rapid identification of unusual changes in passenger flow, routes, or passenger behaviour. The main methods for detecting anomalies include statistical methods, machine learning, time series analysis, and geospatial analysis. These approaches allow for the detection of sudden changes in passenger flow, unusual travel routes, or significant train delays. For example, a sharp increase or decrease in the number of passengers may be the result of accidents or natural disasters, while unusual travel routes may indicate infrastructure problems or changes in passenger behaviour. Key aspects of anomaly detection include defining a baseline level of normal system operation and selecting appropriate metrics for analysis. The use of visualisation can help better understand the nature of anomalies and their causes. Integrating data from various sources, such as meteorological data or social networks, can improve the accuracy and speed of response to unexpected situations.

Therefore, massive and prolonged disruptions have a significant impact on the models of the railway passenger travel networks, which require rapid adaptation of forecasting systems. The use of dynamic model updates and modern anomaly detection methods is a key element in minimising the negative consequences of prolonged disruptions and ensuring the stable operation of the railway transport system.

[1] Butko T., Yashchuk Yu. Enhancing passenger rail transportation efficiency through integrated intermodal hubs and risk management technologies. *Матеріали V Міжнародної науково-практичної інтернет-конференції «Напрями розвитку технологічних систем і логістики в АПВ»* – Харків: ДБТУ, 2024. – С. 7-8

[2] Nallaperuma, Dinithi, et al. Online incremental machine learning platform for big data-driven smart traffic management. *IEEE Transactions on Intelligent Transportation Systems* 20.12 (2019): 4679-4690.

UDK 621.39:656.2

***Kharchenko I.V.**, PhD student*
Ukrainian State University of Railway Transport, Kharkiv
***Lysechko V.P.**, Sc.D. Professor*
Ukrainian State University of Railway Transport, Kharkiv

METHOD FOR EVALUATING THE EFFICIENCY OF QUASI-ORTHOGONAL ACCESS AT SUBCARRIER FREQUENCIES

This paper explores the method of quasi-orthogonal access at subcarrier frequencies (QOFDM), which enhances the efficient use of frequency resources in railway transport systems. The proposed method is based on individual subcarrier frequency allocation for each frequency plan, thereby reducing multiple access interference and enhancing system capacity.

The methodology includes an algorithm for forming ensembles of complex signals using various subcarrier frequency allocation schemes. The spacing between subcarrier frequencies is determined based on the spectrum width and the number of subcarriers in each channel. This approach minimizes overlapping frequency positions between different channels, thus mitigating internal system interference.

The implemented methodology allows for precise evaluation of the amplitude and phase of any combination of components at the output of a non-linear system, modeled through a Taylor series expansion. The impact of interference is assessed based on the analysis of cross-correlation between frequency plans, which helps identify the most vulnerable frequency positions for minimizing interference.

In this study, four distinct frequency plans were simulated, each with a different number of subcarriers and spacing. The analysis demonstrated that even with a significant increase in the number of subcarriers, the level of interference remained within acceptable limits, confirming the effectiveness of the proposed approach.

A field experiment involved transmitting pilot signals between two transmitters with different frequency plans and analyzing signal reception under conditions of internal system interference. The results confirmed that the quasi-orthogonal access method significantly reduces the number of overlapping frequency positions, improving communication quality when multiple users operate simultaneously.

This method can effectively optimize the operation of railway transport control systems, especially in scenarios with many simultaneously operating transmitters.

References:

1. Mitola, J. III, "Cognitive Radio: Making Software Radios More Personal," IEEE Pers. Commun., vol. 6, no. 4, Aug. 1999, pp. 13-185 .
2. Svergunova, Yu.O., "Method for determining the coincidence of subcarrier frequency positions with quasi-orthogonal access at subcarrier frequencies," Information-Control Systems on Railway Transport, Kharkiv: UkrDUZT, 2015 .
3. Haykin, S., "Cognitive Radio: Brain-Empowered Wireless Communications," IEEE J. Areas Commun., vol. 23, no. 2, Feb. 2005, pp. 201-220 .