Visualization of electromagnetic exposure near LTE antennae

M Yu Zvezdina, Yu A Shokova, O Yu Nazarova, H T A Al-Ali and G H A Al-Farhan

Radioelectronic Department, Don State Technical University, 1 Gagarin Square, Rostov-on-Don, 344000, Russian Federation

E-mail: zvezdina_m@mail.ru

Abstract. Technical progress in wireless data transfer has given an opportunity to apply information and communication technologies in various areas of economics. Digital economy is linked to the 4th and 5th generation mobile network deployment. The peculiarities of the abovementioned standards decrease BTS antenna range three times in dense developed areas and worsen electromagnetic background in big cities. In the paper the comparative assessment results for rooftop electromagnetic exposure near BTS LTE and BTS GSM antennae are given. It is shown, that at the same level of transmitter power, energy flux density for LTE standard is three times less than the one for GSM. Moreover, the conclusion is made that the rooftop could be considered safe for people for indefinite time if antenna is placed more than 5 meters above the rooftop. The value of antenna height is taken to be on the safe side, as it is required by an application of "preventive principle".

1. Introduction

Wireless data transfer upgrade allowed an increasing data transfer rate up to 100 Mbps for highly mobile users (users taking a train or riding in a car) and up to 1000 Mbps for moderately mobile users (pedestrians or fixed users) within the standards of LTE-Advanced and WirelessMAN-Advanced (WiMAX). It has opened up a business implementation of mobile technologies [1-3]. As a result, after a year of the 4th generation mobile network deployment the index of mobile technologies implementation business in has scored 57% in the developed countries in 2011 [3]. Five years later, in 2016, Great Britain's information and communication technologies adoption in GDP equaled to 12.4%, while the country has gained the leading positions in digital economy contribution to GDP. In the same time in Russia the same index equaled to 2.8%. In July of 2017 the Government of the Russian Federation has established a program "Digital economy of the Russian Federation" to overcome the development delay.

An implementation of the program is linked, among other things, to expansion of mobile technologies application, thus, is calling for substantial quantity increase for Base Transceiver Station (BTS) to provide broadband Internet access. It is caused by a number of reasons; first of all, by a direct increase of LTE users. For example, in 2020 it is scheduled to provide Internet access to 97% of households and 100% of health care, educational and business organizations. Secondly, LTE standard features the usage of higher frequencies as compared to GSM standard, which leads to distance range decrease. Thus, in dense developed areas, where the population density is the highest, distance range lowers almost three times from 0.7 km to 0.25 km [5]. Negative result of GSM mobile communications usage lies within the complete cover with BTS nonionizing radiation, as it was mentioned in [6, 7]. This radiation has a constant twenty-four-hour impact on health of the area residents, including children, elderly and unhealthy [8]. Locating BTS atop of inhabitant buildings or atop of annexed stores (at the level of 2-3 floor of inhabitant building) worsens electromagnetic environment in residential areas under the conditions of altering building height.

It is impossible to eliminate the antenna harmful factor - radiated electromagnetic field. Thus, regulatory documents [9-12] are adapted; they state that energy flux density for habitable territories should not bypass maximum permissible level of power equal to 10 μW/cm^2. At the same time a socially-oriented electromagnetic monitoring [13] is carried out for these areas. This kind of monitoring encircles large areas and promotes timely and situational provision of information to the public concerning electromagnetic pollution level; it limits sanitary protection zones (SPZ) measured at height of 2 m above ground or above top floor of building if antenna is located at the rooftop. Sanitary protection zone limits correspond to maximum permissible level of 10 μW/cm^2. Population comprehensibility and capability of continuous adjustment to new electromagnetic environment problems are core requirements to socially-oriented monitoring results.

In works [6, 14, 15] the results of electromagnetic exposure near GSM antennae were presented. However, LTE channels differ from GSM in technical characteristics. Thus, the paper is aimed to estimate the electromagnetic exposure near BTS LTE with the visualization of the results obtained with calculation forecast method.

2. Equipment and devices used in studies

Electromagnetic exposure near BTS LTE antenna was estimated basing on regulatory documents [9-12]. The technique is described in [16]. Its peculiarity is an application of “preventive principle”, which is recommended by the World Health Organization [8]. This principle allows for preventive actions to reduce possible harmful effect of electromagnetic radiation on human beings even if the effect itself is not proven, but is assumed with contemporary level of scientific knowledge. As a result, sanitary protection zone limits would exceed the real ones.

3. Results and Discussion

3.1. Electric parameters of BTS antennae for mobile communications

In the process of electromagnetic exposure research near BTS LTE antennae and results comparison to BTS GSM data the operational schemes differences of the abovementioned standards were considered. LTE operation features closed-loop MIMO system [5]. It presumes multielement antenna usage on both ends of a channel - transmitting and receiving ones - to form the effective beam for a given radio path channel. Thus, the number of required transmitters is increased to two, and total. It increases the number of transmitters to 2, and total power output equals to 46 dBm or 40 W [5]. The beam of the obtained directivity patterns is narrower than the one of the GSM antennae.

For an example, table 1 shows electrical characteristics for one of this kind of antennae - ASTRA 3G/4G MIMO panel antenna [17]. A picture of BTS LTE antenna configuration is given on Figure 1.

Table 1. Electrical characteristics for ASTRA 3G/4G MIMO antenna [17]

Characteristics	
Telecommunication standard	LTE 800, LTE 900, LTE 1800, LTE 2600
Frequency range, MHz	790-960 / 1700-2700
Gain, dB	10-15
Half power beamwidth in horizontal plane, degrees	36
Half power beamwidth in vertical plane, degrees	36
Recommended distance to mobile tower, km	<10

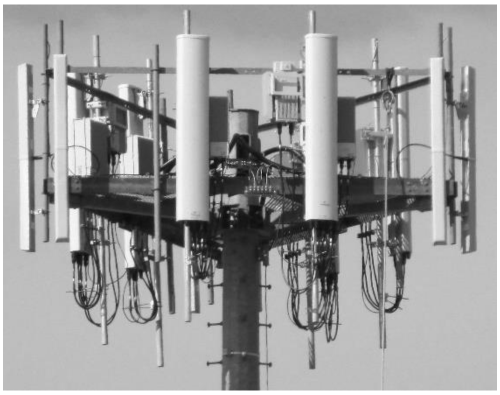


Figure 1 – BTS LTE antenna configuration

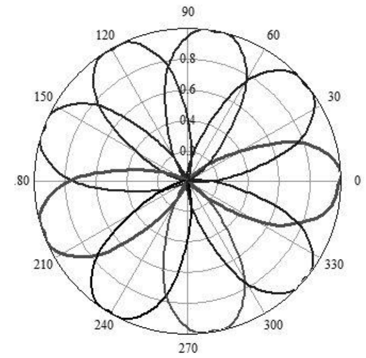


Figure 2 – Directivity pattern of BTS antenna set

3.2. Electromagnetic exposure estimation by forecast calculation

Electromagnetic exposure level near rooftop LTE antennae was estimated with the program set developed by the paper authors. The coordinates of roof angles were set equal to $A(0,0,30)$, $B(-7,4,30)$, $C(-13.5,-4,30)$, $D(-2.5,-8.5,30)$, the same way it was done for GSM antennae research [6, 14]. The research on electromagnetic field radiated by antennae was carried out in horizontal plane 2 m above the rooftop.

The simulation presumed that BTS LTE was a set of nine antennae of the same type with half power beamwidth equaled to 36 degrees (ASTRA), and BTS GSM was a set of three antennae with half power beamwidth equaled to 120 degrees. Directivity pattern for the considered BTS LTE is shown on Figure 2. Antenna gain for both BTS systems was considered equal to 13 dB.

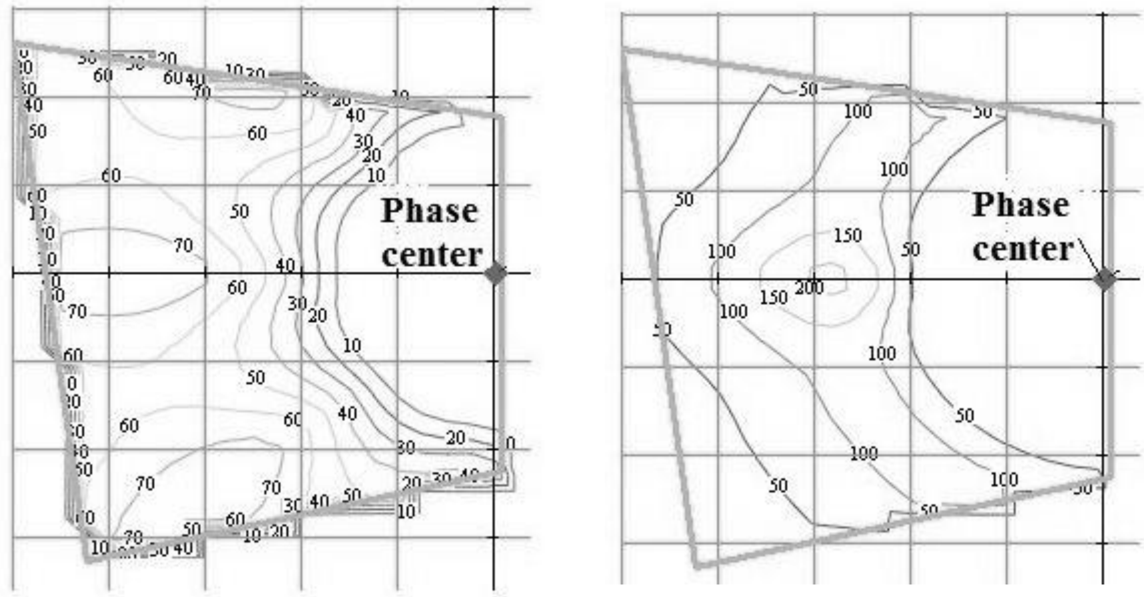
The considered frequency range was limited to 860-900 MHz, because sanitary protection zone area should be maximal for these frequencies [14].

Figures 3 and 4 show simulation results for energy flux density distribution for different transmitter power values; antenna phase center was located 3 m above the rooftop. Figure 3 shows energy flux density distribution for transmitter power equal to 20 W for BTS LTE antennae (Figure 3,a) and BTS GSM antennae (Figure 3,b).

Figure 4 shows energy flux density distributions near BTS LTE antenna for transmitter power equal to 40 W (Figure 4,a) and 10 W (Figure 4,b). Table 2 contains maximum values of energy flux density for BTS LTE and BTS GSM in horizontal plane 2 m above the rooftop.

Table 2. Maximum radiation level for BTS GSM and BTS LTE antenna depending on total power of transmitters

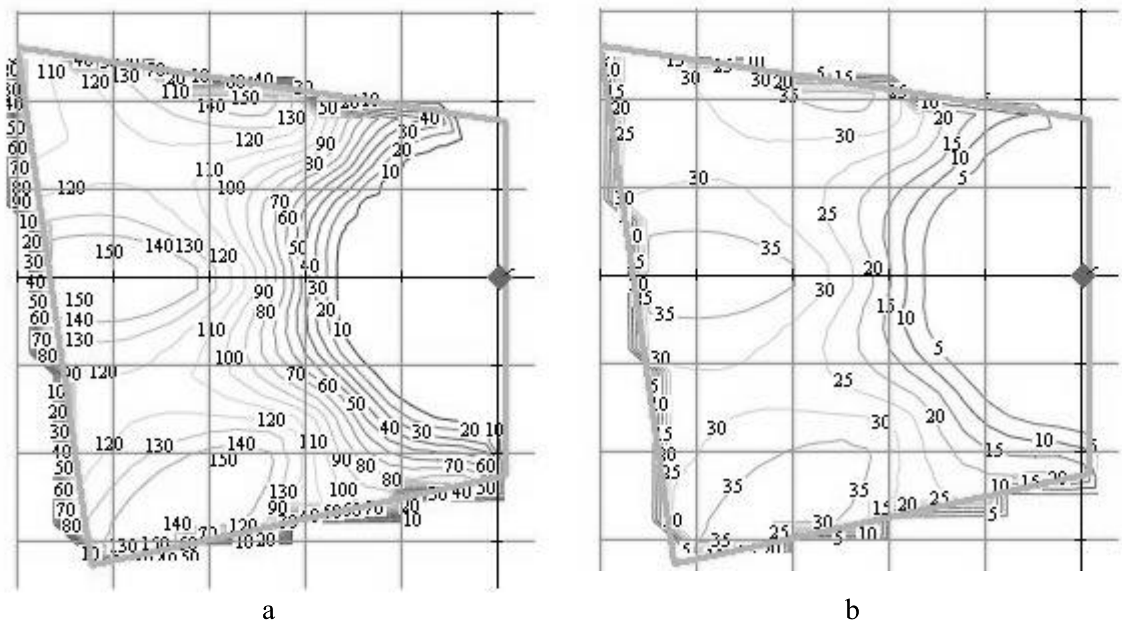
Total power, dB	Maximum energy flux density value, μW/cm^2		Antenna height for no SPZ at the rooftop, m	
	GSM	LTE	GSM	LTE
40	419	159	5	4.5
20	210	80	4.5	4
10	105	40	4.3	3.8



a b

Figure 3 – Directivity pattern for GSM and LTE antennae, transmitter power equals 20 W:

a – nine-element LTE antenna; b – three-element GSM antenna



a b

Figure 4 – Directivity pattern of nine-element LTE antenna for different transmitter power :

a – maximum power equals 40 W; b –transmitter power equals 10 W

The obtained results analysis show that it is required to declare practically all the rooftop as sanitary protection zone for BTS of both systems. Safe zone is located directly under antenna location; however, the area is rather small. As it is shown in table 2, electromagnetic exposure near BTS LTE antennae in terms of energy flux density is almost 3 times lower than the one near BTS GSM ones. However, even if the transmitter power is lowered four times to the value of 10 W, it is still required to declare practically all the rooftop as sanitary protection zone. It is possible to make the roof safe for people for indefinite time if antenna is placed higher. Nonetheless, BTS GSM antenna have to be located 0.5 m higher than LTE ones for any considered value of transmitter power.

Thus, BTS LTE antennae are considered safe for people on the rooftop for indefinite time if they are placed five or more meters above the roof surface. The value of antenna height is taken to be on the safe side, as it is required by an application of "preventive principle".

Conclusion

Wide spread of information and communication technologies in all fields of human activity has led to the necessity of development of digital economy. The adaptation of the Government of the Russian Federation strategies in digital economy is directly linked to wireless communication usage to provide broadband Internet access, and thus, requires substantial increase in BTS LTE numbers. Its negative ecological result lies within worsening of electromagnetic background caused by BTS density increase; it is due to LTE standard features, that in dense developed areas antenna distance range lowers almost three times if compared to BTS GSM.

The analysis of rooftop electromagnetic exposure near BTS LTE antennae and the comparison to the same kind of results for BTS GSM antennae has shown that the rooftop can be considered safe for people for indefinite time if antennae are placed five or more meters above the roof surface. This value is taken to be on the safe side, as it is required by an application of "preventive principle".

The comparison of energy flux density levels for BTS LTE and BTS GSM antennae at the same level of transmitter power has shown that maximum value of energy flux density for LTE standard is almost three times less than the one for GSM standard.

References

[1] ITU (International Telecommunications Union) 2010 ITU-R IMT-Advanced 4G standards to usher new era of mobile broadband communications. Web-site: http://www.itu.int/net/pressoffice/press_releases/2010/40.aspx#.Vkpb87-ns5 (accessed October 24, 2017)

[2] Ali S, Khusro S 2016 *Indian J. of Sci. and Techn.* **9** (19) doi: 10.17485/ijst/2016/v9i19/53088

[3] The New Digital Economy 2011 *Oxford Economics*. Web-site: http://www.pwc.com/mt/en/publications/assets/the-new-digital-economy.pdf (accessed October 24, 2017)

[4] Government of the Russian Federation 2017 Program Digital Economy of the Russian Federation (Moscow) Web-site: http://static.government.ru/media/files/9gFM4FHj4PsB79I5v7yLVuPgu4bvR7M0.pdf (accessed October 24, 2017)

[5] Sesia S, Toufik I, Baker M. LTE – the UMTS long term evolution: from theory to practice 2011 2nd edition. NY: John Wiley & Sons Ltd ISBN 9780470660256

[6] Zvezdina M Yu, Shokova Yu A, Kundrukova N I, Kutukova V D, Pozdnyakova A V 2017 *IOP Conf. Series: Earth and Environmental Science* **50** 012029 doi: 10.1088/1755-1315/50/1/012029

[7] Zvezdina M Yu, Shokova Yu A, Cherckesova L V, Golovko T M, Cherskaya A A 2017 *IOP Conf. Series: Earth and Environmental Science* **66** 012005 doi: 10.1088/1755-1315/66/1/012005

[8] WHO Library Cataloguing-in-Publication Data 2004 Establishing a dialogue on risk from electromagnetic fields. Web-site: http://www.who.int/peh-emf/publications/en/russian_risk.pdf (accessed October 14, 2017)

[9] Ministry of Health of the Russian Federation 2003 *SanPin 2.1.8/2.2.4.1190-03 Hygienic requirements on land-based mobile communication location and operation* (Moscow)

[10] Ministry of Health of the Russian Federation 2002 *MG 4.3-1167-02 Methodological guidelines for energy flux density estimation for electromagnetic field for location of radio facilities with operating band of 300 MHz – 300 GHz* (Moscow)

[11] ICNIRP (International Commission on Non-Ionising Radiation Protection) 1998 Guidelines for limiting exposure to time-varing electric, magnetic and electromagnetic fields (up 300 GHz) *Health Phys.* **74** 494-522
[12] IEEE (Institute of Electrical and Electronic Engineers) 2005 C95.1-2005 IEEE Standart for Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz (New York IEEE) Web-site: https://standards.ieee.org/findstds/standard/C95.1-2005.html (accessed September 24, 2017)
[13] Maslov M Yu, Spodobaev M Yu, Spodobaev Yu M 2014 *Telecommunications* (10) 39-42
[14] Zvezdina M Yu, Shokova Yu A, Shokov A V, Dymchenko A A, Parhomenko P A 2015 *Int. J. Theor. & Appl. Sci.* **03** (23) 10-7 doi: 10.15863/TAS.2015.03.23.3
[15] Zvezdina M Y, Shokova Yu A, Shokov A V 2015 *Proc. Int. Conf. on Application of Information and Communication (Rostov-on-Don)* 399-403 doi: 10.1109/ICAICT.2015.7338588
[16] Spodobayev Yu M, Kubanov D P 2000 Electromagnetic ecology basics. Moscow: Radio i svyaz'.
[17] Antenna ASTRA 3G/4G Web-site: https://gsm-repiteri.ru/prodazha/antenny-yota-lte/antenna-astra-3g-4g-mimo-panelnaja-2x15db (accessed September 24, 2017)