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INTERFERENCE IMPACT ON THE ELECTRONIC SAFETY SYSTEM WITH A PARALLEL STRUCTURE

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Summary

The electronic safety systems are systems, the aim of which is to detect threats in the transport process – for stationary and moving objects. These systems are increasingly being used in the transport process, where they provide safety – to people as well as goods transported in the stationary and moving objects. These systems operate in a diverse electromagnetic environment. The paper presents the research results of the electromagnetic interference impact on the electronic safety system with a structure of the control panels connected in parallel. The interference impact on selected operating parameters was presented for two frequency ranges, i.e. ELF (0÷2) kHz and VLF (2÷100) kHz frequency ranges.

Keywords: safety systems, interference, parallel structure

ODDZIAŁYWANIE ZAKŁÓCEŃ NA ELEKTRONICZNY SYSTEM BEZPIECZEŃSTWA O STRUKTURZE RÓWNOLEGŁEJ

Streszczenie

Elektroniczne systemy bezpieczeństwa są to systemy, których celem jest wykrywanie zagrożeń występujących w procesie transportowym - dla obiektów stacjonarnych i ruchomych. Systemy te są coraz częściej stosowane w procesie transportowym, gdzie zapewniają bezpieczeństwo – ludziom, przewożonym towarom w obiektach stałych oraz ruchomych. Systemy te pracują w zróżnicowanym środowisku elektromagnetycznym. W artykule przedstawiono wyniki badań oddziaływania zakłóceń elektromagnetycznych na elektroniczny system bezpieczeństwa o strukturze central alarmowych połączonych równolegle. Wpływ zakłóceń na wybrane wskaźniki eksploatacyjne przedstawiono dla dwóch zakresów częstotliwości, tj. zakres częstotliwości ELF (0÷2) kHz oraz VLF (2÷100) kHz.

Słowa kluczowe: systemy bezpieczeństwa, zakłócenia, struktura równoległa

1. INTRODUCTION

The proper operation of electronic devices or equipment fitted with electronic circuits is possible by protecting them against the adverse electromagnetic fields effects [2].

The electronic safety systems are systems, the aim of which is to detect threats in the transport process. Within the vast transport area, the electronic safety system of a parallel structure with two (uniform) control panels connected with the RS-232 transmission bus can be used. In Fig. 1, the block diagram of the distributed type electronic safety system, where two control panels (1, 2) and individual modules (of power, extension and keypads) were connected with the transmission bus with the RS-232C interface, was shown. This system has a modular structure with the following configuration options:

- modules allow to extend the system capabilities to the maximum number of inputs – 256 detection circuits;
- module can be connected to max. 16 detection circuits;
- 1, 2 and d power modules are used for the entire subsystem current gain – their location depends on the lengths of the transmission buses between individual elements of the system (e.g. the d module – current gain for 40 – 45 and 46 – 50 detection circuits located in the station building);
- 1 and 2 control panels are connected with the use of separate, supervised transmission lines to a radio transmitter (alarm notification backup source to the alarm receiving centre, e.g. Railroad Guards);
- 1 and 2 control panels supervise two separate, vast transport areas of various sizes and traffic (buildings and railway platforms) [1,7,9];
- 1 and 2 control panels connected with the transmission bus exchange internal information of the microprocessors supervising the systems, operational events, provide controlling the entire system from individual control panels (CA1- CA2

– control panels do not have a priority) [3,5,7,9,15];

- control panels operate under the same operating conditions (they have the same priorities of control, surveillance, power and information supplies and operation) [1,11,16];
- keypads (w1-w4 and a4-a8) and synoptic tables are selected according to the needs of the protected transport facility [2,4,6,16].

All the modules with central processing units (1 and 2 control panels) are connected with the RS -232C interface with the use of two separate transmission buses – Fig. 1.

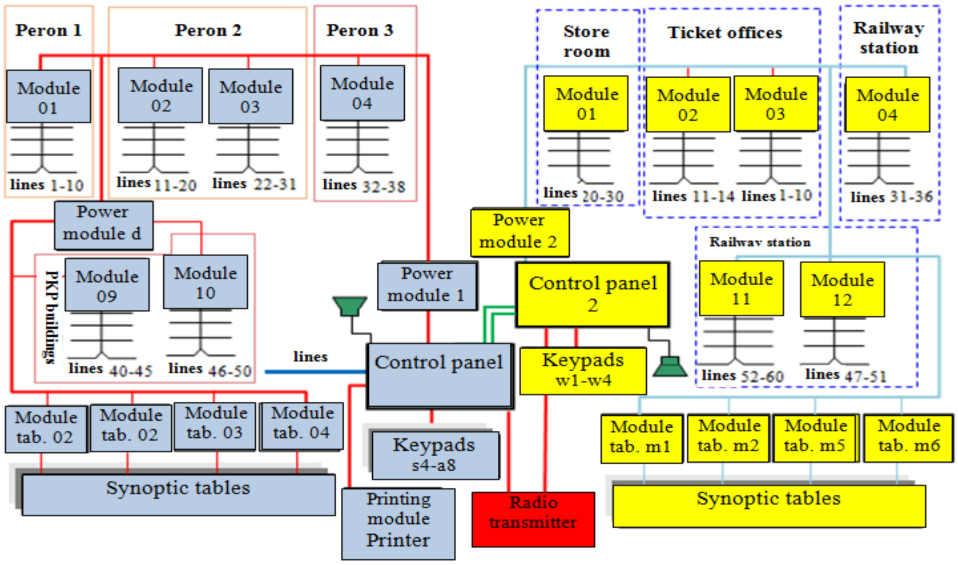

Fig. 1. The block diagram of the distributed electronic safety system with control panels (1,2) and the modules connected with the RS-232C interface with the use of transmission buses

2. THE OPERATION AND RELIABILITY RESEARCH OF ELECTRONIC SAFETY SYSTEMS

In order to determine the selected reliability indicators, the operation research of the electronic safety system was conducted. The operation and reliability [17] research included the electronic safety systems consisting of two control panels (n = 30 units) and were carried out during the one-year period (1 year = 8760 hours). At that time, the control panels were damaged – m_l=3 units. In total, m = 2 systems were damaged (within one system, two control panels were damaged, and in the second case – one control panel).

In order to estimate the reliability during the observation period t_B = 8760 hours, the following stochastic dependence, suitable for irreparable elements, that is operating to the first damage, can be assumed:

$$R_{c1}(t_B) = \frac{n - m_1}{n} = \frac{30-2}{30} = 0{,}93$$

$$R_{c2}(t_B) = \frac{n - m_2}{n} = \frac{30-1}{30} = 0{,}97$$

By knowing the $R_{c1}(t_B)$ and $R_{c2}(t_B)$ reliability values, the λ_{c1} and λ_{c2} parameters of this distribution can be determined [9,12,13]. For the exponential distribution (assumption: the electronic safety system elements are subject to preliminary ageing in the manufacturing plant), the following dependence can be used:

$$R(t_B) = e^{-\lambda t_B} \text{ for } t \geq 0$$

so

$$\lambda = -\frac{\ln R(t_B)}{t_B}$$

For t = 8760 [h], $R_{c1}(t_B)$ = 0.93, $R_{c2}(t_B)$ = 0.97 we obtain:

$$\lambda_{C1} = -\frac{\ln R_{C1}(t_B)}{t_B} = -\frac{\ln 0{,}93}{8760} = \frac{0{,}0725}{8760} = 8{,}28 \cdot 10^{-6} \quad \frac{1}{h}$$

$$\lambda_{C2} = -\frac{\ln R_{C2}(t_B)}{t_B} = -\frac{\ln 0{,}97}{8760} = \frac{0{,}16}{8760} = 3{,}48 \cdot 10^{-6} \quad \frac{1}{h}$$

By knowing the λ_{C1} and λ_{C2} parameter values, it is possible to calculate the expected operation time value between subsequent damage:

$$E(T_{C1}) = \frac{1}{\lambda_{C1}} = 120773 \quad h$$

$$E(T_{C2}) = \frac{1}{\lambda_{C2}} = 287356 \quad h$$

In case of the electronic safety system with a parallel structure operating without interference and the observation time t_B = 8760 h, the probability of the system's staying in the following states is:

- in the state of complete usability $R_O(t_B)$:

$$R_0(t_B) = \exp(-\lambda_{C1} \cdot t_B) = 0{,}93$$

- in the state of impendency over safety $Q_{ZB1}(t_B)$:

$$Q_{ZB1}(t_B) = \lambda_{C1} \cdot \left[\frac{\exp(-\lambda_{C2} \cdot t_B) - \exp(-\lambda_{C1} \cdot t_B)}{\lambda_{C1} - \lambda_{C2}} \right] = 0{,}068896$$

- in the state of unreliability of safety $Q_B(t_B)$:

$$Q_B(t_B) = \lambda_{C1} \cdot \lambda_{C2} \left[\frac{\exp(-\lambda_{C1} \cdot t_B)}{\lambda_{C1} \cdot (\lambda_{C1} - \lambda_{C2})} - \frac{\exp(-\lambda_{C2} \cdot t_B)}{\lambda_{C2} \cdot (\lambda_{C1} - \lambda_{C2})} + \frac{1}{\lambda_{C1} \cdot \lambda_{C2}} \right] = 0{,}001068$$

The reliability of the entire system is:

$$R_S(t_B) = R_0(t_B) + Q_{ZB1}(t_B) = 0{,}998896$$

The mean time to repair single damage was Tnśr = 20 h. During the annual observation period, among n=30 units of the electronic safety systems, m=3 damage to the systems were observed. Therefore, the average operation time of individual systems is:

$$T_{psr1} = \frac{1}{n} \left(\sum_{i=1}^{n-m} t_{pi} \cdot n_1 + \sum_{j=1}^{m} t_{pjsr} \cdot m_1 \right) = \frac{1}{30} (8760 \cdot 27 + 8740 \cdot 3) = 8758 \ h$$

where: n_1 – a number of expansion modules, which were not damaged during the annual observation (n_1= n - m = 27), m_1 – a number of expansion modules, which were damaged during the annual observation (m = 3).

In case of such conducted research and presented statistical analysis, the availability coefficient (stationary value) is a more meaningful reliability indicator:

The availability coefficient value can be taken as the electric safety system stationary reliability measure during the annual observation [9,8,10,13].

$$K_{g1} = \frac{T_{psr1}}{T_{psr1} + T_{nsr}} = \frac{8758}{8758 + 20} = 0{,}997722$$

The availability coefficient value can be taken as the electric safety system stationary reliability measure during the annual observation [9,8,10,13].

3. OPERATING PARAMETERS OF THE INTERFERENCE IMPACT ON THE ELECTRONIC SAFETY SYSTEM

The electronic safety systems are operated in different electromagnetic environment conditions – the affecting intended or unintended electromagnetic interference, static and mobile [1,3,7,18,19]. For the electronic safety system installed within the railway area, the probability values of staying in individual safety states were presented in Table 1 a, b, c, d. The calculation of the probability values of the electronic safety system's states corresponds to the interference generated within the railway area, i.e. in the following order – the electromagnetic field background in the station premises (without interference), the electromagnetic field background on the railway platform, the electromagnetic field background in the carriage during its movement, a certain level of operation safety of Γ the electric safety system (resistance) due to the electromagnetic interference [1,7,15,16,20]. The indicator value of γ the system total damage – there was accepted a level of the impact of the electromagnetic interference conducted, induced, and generated during the lightning strike impulse of certain parameters (I_{max} = 100 kA, time: pulse leading edges t_n=10 μs, half-crest-value time on the wave tail t_p=350 μs) [1,4,6,16].

Fig. 2 and 3 show the probability of the electric safety system's parallel staying for the selected γ interference indicators.

Tab. 1. The probability of the electronic safety system's staying in the individual states for the selected γ interference indicators

a) the B induction impact of the magnetic field, the ELF frequency range

γ_{B1} interference indicator value	γ_{B1}=0.44·10^{-6}	γ_{B1}=1·10^{-3}	γ_{B1}=1.56·10^{-3}	Γ_{B1}=3.66·10^{-3}	γ_{B1}=1
R_0(t)	0.966243699	0.0001522	0.0000011269	1.16·10^{-14}	0
Q_{ZB1}(t)	0.0622784	0.001316217	0.0000151599	3.6·10^{-13}	0
Q_B(t)	0.00126417	0.99853787	0.99998376	0.999999999	1

b) the B induction impact of the magnetic field, the VLF frequency range

γ_{B2} interference indicator value	γ_{B2}=2.26·10^{-6}	γ_{B2}=2.72·10^{-6}	γ_{B2}=45·10^{-6}	Γ_{B2}=342.2·10^{-6}	γ_{B2}=1
R_0(t)	0.95096084	0.947136554	0.65397588585	0.04840474	0
Q_{ZB1}(t)	0.08598224	0.089373914	0.29890381	0.1455314793	0
Q_B(t)	0.0022139244	0.002489059	0.07404858	0.808056872	1

c) the E electric field strength impact, the ELF frequency range

γ_{E1} interference indicator value	$\gamma_{E1}=7.5\cdot10^{-6}$	$\gamma_{E1}=175\cdot10^{-6}$	$\gamma_{E1}=375\cdot10^{-6}$	$\Gamma_{E1}=550\cdot10^{-6}$	$\gamma_{E1}=1$
$R_0(t)$	0.908296147	0.20940506	0.03631644	0.0078402481	0
$Q_{ZB1}(t)$	0.112953236	0.32923632636	0.119405655	0.03754805	0
$Q_B(t)$	0.006150841	0.469981124	0.84577328	0.954934536	1

d) the E electric field strength impact, the VLF frequency range

γ_{E2} interference indicator value	$\gamma_{E2}=1.63\cdot10^{-6}$	$\gamma_{E2}=20\cdot10^{-6}$	$\gamma_{E2}=37\cdot10^{-6}$	$\Gamma_{E2}=93.4\cdot10^{-6}$	$\gamma_{E2}=1$
$R_0(t)$	0.95622350835	0.814089637	0.7014506017	0.427984286	0
$Q_{ZB1}(t)$	0.0812902693	0.19749546	0.27246392	0.3733093	0
$Q_B(t)$	0.0018599169	0.02193605	0.05496858	0.2163291624	1

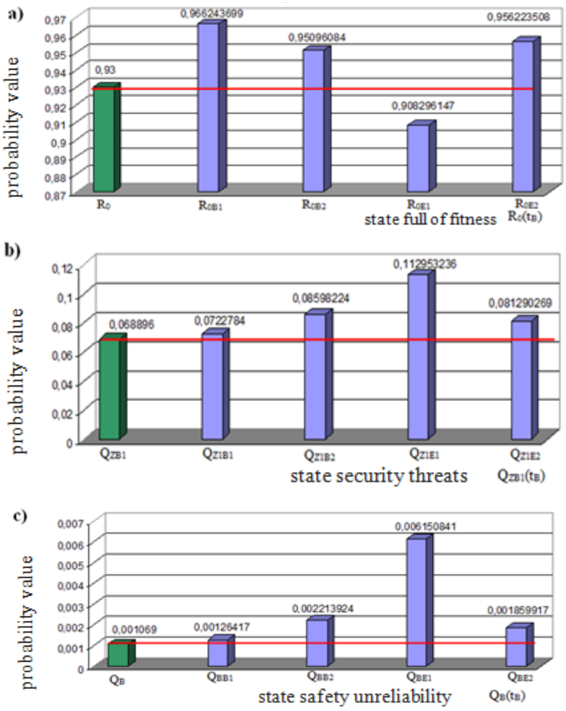

Fig. 2. The electronic safety system's staying in the individual safety states for the entire frequency range, the system used in the railway station premises with a certain level of the electromagnetic field background, a) the state of the system's complete usability $R_0(t)$, b) the state of impendency over safety $Q_{ZB1}(t_B)$, c) the state of unreliability of safety $Q_B(t_B)$, marked in Figures:

- R_0, Q_{ZB1}, Q_B – state probability values of the system operating without interference, interference indicator $\gamma = 0$;
- R_{0B1}, Q_{Z1B1}, Q_{BB1} – state probability values of the system operating with interference (the B induction of the magnetic field, the ELF frequency range);
- R_{0B2}, Q_{Z1B2}, Q_{BB2} – state probability values of the system operating with interference (the B induction of the magnetic field, the VLF frequency range);
- R_{0E1}, Q_{Z1E1}, Q_{BE1} – state probability values of the system operating with interference (the E electric field strength, the ELF frequency range);
- R_{0E2}, Q_{Z1E2}, Q_{BE2} – state probability values of the system operating with interference (the E electric field strength, the VLF frequency range).

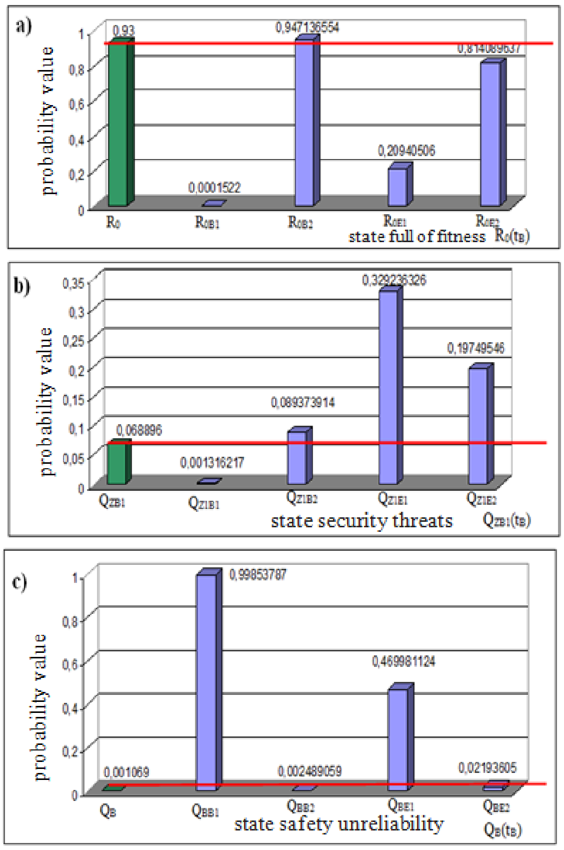

Fig. 3. The electronic safety system's staying in the individual safety states for the frequency range (the system installed within the railway area), a) the state of the system's complete usability $R_0(t)$, b) the state of impendency over safety $Q_{ZB1}(t_B)$, c) the state of unreliability of safety $Q_B(t_B)$, marked in Figures:

- R_0, Q_{ZB1}, Q_B – state probability values of the system operating without interference, interference indicator $\gamma = 0$;
- R_{0B1}, Q_{Z1B1}, Q_{BB1} – states probability values of the system operating with interference (the B induction of the magnetic field, the ELF frequency range);
- R_{0B2}, Q_{Z1B2}, Q_{BB2} – state probability values of the system operating with interference (the B induction of the magnetic field, the VLF frequency range);
- R_{0E1}, Q_{Z1E1}, Q_{BE1} – state probability values of the system operating with interference (the E electric field strength, the ELF frequency range);
- R_{0E2}, Q_{Z1E2}, Q_{BE2} – state probability values of the system operating with interference (the E electric field strength, the VLF frequency range).

4. COMPARISON OF OPERATING PARAMETERS OF THE ELECTRONIC SAFETY SYSTEMS WITH DIFFERENT RELIABILITY STRUCTURES

In Table 2, the research results of the examined electronic safety systems with different reliability structures were presented.

Two different types of the electromagnetic environment were included – the electronic safety system operated: without interference – $\gamma = 0$ and with interference (installed within the railway area - $\gamma \neq 0$ [1,4,7,16].

The impact of electromagnetic interference on the electronic safety system results in changes of the probability values of the state of complete usability $R_0(t_b)$ – Fig. 4.

The increase of the interference level results in the fact that the parameter value $R_0(t_b)$ for the parallel structure decreases linearly, reaching a value of zero for the indicator $\gamma = 1$.

Table 2. The probability of the electronic safety system's staying in the states: R_O, Q_{ZB1}, Q_B

Indicator name		Type of the electronic safety system			
		The serial-parallel reliability structure		The parallel reliability structure	
		System operating without interference $\gamma = 0$	System operating within the railway area $\gamma \neq 0$	System operating without interference $\gamma = 0$	System operating within the railway area $\gamma \neq 0$
a)	R_O	0.68	0.6667	0.9	0.882357
	Q_{ZB1}	0.127556	0.140886	0.0947435	0.113474
	Q_B	0.192444	0.193041	0.002565	0.004168
b)	R_O	0.68	0.458469	0.9	0.606797
	Q_{ZB1}	0.127556	0.349087	0.0947435	0.311476
	Q_B	0.192444	0.24693	0.002565	0.081726

a) The electronic safety system installed in the usable room of the railway station – the electromagnetic field background – the B induction impact of the magnetic field in the VLF frequency range $\gamma = 2.26 \cdot 10^{-6}$;
b) The electronic safety system installed in the carriage – the electromagnetic field measurement during the train movement – the B induction impact of the magnetic field in the VLF frequency range $\gamma = 45 \cdot 10^{-6}$.

Within the electric safety system serial-parallel reliability structure, the increase in the interference value $\gamma = 93 \cdot 10^{-6}$ does not result in changes $R_0(t_b)$ (system more resistant to interference). Above this value ($\gamma = 93 \cdot 10^{-6}$), the $R_0(t_b)$ value decrease occurred.

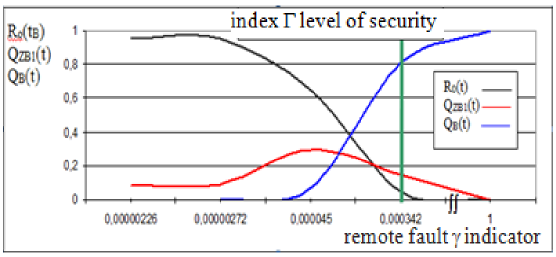

Fig. 4. The change of the probability values of the electronic safety system's operating states: the state of complete usability $R_0(t_b)$, the state of impendency over safety $Q_{ZB1}(t_b)$ and the state of unreliability of safety $Q_B(t_b)$ for the system with a parallel structure (the B induction impact of the magnetic field – the VLF frequency range).

Figure 5 presents the progression of the probability function of the system's staying in the $R_0(t_b)$, $Q_{ZB1}(t_B)$ and $Q_B(t_B)$ states depending on the γ interference indicator in case of the system with a parallel structure for a different number of the damaged control panels of the "i" installed in sequence (vector 2 1 – damage to one control panel, vector 3 2 – damage to two control panels, vector 4 3 – damage to three control panels). In case of small values of the γ interference indicator, the probability value of the system's staying in the state of complete usability is at a constant level, which has the $R_0(t_b)$ value in the following case $\gamma = 0$. Within the range of values $\gamma = (10 \div 500) \cdot 10^{-6}$, a rapid, linear decrease in the $R_0(t_b)$ value occurs. In case of this range, γ there is an increase of the $Q_B(t_B)$ value to the maximum value of one (the electronic safety system changes into the state of unfitness). The function progression of the state of impendency over safety $Q_{ZB1}(t_B)$ reaches the maximum value of $\gamma = 100 \cdot 10^{-6}$, and then it gradually decreases obtaining a value of zero for great values $\gamma > 800 \cdot 10^{-6}$ – Fig. 6.

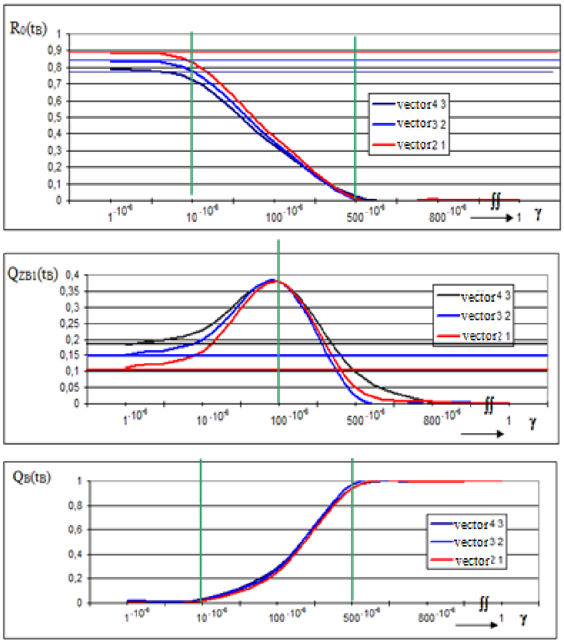

Fig. 5. The probability function progression of the system's staying in the $R_0(t_b)$, $Q_{ZB1}(t_B)$ and $Q_B(t_B)$ states depending on the γ interference indicator in case of the system with a parallel structure, for a different number of the damaged control panels.

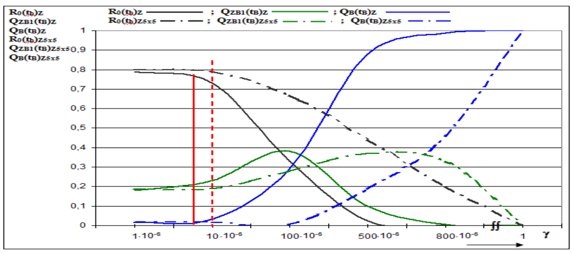

Fig. 6. The probability function progression of the electronic safety system's staying in the following states:

- $R_0(t_b)_Z$, $Q_{ZB1}(t_B)_Z$, $Q_B(t_B)_Z$ – the system installed within the railway platform area;
- $R_0(t_b)_{Z5x5}$, $Q_{ZB1}(t_B)_{Z5x5}$, $Q_B(t_B)_{Z5x5}$ – the system installed in the railway station building, which has a lightning rod of the 5x5 m "eye" dimensions.

5. SUMMARY AND CONCLUSIONS

The electronic safety systems installed in the railway station buildings due to the existing lightning rods as well as reinforced ceilings and wall barriers are characterised by greater resistance to electromagnetic interference (shielding impact of the construction works on spreading the interference within the railway area) [1]. In case of the systems with a parallel structure, the γ interference value indicator, for which the electronic safety system reaches the state of unfitness, is accordingly increased. The $R_0(t_b)_Z$ parameter decreases for $\gamma < 10\cdot10^{-6}$ in case of the electronic safety system installed within the railway platform. However, for the electronic safety system installed in the railway buildings, $R_0(t_b)_Z$ decreases for the parameter γ above the value $\gamma = 10\cdot10^{-6}$. The system changes into the state of unfitness respectively for $\gamma>500\cdot10^{-6}$ (railway platform area) and for $\gamma \approx 1$, i.e. the system (or the system's component), which is used in the railway station buildings. While designing the electronic safety system, which will be applied in a vast railway area, it is important to take into consideration the place of installing the individual system components (devices). The first step that should be completed before the system installation is to determine the natural, distorted electromagnetic environment in the railway area [1,6,14,20]. All the devices, electrical and electronic systems, which are used within the-above mentioned area, should operate with the maximum permitted power. Within the areas, where a large distortion of the electromagnetic environment occurs, it is crucial to apply the electronic safety system devices, which are less susceptible to interference, or other measures of the compatibility pyramid (e.g. shielding, signal filtering, distribution, etc.).

BIBLIOGRAPHY

1. Dyduch J, Paś J, Rosiński A. Basics of maintaining electronic transport systems. Radom: Publishing House of Radom University of Technology, 2011.
2. Paś J. Operation of electronic transportation systems. Publishing House University of Technology and Humanities, Radom 2015.
3. Burdzik R, Konieczny Ł, Figlus T: Concept of on-board comfort vibration monitoring system for vehicles, J. Mikulski (Ed.): Activities of Transport Telematics, TST 2013, CCIS 395. Springer, Heidelberg 2013. pp. 418-425.
4. Charoy A. Zakłócenia w urządzeniach elektronicznych. WNT, Warszawa 1999.
5. Duer S, Zajkowski K, Duer R, Paś J. Designing of an effective structure of system for the maintenance of a technical object with the using information from an artificial neural network. Neural Computing & Applications, vol. 23, issue 3-4, 2013.
6. Ott H W. Metody redukcji zakłóceń i szumów w układach elektronicznych. WNT, Warszawa 1979.
7. Paś J, Duer S. Determination of the impact indicators of electromagnetic interferences on computer information systems. Neural Computing & Applications, vol. 23, issue 7-8, special Issue: SI, 2013.
8. Stawowy M. Model for information quality determination of teleinformation systems of transport. In: "Proceedings of the European Safety and Reliability Conference ESREL 2014", editors: Nowakowski T., Młyńczak M., Jodejko-Pietruczuk A. & Werbińska–Wojciechowska S. CRC Press/Balkema 2015, pp. 1909–1914.
9. Rosiński A. Modelling the maintenance process of transport telematics systems. Publishing House Warsaw University of Technology, Warsaw 2015.
10. Laskowski D, Łubkowski P, Pawlak E, Stańczyk P. Anthropotechnical systems reliability. In: the monograph „Safety and Reliability: Methodology and Applications - Proceedings of the European Safety and Reliability Conference ESREL 2014", editors:

Nowakowski T., Młyńczak M., Jodejko-Pietruczuk A. & Werbińska–Wojciechowska S. CRC Press/ Balkema, London, 2015, pp. 399-407.
11. Siergiejczyk M, Paś J, Rosiński A. Evaluation of safety of highway CCTV system's maintenance process. The monograph „Telematics – support for transport", editors: Jerzy Mikulski, given as the monographic publishing series – „Communications in Computer and Information Science", Vol. 471. The publisher: Springer-Verlag, Berlin Heidelberg 2014. pp. 69-79.
12. Siergiejczyk M, Paś J, Rosiński A. Train call recorder and electromagnetic interference. Diagnostyka, vol. 16, no. 1 (2015). pp. 19-22.
13. Siergiejczyk M, Rosinski A. Reliability analysis of electronic protection systems using optical links. In W. Zamojski & J. Kacprzyk & J. Mazurkiewicz & J. Sugier & T. Walkowiak (eds) "Dependable Computer Systems", given as the monographic publishing series – „Advances in intelligent and soft computing", Vol. 97. Berlin Heidelberg: Springer-Verlag 2011, pp. 193–203
14. Sumila M. Selected aspects of message transmission management in ITS systems. In: the monograph „Telematics in the transport environment", editors: Jerzy Mikulski, given as the monographic publishing series – „Communications in Computer and Information Science", Vol. 329. Springer-Verlag, Berlin Heidelberg 2012, pp. 141-147.
15. Paś J. Analysis of exploitation access control system selected object. Przegląd elektrotechniczny, vol 2015, no 10, r. 91, pp. 219-224.
16. Paś J, Choromański W. Impact electric component of the electromagnetic field on electronic security and steering systems in personal rapid transit. Springer, Telematics-Support for Transport CCIS 471, Communications in Computer and Information Science, Springer -Verlag Berlin Heidelberg 2014, pp. 252 – 262.
17. Rosiński A. Rationalisation of the maintenance process of transport telematics system comprising two types of periodic inspections. In „Proceedings of the Twenty-Third International Conference on Systems Engineering", editors: Selvaraj H, Zydek D, Chmaj G. given as the monographic publishing series – „Advances in intelligent systems and computing", Vol. 1089, Springer 2015. pp. 663-668.
18. Lewiński A, Perzyński T, Toruń A. The analysis of open transmission standards in railway control and management. Communications in Computer and Information Science (329), Springer-Verlag Berlin Heidelberg 2012.
19. Perzyński T, Lewiński A, Łukasik Z. Safety analysis of accidents call system especially related to in-land water transport based on new telematic solutions. Communications in Computer and Information Science . Tools of Transport Telematics, No. 531. Springer-Verlag Berlin Heidelberg 2015. ISBN-13: 978-3319245768, ISBN-10: 3319245767. pp. 90-98.
20. Choromański W, Dyduch J, Paś J. Minimizing the Impact of Electromagnetic Interference Affecting the Control System of Personal Rapid Transit in the Context of the Competitiveness of the Supply Chain, Archives Of Transport, Polish Academy of Sciences Index 201 901, Volume 23, Issue 2, Warsaw 2011 pp. 137-152

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Jacek PAŚ Ph.D. Eng. - scientific interests (analog circuits, electromagnetic compatibility, reliability, low frequency noise, exploitation, diagnostics, projecting) are problems connected with comprehended wide electronic systems of the safety both for stationary as well as for movable objects.

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