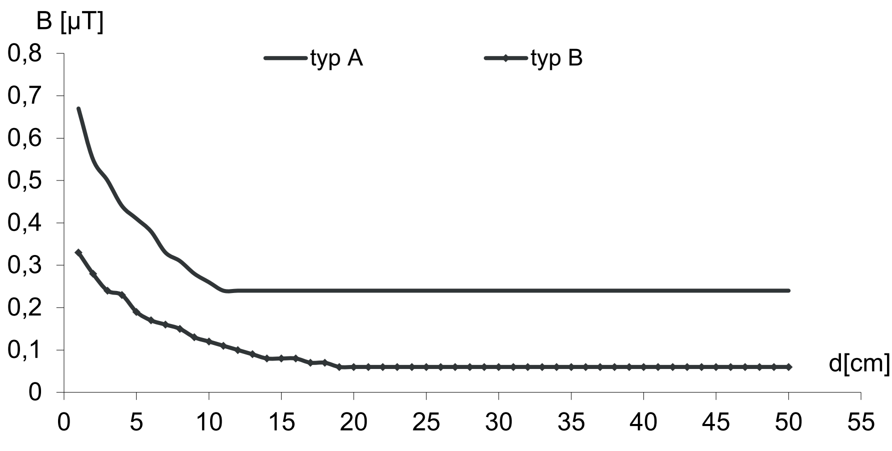

Fig. 2. Characteristics of avoiding the B magnetic field induction [µT] within the distance function d[cm] for a stereo system, in the ELF frequency range

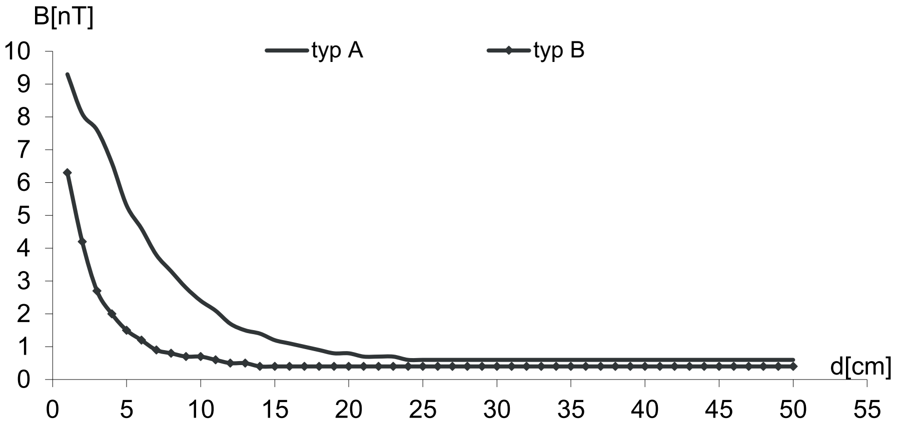

Fig. 3. Characteristics of avoiding the B magnetic field induction [nT] within the distance function d[cm] for a stereo system, in the VLF frequency range

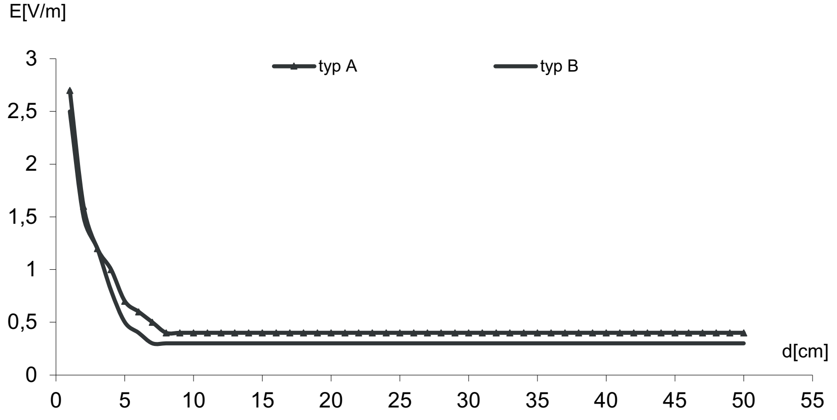

Fig. 4. Characteristics of avoiding the E electric field strength [V/m] within the distance function d[cm] for a stereo system, in the VLF frequency range

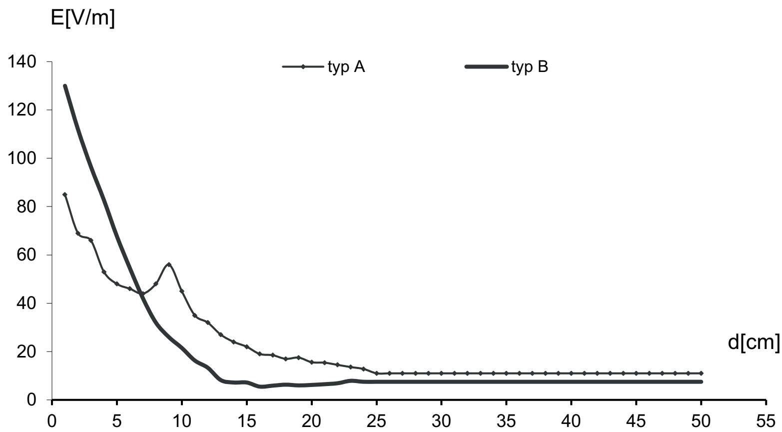

Fig. 5. Characteristics of avoiding the E electric field strength [V/m] within the distance function d[cm] for a stereo system, in the ELF frequency range

By analysing the presented characteristics, it can be stated that the B type stereo system has smaller magnetic field induction values, however the electric field strength values are comparable. The B magnetic field maximum values of both sets of columns were examined.

The B type stereo system confirmed the above statement and the magnetic field was ELF (0.05 ÷ 0.85) μT and, VLF (0.3 ÷ 0.4) nT. Appropriately for a range of the A type, the B magnetic field values significantly varied and respectively amounted to: ELF (0.09 ÷ 1.8) μT, and VLF (0.09 ÷ 61) nT. The above-mentioned measurements were carried out with the turned on passenger information announcements, and at the same level of the playback devices power.

In order to minimise the electromagnetic interference impact [10] from external devices on the electronic railcar public address systems, it is important to determine the interference source, receivers and the way in which the source is coupled with the receiver. Therefore, if the designers are familiar with the electromagnetic environment conditions, in which the railcar public address system will probably operate, then the EMC requirements, which are usually known, should be met. They can be taken into consideration already at the stage of development of the device design.

4. SUMMARY AND CONCLUSIONS

The issues presented in this paper, which were related to the electromagnetic compatibility of railcar public address systems, show the importance of these kinds of problems. The electrical and electronic systems used in the railway transport result in the fact that they operate in a very close location. It may result in an increase of the interference probability occurrence in the device operation. Therefore, while designing the railcar public address systems, it is important to prepare them to operate in actual conditions, that is among other devices. It means that the device operation should not be affected by any external sources of interference, and the public address system itself should not be a source of interference (a concept of external and internal electromagnetic compatibility).

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EKSPLOATACJA WAGONOWYCH SYSTEMÓW ROZGŁOSZENIOWYCH Z UWZGLĘDNIENIEM ZAKŁÓCEŃ ELEKTROMAGNETYCZNYCH

Streszczenie: W artykule przedstawiono zagadnienia związane z problematyką eksploatacji wagonowych systemów rozgłoszeniowych, które są stosowane w transporcie kolejowym. Są to urządzenia zaliczane do systemów telematyki transportu. Ich celem jest zapewnienie odpowiedniego poziomu obsługi informacyjnej pasażerów poprzez przekazywanie głosowe informacji. Są one eksploatowane w różnych warunkach otaczającego ich środowiska elektromagnetycznego. Występujące na rozległym obszarze kolejowym zaburzenia elektromagnetyczne zamierzone lub niezamierzone (stacjonarne lub ruchome) mogą być przyczyną zakłócenia ich funkcjonowania. Dlatego tak istotne jest prawidłowe funkcjonowanie wagonowych systemów rozgłoszeniowych w środowisku elektromagnetycznym występującym na obszarze kolejowym.
Słowa kluczowe: eksploatacja, wagonowy system rozgłoszeniowy, zakłócenia elektromagnetyczne