Problem of Electromagnetic Compatibility between 4G/5G Mobile Communications and Railway Signaling/Telecommunication Equipment

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***Abstract*—A system-level analysis of EMC between the equipment of 4G/5G mobile communications and railway equipment is performed by using the standardized criteria for the immunity of railway signaling and telecommunication equipment to radio-frequency electromagnetic exposure through enclosure ports. Both a statistical approach based on the analysis of the conditional average level of the electromagnetic background created by 4G/5G base stations and the worst-case assessment of the required spacing of 4G/5G equipment and railway equipment, which ensures their EMC, were used. The results of the analysis show a significant potential danger of radiations of 4G/5G base stations and user's equipment for this railway equipment; underestimation of this danger is fraught with catastrophic consequences. Possible ways to eliminate the risk of disrupting the operation of railway signaling and telecommunication equipment in a complex electromagnetic environment created by 4G/5G systems are discussed.**

Keywords—Mobile communications, 5G, railway signaling and telecommunication, electromagnetic exposure, immunity

I. INTRODUCTION

The massive use of electronics and wireless technologies in all infrastructures of modern society without a timely solution of the emerging EMC problems of the shared equipment of various infrastructures can cause conflicts between them. Such conflicts are especially acute at the explosive nature of the expansion of the use of wireless technologies in a separate infrastructure. Today, the most rapidly expanding is information infrastructure which encompasses mobile communication (MC) systems and networks. During the 4G→5G→6G evolution of MC, the change of MC generations every 10 years is accompanied by a tenfold increase in the quantity of sources of radio-frequency electromagnetic radiation, a hundredfold increase in the area traffic capacity (mobile traffic area density) and data rates over radio channels with a corresponding increase in broadbandness and the complication of the time-frequency structure of MC radiations, as well as a significant expansion of the used frequency range [1, 2]. All this causes a very significant complication of the electromagnetic environment (EME), especially in places with a high population density and economic activity, which can cause disruption of the operation of the technical systems of other infrastructures. This is confirmed in works [3-5], which proved the potential danger of interference from base stations (BS) and user equipment (UE) of 4G/5G MC for healthcare infrastructure equipment. Therefore, an important task is to analyze the EMC of 4G/5G MC equipment and technical systems of other infrastructures of modern society.

Modern railway control systems are among the critically important objects of informatization; they are complex and have several control levels: the operation control level, the interlocking (centralization) level, and the element control level. The widespread use of wired and wireless communication, microprocessor interlocking, signaling, and auto-blocking in these systems, which unlike electromechanical equipment has a significantly higher susceptibility to radio-frequency electromagnetic fields (EMF), causes the need to analyze and ensure the reliability of operation of modern railway signaling systems, railway communication & data transmission systems and microelectronic systems for ensuring the safety of train traffic in the context of the rapid EME complication due to the extremely intensive development of wireless technologies and 4G/5G MC.

The objective of this paper is to perform a system-level analysis of EMC between the 4G/5G MC equipment and the railway equipment, namely to estimate a danger of interference from BS and UE of 4G/5G MC to the railway signaling and telecommunication equipment.

II. PRINCIPLES OF EMC ANALYSIS OF RAILWAY AND 4G/5G EQUIPMENT

1) The EMC analysis for railway equipment and MC 4G/5G radio equipment have been performed using exposure limits - maximum permissible levels (MPL) of EMFs in various frequency bands specified by current standards [6-8] and typical data [9-16] for parameters of 4G/5G BS and UE radiations.

2) The analysis of the EMC conditions of the specified equipment was carried out by calculating the required spatial separation between them for the case of free-space radio wave propagation – the minimum distance at which the EMF level of the MC equipment affecting the railway equipment is equal to MPL.

3) Integral assessments of the danger created in the places of operation of railway equipment by MC radiations

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