TRAIN CALL RECORDER AND ELECTROMAGNETIC INTERFERENCE

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Summary

Fundamental issues of electromagnetic interference influencing transport electrical equipment used for railway purposes were presented in this paper. Train call recorder is an example of such equipment and it is the focal point here. In its daily operation it is exposed to electromagnetic environment. That interference may originate from both intended and unintended (static and mobile) electromagnetic interference spanning across vast areas of railway activity. Hence the importance of uninterrupted and undisrupted functioning of train call recorders under conditions of electromagnetic environment present over areas of railway activity.

Keywords: operation, train call recorder, electromagnetic interference

PROBLEMATYKA EKSPLOATACJI REJESTRATORA ROZMÓW W ŚRODOWISKU KOLEJOWYM Z UWZGLĘDNIENIEM ZAKŁÓCEŃ ELEKTROMAGNETYCZNYCH

Streszczenie

W artykule przedstawiono podstawowe zagadnienia związane z oddziaływaniem zakłóceń elektromagnetycznych na transportowe urządzenia elektroniczne stosowane w środowisku kolejowym. Takim urządzeniem jest m.in. kolejowy rejestrator rozmów i na nim skupiono szczególną uwagę. Jest on eksploatowany w różnych warunkach otaczającego go środowiska elektromagnetycznego. Występujące na rozległym obszarze kolejowym zaburzenia elektromagnetyczne zamierzone lub niezamierzone (stacjonarne lub ruchome) mogą być przyczyną zakłócenia jego funkcjonowania. Dlatego tak istotne jest prawidłowe funkcjonowanie kolejowych rejestratorów rozmów w środowisku elektromagnetycznym występującym na obszarze kolejowym.

Słowa kluczowe: eksploatacja, kolejowy rejestrator rozmów, zakłócenia elektromagnetyczne

1. INTRODUCTION

Fundamental issues of electromagnetic interference influencing transport electrical equipment used for railway purposes were presented in this paper [4,9]. Train call recorder is an example of such equipment and it is the focal point here. In its daily operation it is exposed to electromagnetic environment. That interference may originate from both intended and unintended (static and mobile) electromagnetic interference spanning across vast areas of railway activity [1]. Because it is used in controlling train traffic, recorded data might be critical in an event of emergency concerning both people and cargo transport. After the incident, they may be used during investigation to determine the potential causes of threat to life and health of people. Hence the importance of uninterrupted and undisrupted functioning of train call recorders under conditions of electromagnetic environment present over areas of railway activity.

2. TRAIN CALL RECORDER

Train call recorder is an electronic device recording conversations and radio-telephony events [5, 6, 7]. It may be used (depending on the manufacturer) as either stationary or mobile device. The stationary model records conversations and events held over train radiotelephones or low-frequency signals generated by another analogue source. The mobile model records conversations and events held by mobile radiotelephones.

Recorded conversations and events are coded, saved into digital format, often to a flash type memory, which may be removed or replaced on an as-needed basis. It is only possible by using a special (electronic and mechanical type) key. Once the storage is full, the device overwrites oldest recordings by recording new inputs over them. Recorded alongside the sound are other parameters like time of recording which make the exercise of analysing recording all the more easier and more accurate.

Conversations and events recorded to memory card, could be played on a computer with dedicated software. The connection between train call recorder and computer is established using USD or via Ethernet. Then the recordings saved to memory card could be copied to computer hard drive. Another solution for playing and copying recorded conversations and events is to remove the memory card and insert it in a dedicated card reader.

Train call recorder is compatible with any radiotelephone. Many manufacturers equip them with additional modules, such as: GPS (either built-in or peripheral), GSM with data transfer capabilities (built-in or peripheral).

The GPS module enables location services as in determining geographical coordinates of call recorded and its current speed. The GSM module enables sending data from the recorder (concerning e.g. recorder's status) to the train traffic control room.

Fig. 1 shows general block diagram of train call recorder. It has the functionality to connect other radiotelephones (to connect the conversations they facilitate) and GPS and GSM antennas. It is powered by an external power supply. If it fails (state of reached operational capability), the redundant power supply (internal, built-in) starts running to keep the device powered up. Device is equipped with the following ports: LAN, RS-232 and USB.

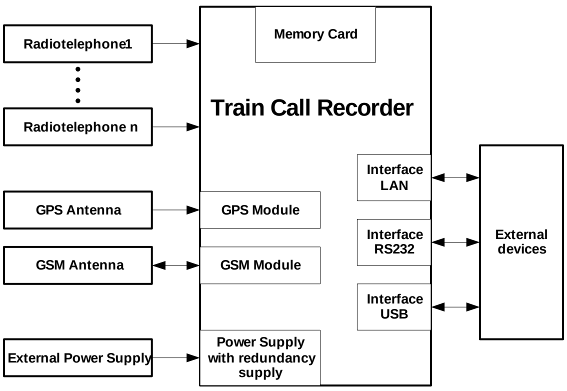

Fig. 1. General block diagram of train call recorder

3. ELECTROMAGNETIC COMPATIBILITY IN RAILWAY ENVIRONMENT

Electrical equipment used in transport systems operate in specific electromagnetic environment. The natural electromagnetic environment created by natural phenomena and elements is seriously disrupted especially over railway areas. The reason being there are numerous sources of electromagnetic fields radiating both intentionally and unintentionally. Every electric and electronic device powered with electricity generates its own electromagnetic field as it operates. Both rail track and railside equipment/electronic systems should function properly regardless of any interference [2,3]. Electromagnetic compatibility was defined as systems' ability to coincide and simultaneously function properly over railway area in given electromagnetic environment without having to introduce inadmissible disrupting factors.

Wide-band electromagnetic interference generated across railway area affects train call recorders. The spectrum of disruptive signal is determined by operating frequency of the system (devices), harmonic oscillations and intermodulation frequencies caused by non-linearity of e.g. electronic components.

Modern electronic equipment used among others in rail transport is expected to e.g. be miniature in size, energy efficient and highly reliable [10,11,12,13]. All those parameters mean the useful signals may equal interference generated by e.g. static and mobile source of interference (radio and TV stations, power transmission lines, transformer stations, electric equipment).

In order to determine the influence of electromagnetic interference on train call recorder, low frequency electromagnetic field measurements were taken, between 9^{00}am ÷12^{00} pm, at below zero ambient temperature (-3^{0}C and moderate wind). In those conditions power consumption is greater due to heating of passenger cars. Measurements were taken for two frequency bands:

- ELF – frequency band from 5[Hz] to 2 [kHz],
- VLF – frequency band from 2[Hz] to 100 [kHz],

Electromagnetic field measurements were taken in near proximity to source of interference, hence each component was measured - induction B of electromagnetic field and electric field strength E. Measurements were also taken inside a moving passenger carriage. Figure 2 illustrates the lay-out of measuring points Table 1 shows value of induction B of magnetic field. Three passenger cars were tested for sources of strong electromagnetic interference. The measurements taken were consistent with current standards for electromagnetic field measurements of frequency band (0-100) kHz.

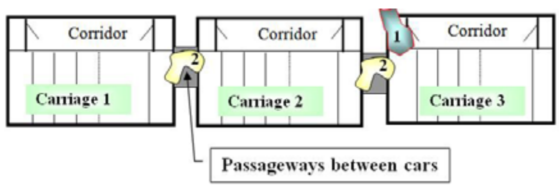

Fig. 2. Positioning of measuring points in three passenger cars

Tab. 1 Measurements of low-frequency electromagnetic field components in corridors of passenger cars

Electromagnetic field component			Carriage 1	Carriage 2	Carriage 3
Induction B of magnetic field in corridors	Induction B[μT] of the magnetic field for frequency band ELF		(0.03÷0.11)	(0.01÷0.13)	(0.07÷0.14)
	Components of induction B[μT] of the magnetic field for frequency band ELF	B_x[μT]	(0.01÷0.04)	(0.02÷0.05)	(0.03÷0.06)
		B_y[μT]	(0.03÷0.06)	(0.01÷0.04)	(0.04÷0.05)
		B_z[μT]	(0.01÷0.02)	(0.01÷0.03)	(0.01÷0.02)
Induction B[nT] of magnetic field for frequency band VLF			(0.3÷0.8)	(0.2÷1.1)	(0.5÷0.9)
Strength E[V/m] of electric field for frequency band ELF			(5.2÷15.8)	(4.2÷21)	(2.3÷24.5)
Strength E[V/m] of electric field for frequency band VLF			(0.9÷1.8)	(0.4÷2.2)	(0.7÷1.7)

The maximum value of induction B of magnetic field in passenger cars was recorded in the area behind hallway doors (measuring point 1 in fig. 2). The value of induction B of magnetic field for frequency band ELF was:

- B [μT] = (0.34÷0.51),

and of its components:

- B_x [μT] = (0.24÷0.3),
- B_y [μT] = (0.1÷0.11),
- B_z [μT] = (0.11÷0.14),

The value of induction B of magnetic field varied depending on the distance from car's floor as follows:

- 30 [cm] from floor B [μT] = 0.19,
- 1 [cm] from floor B [μT] = 0.25,
- 2 [cm] from floor B [μT] = 0.16,

In measuring point no 1, maximum value of induction B of magnetic field within the VLF frequency band was 3.1 [nT].

The electric field strength E in point 1 was recorded as follows (within both frequency bands):

- for frequency band ELF – (14÷26) [V/m];
- for frequency band VLF – (1.5÷2) [V/m];

Maximum values of electromagnetic field in lower frequency band were recorded in passageways between the cars (measuring point 2 in fig. 2). The value of induction B of magnetic field for frequency band ELF was:

- B [μT] = (0.4÷0.61),

and of its components:

- B_x [μT] = (0.02÷0.1),
- B_y [μT] = (0.41÷0.5),
- B_z [μT] = (0.02÷0.04),

The value of induction B of magnetic field for frequency band VLF B [nT]=(15÷32).

The electric field strength E was recorded as follows (within both frequency bands):

- for frequency band ELF – (14.6÷21.6) [V/m];
- for frequency band VLF – (1.2÷1.6) [V/m];

In order to minimise influence of electromagnetic interference on train call recorder a distinction has to be made between what is the source of interference and what is the receiver and how do they interact. There are three ways of stopping propagation of interference [8]:

- damping of interference at the source (e.g. shielding screening),
- employing train call recorder insensitive to interference from electromagnetic environment (electronic elements utilising latest technology);
- minimise interference transmission (e.g. decoupling filters, grounding, photocouplers, screening etc.).

Hence on the back of information concerning electromagnetic environment conditions (based on the above-mentioned tests) to which train call recorder would be exposed on a daily basis, EMC requirements should be complied with, which are usually known and should be factored in by design of device.

4. SUMMARY AND CONCLUSIONS

Because electric and electronic devices are widespread in telecommunications, automatics, IT and power engineering as well as other areas they often have to operate within close proximity from each other. Thanks to electronic circuitry used in train call recorder they shed considerably bulk of their size and they became a more "tightly packed" package. The consequence is higher probability of disruptions caused by electromagnetic interferences. Therefore, by design train call recorders need to be prepared to operate in real-life conditions i.e. to co-operate alongside other devices. Therefore, external sources of interference and the call recorder itself should not generate interference (external and internal electromagnetic compatibility).

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