Influence of Base Stations Radiation Patterns on the Level of the Outdoor Electromagnetic Background Created by Mobile (Cellular) Communications

Vladimir Mordachev
EMC R&D laboratory
China-Belarus Belt and Road joint Laboratory on Electromagnetic Environment Effect
Belarusian State University of Informatics and Radioelectronics
Minsk, Belarus
mordachev@bsuir.by

Dzmitry Tsyanenka
EMC R&D laboratory
China-Belarus Belt and Road joint Laboratory on Electromagnetic Environment Effect
Belarusian State University of Informatics and Radioelectronics
Minsk, Belarus
tsiond@tut.by

***Abstract*—Base stations (BS) radiation is the main source of electromagnetic background generated by mobile (cellular) communications. The known technique for estimating an average intensity of background generated by BS radiation takes into account the directivity of BS antennas in a simplified form, assuming that the width of the main lobe of the radiation pattern is equal to the width of BS servicing sector and not taking into account the radiation directivity in vertical plane. Noted simplifications determine too pessimistic nature of these estimations. The paper contains results of the refined analysis of this problem using a two-level models of antenna radiation patterns, which give the actual values of the width of antennas main lobe in horizontal and vertical planes, the relative levels of side lobes and the ratio of radiation power of the main and side lobes. The analysis was performed both for stationary sector antennas of cellular communication systems and for adaptive phased antenna arrays of 4G/5G systems capable of providing service using narrow beams. Obtained results reduce by 5-15 dB the degree of pessimism provided by known techniques in the estimation of the average levels of electromagnetic background created by BS radiations near the Earth's surface.**

Keywords—mobile communications, base station, electromagnetic radiation, antenna, pattern, main lobe, side lobes, electromagnetic background

I. INTRODUCTION

Electromagnetic pollution of the environment caused by the intensive use of wireless information services, their penetration into all spheres of human activity, is becoming one of the most acute technogenic problem of our time. Of course, the rapid evolution of generations of mobile (cellular) communications (MC) 4G→5G→6G determines one of the main directions of human progress. MC 4G/5G/6G are deeply integrating with all spheres of human existence, but at the same time they use technologies that are potentially dangerous to public health. Under certain conditions, this can cause a significant deterioration of an electromagnetic ecology of the habitat, and an unacceptable increase in forced and voluntary risks to public health.

In [1-3], a technique for estimating the averaged total intensity of the radio frequency electromagnetic background (EMB) created by electromagnetic (EM) radiations of base station (BS) was proposed and verified using the published results of experimental studies of the electromagnetic environment (EME) in dozens of countries on five continents. This technique is based on the analysis of system characteristics of MC networks: average area density of wireless traffic ("Area Traffic Capacity" (ATC)) and average electromagnetic loading on area (EMLA), created by the totality of BS EM radiation in various MC frequency bands; spectral efficiency of downlink data transmission, etc. This technique allows us to take into account the influence of the spatial selectivity of BS radiation on the averaged intensity of EMB.

This analysis becomes particularly relevant in connection with the use of active phased antenna arrays (AAA) as BS antennas in MC 4G/5G. "2D MIMO" antenna arrays ensure the formation of a "fan" multipath radiation pattern with a width of each beam of 12°-36° in the BS service sector, and AAA "Massive MIMO" using the beamforming mode, provides the formation of individual relatively narrow beams for each of the serviced subscriber stations (SS) [4].

The goal of this paper is to clarify the influence of the directivity of BS EM radiation in the horizontal and vertical planes on the EMB intensity created by MC radio networks.

II. ANALYSIS METHODOLOGY

A. Basic expressions for estimation the EMB intensity generated by BS

EMB is created at randomly selected observation point (OP), placed near the earth surface at a height H_{OP}, by a set of BSs, located in the region of radio visibility from OP. Pessimistic (worst-case assessment) of the averaged total intensity of EMB $Z_{BS\Sigma}$ [W/m^2] is determined in OP by the following expression [1-3]:

$$Z_{BSn} \approx \frac{B_n}{2} ln\left(\frac{4H_{OP}\sqrt{e}}{\lambda}\right), H_{OP} \geq \frac{\lambda}{4};\ Z_{BS\Sigma} = \sum_{n=1}^{N} \left|Z_{BSn}\right|, \quad (1)$$

where the value of $Z_{BS\Sigma}$ is defined as the scalar sum of the values of levels Z_{BSn} , $n \in [1, N]$ of averaged EMB intensities of each of N frequency bands of MC;

B_n [in W/m^2] is the average EMLA created by BS radiations of the n-th frequency band in the considered area;

λ is the wavelength of the n-th frequency band used;

OP height $H_{OP} \approx 1...2$ approximately corresponds to the human height, and heights of BS antennas $H_{BS} >> H_{OP}$.

The averaged EMLA over an area of A [m^2], generated by a set of K base stations distributed uniformly, is the sum of values of the total radiated power covering this area

979-8-3503-2400-6/23/$31.00 ©2023 IEEE