Required Levels of Radiation Power of GSM Base Stations on Urban Area Taking Into Account Attenuation in Buildings and Intrasystem EMC

Alexander Svistunov, Vladimir Mordachev
EMC R&D laboratory
Belarusian State University of Informatics and Radioelectronics
Minsk, Belarus
emc@bsuir.by

***Abstract*—Results of estimation of required levels of radiated power of base stations of cellular communications at the voice communication mode on urban area, taking into account attenuation of radio waves in buildings, and levels of intranetwork interference, are resulted. Analysis is made on the basis of behavior simulation of the fragment of GSM network at voice communication mode, executed with the use of multibeam radiowave propagation model X3D and the topological model of a fragment of urban area of the central part of Minsk, by comparison of statistical distributions of levels of signals received on various floors of buildings taking into account average attenuation of radio waves on each of floors, and also statistical distributions of SNIR values for the coincident conditions. The results indicate that in typical urban areas of medium number of building storeys the high communication quality at BS equivalent isotropic radiated power ≥43-45 dBm in GSM-1800 networks can be achieved only by diagnostics and improvement of intrasystem EMC of cellular network and network optimization, including optimization of spatial structure and of frequency sharing, but not by increase of radiated power of stationary and mobile GSM radio equipment.**

Keywords*—Intrasystem EMC, cellular communications, EIRP, base stations, GSM, electromagnetic safety

I. Introduction

In conditions of constant growth of terrestrial density of base stations (BS) of cellular communications, and also usage of overrated levels of BS electromagnetic radiation (EMR) [1,2] the state of intrasystem EMC of cellular radio networks and the relation of levels of intrasystem interference in these radio networks with their safety for the population are of the great interest. Earlier in [2] the estimations of necessary levels of BS EMR for three terrestrial categories were made: for domestic area, for pedestrian area and for vehicular area. This estimations indicated, that overrated BS equivalent isotropic radiated power (EIRP) at levels about 53-58 dBm/channel, taking into account power at BS antenna input and BS antenna gain, used today by GSM operators in some countries on urban areas, is essentially superfluous, and reduction of BS EIRP on urban areas up to 43-45 dBm/channel is possible at preservation of a necessary communication quality.

Results [2] are received by statistical treatment of results of simulation of radio wave propagation (RWP) from BS to mobile stations (MS) of outdoor allocation, and are based on rough estimations of MS indoor operation conditions, by implementation of fixed average attenuation of radio waves in buildings. Such estimation can be considered as acceptable only at stages of tentative estimations, since RWP conditions between indoor MS and outdoor BS essentially depend on characteristics of MS indoor allocation, in particular, on floor number (on height over a terrestrial surface). Conditions of indoor radio reception in considered frequency range are defined by degree of MS shadowing by elements of building construction (walls, baffles, interfloor bridging, etc.) that along with wall's characteristics (thickness, type of material) and MS height over a room floor, is defined substantially by the difference between MS height and BS antenna height over a terrestrial surface, connected with values of reference angles of radio waves and its reflections order by walls of buildings and by terrestrial surface [3].

It is determined experimentally [4-6], that for BS with antenna height which is not less than the building height, the attenuation of radio waves at their propagation into a building decreases as the floor number increases, i.e. the worst conditions of the MS reception of BS signals can be watched inside buildings on ground floors, where levels of BS signals can be comparable or less than levels of BS signals out of buildings at a terrestrial surface in shadow zones. At the same time high levels of intranetwork interference, caused by signals of the nearest BS with the same operating frequencies, can fit with relatively high levels of signals of BS on the top floors of buildings; that is the main reason of cellular communication quality degradation in upper floors of city areas.

Taking into consideration that the MS quantity inside buildings is relatively high and can be prevailing in many situations (evening in dormitory area, daytime in business area, bad weather periods, etc.), the updating of results and conclusions of [2] taking into account the difference of MS radio reception at MS allocation on various floors of buildings is of the great interest.

The goal of this paper is to update the estimations [2] of levels of EIRP BS, necessary and sufficient for high quality of cellular communication on urban area, at allocation of MS on

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various floors of buildings, and also taking into account conditions of intrasystem EMC (levels of intranetwork interference). This updating will be performed on the basis of behavior simulation of GSM network (voice communication mode of cellular system) with the use of model of real urban area of a central part of Minsk and the multipath RWP model, implemented with the application of [7].

II. Initial Models and Data

The models and initial data, used at behavior simulation of an urban fragment of GSM network, are given below.

A. RWP Model for urban (city) area

The three-dimensional model X3D [7] of multipath RWP on urban area, not having restrictions on usage in the accepted conditions and considering up to *N* possible ways of propagation of BS EMR to the place of MS allocation, is used. The remotely similar model (with differing semi-empirical algorithm of taking into account reflection of radio waves from buildings) is used and experimentally tested in [8-11]. In comparison with this analog, the 3XD model [7] directly simulates signal reflections at RWP between buildings, and diffraction on corners of buildings. Initial system parameters are following: height of BS antennas, EIRP of BS, quantity and coordinates of location of BS on urban area, type of BS antennas, frequency of BS EMR, signal bandwidth, coordinates of MS allocation, MS height over a terrestrial surface (number of floor of MS allocation). Results of [12,13] are also considered at a choice of values of model's parameters.

B. Model of urban area.

The topographical computer model of a fragment of city housing of a central part of Minsk is used (Fig.1). This model correspond to the updated model of urban area represented in [2] at various modification of BS allocation and BS frequency sharing.

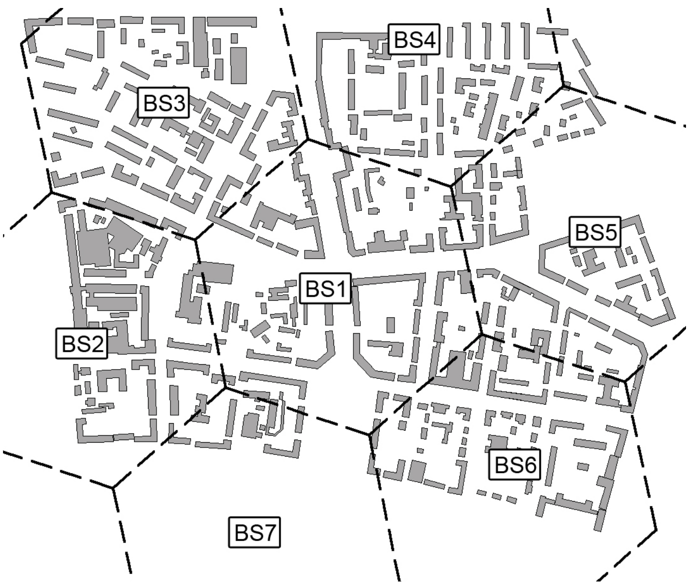

Fig. 1. Model of a fragment of city housing of a central part of Minsk with seven BS (BS1 – BS7)

The following characteristics of model are accepted at analysis performance:

1) Characteristics of buildings: number of storeys is from 2 to 6 floors, floor height is 3 m, distance between neighbour windows is 3 m.

2) Terrestial density of BS is appromaxitely 3 BS/km^2, analysis is performed for heiths of BS antennas H_{BS} = 25 m and H_{BS} = 35 m.

3) The various scenarios of mutual influence of network sites at various stages of analysis are used (for different scenarios the different locations of BS1 – BS3 on simulated fragment of urban area can be defined):

- at estimation of levels of useful signal on an MS receivers inputs, the basic scenario is used. In this scenario levels of signal of BS1, that serves the considered site, and also levels of signals of BS2-BS7 from adjacent sites, are analyzed in all points of MS locations at the considered site (site of BS1 in the center of a fragment on Fig.1). The prevailing level of signal is chosen as the MS useful signal (BS with prevailing level of signal is chosen as servicing BS);
- at estimation of the "Signal / (Noise + Interference)" Ratio (SNIR) value on an inputs of MS receivers, the scenarios with three-sector structure of a network at various cluster dimensionality *N* of frequency sharing are used (Fig.2): first scenario with poor intranetwork EMC ($N = 4$) and second scenario with improved intranetwork EMC ($N = 7$). On this figure the filled sector of BS1 service zone is the area of location of analyzed set of MS. Radio transmitters of BS2 and BS3 which are servicing the filled sectors of BS2 and BS3 service zones using the same frequency channels, are considered as the sources of intranetwork interference for MS of considered sector of BS1 site. BS of other sites (sites without filled sectors) use other frequency channels and does not effect on MS served by BS1.

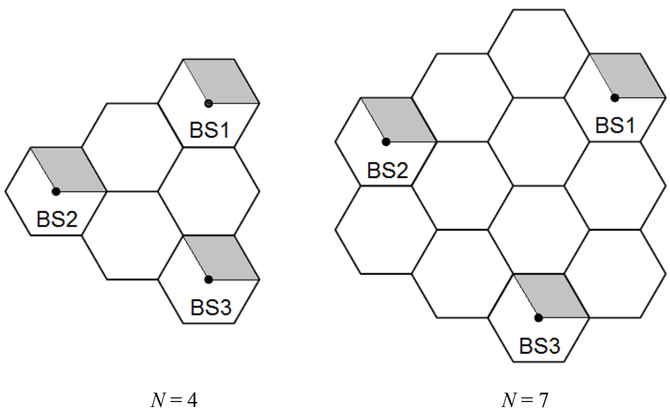

Fig. 2. Scenarios of simulation for estimation of SNIR value on an input of MS receiver at various cluster dimentionality of frequency sharing.

4) The points of intermediate analysis of signal levels at facades of buildings are placed at heights corresponded to the centres of window apertures, and divided on 6 groups according to the floor number. The distance between points on each of floor is multiple to 3 m (Fig.3).

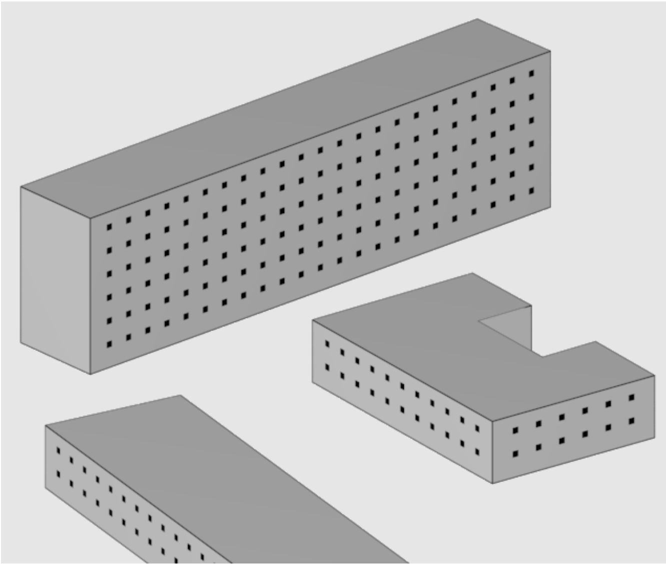

Fig. 3. The allocation of points at facades of buildings.

5) Type of a covering of an earth surface – asphalt.

C. Model RWP into a building.

Simplified empirical model of RWP into buildings is used, based on experimental data [4] and assuming the fixed attenuation of radio waves at penetration through window apertures of corresponding floor: 13,4 dB for the floor No.1 (ground floor), 12 dB for the floor No.2, 10,6 dB for the floor No.3, 9,2 dB for the floor No.4, 7,8 dB for the floor No.5 and 6,4 dB for the floor No.6. Calculation of levels of input signals at MS allocation points inside buildings is made using the technique [14]: levels of signals are calculated at facades of buildings in corresponding points, with subsequent reduction of these levels on specified values for MS indoor allocations taking into account number of floor.

D. The system parametres of simulation.

1) Behaviour simulation of cellular system is performed for conditions of high quality of reception of BS signal by MS receiver, corresponding to high probability of communication ("Grade of Service") $B = 0{,}98\text{-}0{,}99$ at various levels of BS channel EIRP.

2) The analysis is performed for BS of GSM-1800 which are using 75 % of volume of the radio-frequency spectrum, assigned for GSM networks. A range of analyzable levels of EIRP BS is 40-53 dBm per GSM frequency channel.

3) The noise factor of BS and MS receivers is accepted at level 7 dB [2] that corresponds to level P_0 = –114 dBm of threshold sensitivity of the receiver, i.e. to the corresponding level of the BS receiver own noise resulted to the receiver input in a frequency band of radio reception equal to 200 kHz.

4) It is accepted that the useful signal received by MS receiver, is a signal of prevailing BS, for which RWP losses in a point of MS allocation are minimal.

5) It is accepted that the level of intrasystem EMC is defined by SNIR value assigned by dimensionality *N* of the cluster of network frequency sharing, and SNIR value on an MS receiver input must be more than 9 dB for GSM networks.

6) Type of MS antenna accepted as isotropic. Types of BS antenna are accepted as isotropic (at estimation of levels of useful signal on an MS inputs), and as sectoral with beamwidth of antenna pattern on the horizontal plane 90° (at level –3 dB at estimation of SNIR value).

III. The Results of Behaviour Simulation and Discussion

A. Levels of useful signal at MS radio reception inside buildings.

Estimations of boundaries of ranges of signal levels of prevailing BS on an MS receiver inputs inside buildings for communication probability ("Grade of Service") $B = 0{,}99$ and $B = 0{,}98$, are given below In Tables 1-4.

TABLE I. RANGES OF SIGNAL LEVELS OF PREVAILING BS ON MS RECEIVER INPUTS INSIDE BUILDINGS FOR COMMUNICATION PROBABILITY ("GRADE-OF-SERVICE") $B = 0{,}99$ AND $H_{BS} = 25$ M

Floor No.	**Ranges of signal levels of prevailing BS on MS receiver inputs, dBm, at EIRP BS of frequency channel P_{BS}, dBm**			
	$P_{BS} = 40$ dBm	$P_{BS} = 43$ dBm	…	$P_{BS} = 53$ dBm
1	–88,1…–32,1	–85,1…–29,1	…	–75,1…–19,1
2	–83,4…–30,3	–80,4…–27,3	…	–70,4…–17,3
3	–77,0…–29,1	–74,0…-26,1	…	–64,0…–16,1
4	–69,5…–26,6	–66,5…–23,6	…	–56,5…–13,6
5	–63,3…–24,4	–60,3…–21,4	…	–50,3…–11,4
6	–59,0…–21,9	–56,0…–18,9	…	–46,0…–8,9

TABLE II. RANGES OF SIGNAL LEVELS OF PREVAILING BS ON MS RECEIVER INPUTS INSIDE BUILDINGS FOR COMMUNICATION PROBABILITY ("GRADE-OF-SERVICE") $B = 0{,}98$ AND $H_{BS} = 25$ M

Floor No.	**Ranges of signal levels of prevailing BS on MS receiver inputs, dBm, at EIRP BS of frequency channel P_{BS}, dBm**			
	$P_{BS} = 40$ dBm	$P_{BS} = 43$ dBm	…	$P_{BS} = 53$ dBm
1	–85,3…–32,1	–82,3…–29,1	…	–72,3…–19,1
2	–79,4…–30,3	–76,4…–27,3	…	–66,4…–17,3
3	–73,8…–29,1	–70,8…–26,1	…	–60,8…–16,1
4	–68,0…–26,6	–65,0…–23,6	…	–55,0…–13,6
5	–60,7…–24,4	–57,7…–21,4	…	–47,7…–11,4
6	–53,7…–21,9	–50,7…–18,9	…	–40,7…–8,9

TABLE III. RANGES OF SIGNAL LEVELS OF PREVAILING BS ON MS RECEIVER INPUTS INSIDE BUILDINGS FOR COMMUNICATION PROBABILITY ("GRADE-OF-SERVICE") $B = 0{,}99$ AND $H_{BS} = 35$ M

Floor No.	**Ranges of signal levels of prevailing BS on MS receiver inputs, dBm, at EIRP BS of frequency channel P_{BS}, dBm**			
	$P_{BS} = 40$ dBm	$P_{BS} = 43$ dBm	…	$P_{BS} = 53$ dBm
1	–78,4…–29,3	–75,4…–26,3	…	–65,4…–16,3
2	–76,7…–27,5	–73,7…–24,5	…	–63,7…–14,5
3	–70,1…–27,4	–67,1…–24,4	…	–57,1…–14,4
4	–63,6…–25,1	–60,6…–22,1	…	–50,6…–12,1
5	–58,4…–24,1	–55,4…–21,1	…	–45,4…–11,1
6	–50,3…–23,2	–47,3…–20,2	…	–37,3…–10,2

TABLE IV. RANGES OF SIGNAL LEVELS OF PREVAILING BS ON MS RECEIVER INPUTS INSIDE BUILDINGS FOR COMMUNICATION PROBABILITY ("GRADE-OF-SERVICE") $B = 0{,}99$ AND $H_{BS} = 35$ M

Floor No.	Ranges of signal levels of prevailing BS on MS receiver inputs, dBm, at EIRP BS of frequency channel P_{BS}, dBm			
	$P_{BS} = 40$ dBm	$P_{BS} = 43$ dBm	…	$P_{BS} = 53$ dBm
1	–71,4…–29,3	–68,4…–26,3	…	–58,4…–16,3
2	–71,0…–27,5	–68,0…–24,5	…	–58,0…–14,5
3	–66,3…–27,4	–63,3…–24,4	…	–53,3…–14,4
4	–61,6…–25,1	–58,6…–22,1	…	–48,6…–12,1
5	–53,7…–24,1	–50,7…–21,1	…	–40,7…–11,1
6	–48,9…–23,2	–45,9…–20,2	…	–35,9…–10,2

The analysis of the resulted estimations testifies to the following:

1) Levels of MS input signals inside buildings on ground floors (floors No. 1-3) are less on 3-21 dB in comparison with levels of MS input signals, estimated with the use of technique [2] for outdoor conditions (domestic, pedestrian and vehicular areas), and on the top floors (floors No. 4-6) these levels are comparable with estimations [2] for outdoor conditions near ground level or exceeds it on 3-16 dB.

2) At EIRP BS 53 dBm/channel (200 W/channel), widely used today, and at BS antenna height H_{BS} = 25 m, the lower bounds P_D of values of levels of useful signal on MS receiver inputs, taking into account signal attenuation at its penetration into a buildings at various requirements to communication quality, are following:

- on the ground floor (floor No.1) $P_D = –75{,}1…–72{,}3$ dBm, i.e. on 38,9…41,7 dB above the threshold sensitivity of the MS receiver;
- on the floor No.2 $P_D = –70{,}4…–66{,}4$ dBm, i.e. on 43,6…47,6 dB above the threshold sensitivity of the MS receiver;
- on the floor No.3 $P_D = –64{,}0…–60{,}8$ dBm, i.e. on 50,0…53,2 dB above the threshold sensitivity of the MS receiver;
- on the floor No.4 $P_D = –56{,}5…–55{,}0$ dBm, i.e. on 57,5…59 dB above the threshold sensitivity of the MS receiver;
- on the floor No.5 $P_D = –50{,}3…–47{,}7$ dBm, i.e. on 63,7…66,3 dB above the threshold sensitivity of the MS receiver;
- on the floor No.6 $P_D = –46{,}0…–40{,}7$ dBm, i.e. on 68,0…73,3 dB above the threshold sensitivity of the MS receiver.

3) At EIRP BS 43 dBm/channel (20 W/channel) the difference between the level of useful signal on MS receiver inputs and the MS threshhold sensitivity on various floors of buildings, belong to the range $P_D – P_0 = 28{,}9…63{,}3$ dB.

4) With increase in number of a floor the increase in levels of useful signals on an MS receiver inputs on 4,3-7,5 dB per floor is observed.

5) At increase in height of BS antenna up to $H_{BS} = 35$ m the levels of useful signal on an MS receiver inputs increase on 4,9-8,7 dB for probability communication $B = 0{,}99$, and on 4,8-13,7 dB for probability communication $B = 0{,}98$ (depending on floor number).

6) If the communication quality requirements increases (B increases on 1% from 0,98 to 0,99) then the lower bounds of values of levels of the useful signal on the MS receiver inputs decreases on 1,5-5,3 dB (also depending on floor number).

Taking into account the simulation results given above in Section III.A, it is possible to come to the conclusion, that at BS EIRP near to 53 dBm/channel (widely used today by GSM operators on urban areas), the minimal reserve on levels of desired signal on an MS receiver inputs inside buildings is approximately 40 dB. These BS EIRP levels are essentially overrated. At decrease of BS EIRP levels by a factor of ten (up to 43 dBm/channel) this reserve decrease up to 30 dB and remaining acceptable for support the necessary quality of cellular communications on urban areas even inside buildings.

B. SNIR levels at MS radio reception inside buildings.

In Tables 5-8 the results of statistical treatment of samples of SNIR values on an MS receiver inputs inside buildings at various levels of BS EIRP and at various BS antenna height H_{BS} and dimensionality N of frequency sharing cluster are given below. Typical histograms of distributions of SNIR values on an MS receiver inputs inside building for the ground floor and for the top floor are resulted on Fig. 4-5.

TABLE V. THE RELATIVE QUANTITY OF INDOOR MS FOR WHICH THE INTRANETWORK EMC IS NOT ENSURED, AT VARIOUS BS EIRP P_{BS} VALUES AT BS ANTENNA HEIGHT $H_{BS} = 25$ M AND CLUSTER DIMENSIONALITY $N = 4$

Floor No.	Relative quantity of MS, for which SNIR $\leq$ 9 dB, %				
	$P_{BS} = 33$ dBm	$P_{BS} = 40$ dBm	$P_{BS} = 43$ dBm	$P_{BS} = 47$ dBm	$P_{BS} = 53$ dBm
1	8,0	6,8	6,6	6,6	6,6
2	7,2	6,6	6,5	6,5	6,5
3	9,1	8,7	8,7	8,7	8,7
4	10,5	10,1	10,1	10,1	10,1
5	12,6	12,3	12,3	12,3	12,3
6	20,9	20,0	19,8	19,8	19,8

TABLE VI. THE RELATIVE QUANTITY OF INDOOR MS FOR WHICH THE INTRANETWORK EMC IS NOT ENSURED, AT VARIOUS BS EIRP P_{BS} VALUES AT BS ANTENNA HEIGHT $H_{BS} = 35$ M AND CLUSTER DIMENSIONALITY $N = 4$

Floor No.	Relative quantity of MS, for which SNIR $\leq$ 9 dB, %				
	$P_{BS} = 33$ dBm	$P_{BS} = 40$ dBm	$P_{BS} = 43$ dBm	$P_{BS} = 47$ dBm	$P_{BS} = 53$ dBm
1	6,6	6,4	5,9	5,9	5,9
2	8,4	7,9	7,9	7,8	7,7
3	17,3	16,8	16,6	16,4	16,4
4	20,3	19,8	19,8	19,8	19,8
5	25,2	25,0	25,0	25,0	24,8
6	22,7	22,4	22,2	22,2	22,2

TABLE VII. THE RELATIVE QUANTITY OF INDOOR MS FOR WHICH THE INTRANETWORK EMC IS NOT ENSURED, AT VARIOUS BS EIRP P_{BS} VALUES AT BS ANTENNA HEIGHT H_{BS} = 25 M AND CLUSTER DIMENSIONALITY N = 7

Floor No.	Relative quantity of MS, for which SNIR ≤ 9 dB, %				
	P_{BS} = 33 dBm	P_{BS} = 40 dBm	P_{BS} = 43 dBm	P_{BS} = 47 dBm	P_{BS} = 53 dBm
1	4,2	2,6	2,1	1,8	1,7
2	3,7	2,1	1,8	1,8	1,8
3	3,3	2,4	2,4	2,3	2,3
4	4,6	3,9	3,8	3,8	3,8
5	3,5	3,0	3,0	3,0	3,0
6	3,6	2,9	2,7	2,7	2,7

TABLE VIII. THE RELATIVE QUANTITY OF INDOOR MS FOR WHICH THE INTRANETWORK EMC IS NOT ENSURED, AT VARIOUS BS EIRP P_{BS} VALUES AT BS ANTENNA HEIGHT H_{BS} = 35 M AND CLUSTER DIMENSIONALITY N = 7

Floor No.	Relative quantity of MS, for which SNIR ≤ 9 dB, %				
	P_{BS} = 33 dBm	P_{BS} = 40 dBm	P_{BS} = 43 dBm	P_{BS} = 47 dBm	P_{BS} = 53 dBm
1	1,6	1,4	0,7	0,6	0,6
2	1,9	1,4	1,3	1,2	1,2
3	1,6	1,1	1,0	0,8	0,8
4	2,4	2,4	2,1	2,1	2,1
5	4,6	4,2	4,1	4,1	4,1
6	13,3	12,4	11,8	11,6	11,6

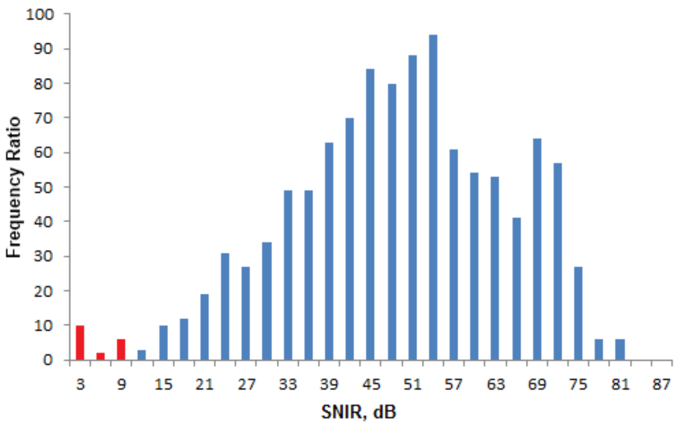

Fig. 4. Typical SNIR distribution for MS set inside building on the floor No.1 at H_{BS} = 35 m, N = 7. Sample size is 1100, the histogram columns at the left part SNIR ≤ 9 dB are assigned by red color.

The results of analysis of SNIR values on a receiver inputs of MS inside buildings presented in simulated fragment of city area, for various BS EIRP levels P_{BS} at various BS antenna height H_{BS} and frequency cluster dimensionality N testify the following.

1) At low quality of cellular network frequency sharing, corresponding to the frequency cluster dimensionality N = 4 (poor intranetwork EMC), and height of BS antennas which is comparable with the height of buildings, the relative quantity of MS inside buildings, for which conditions of intrasystem EMC are not ensured (SNIR ≤ 9 dB), depending on floor number and achieves 10…25%. Increase of BS antenna height up to H_{BS} = 35 m reduces slightly the quantity of MS affected by intranetwork interference on ground floors (on 1-2% of the total MS amount), but increase substantially the relative quantity of these MS on the 3-5 floors (on 3-10% of the total MS amount) in spite of the essential increase of levels of useful signal.

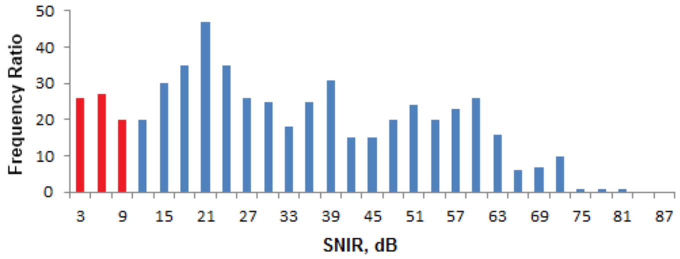

Fig. 5. Typical SNIR distribution for MS set inside building on the floor No.6 at at H_{BS} = 35 m, N = 7. Sample size is 550, the histogram columns at the left part SNIR ≤ 9 dB are assigned by red color.

2) At higher quality of cellular network frequency sharing, corresponding to the frequency cluster dimensionality N = 7, and height of BS antennas which is comparable with height of city building, the relative quantity of MS inside building, for which conditions of intrasystem EMC are not ensured (SNIR ≤ 9 dB), reduces essentially up to 2…4% of the total MS amount. Increase of BS antenna height up to H_{BS} = 35 m reduces this quantity additionally up to 1…3% on the floors No. 1-4, but also increases appreciably the relative quantity of MS affected by intranetwork interference, on the top floors No. 5-6 (on 8-9% of the relatively total amount of MS) in spite of essential increase of levels of useful signal.

3) BS EIRP reduction from 53 dBm to 43 dBm does not lead to appreciable growth of relative quantity of MS inside buildings, for which SNIR ≤ 9 dB and communication quality become poor; the given growth depends on floor number and makes 0,1…0,4 % of the relatively total amount of MS.

4) At BS EIRP ≥ 43 dBm SNIR values for indoor MS are defined mainly by levels of intranetwork interference (by level of intrasystem EMC), and contribution of internal noise of MS receivers in SNIR values, as a rule is unsignificant, because even in cases when SNIR ≤ 9, levels of useful signal exceeds level of internal noise of MS receivers on 25-30 dB and more. Consequently, for the simulated fragment of urban area, at BS EIRP ≥ 43 dBm, communication quality is defined only by the level of intrasystem EMC and can be improved by increase of dimensionality of a frequency sharing cluster (by increase of BS terrestial density at simultaneous reduction of quantity of frequency channels per each BS, or by increase of volume of the radio-frequency spectrum by increase of the ratio “network channel total quantity/BS channel quantity” from 5-7 to 8-10 and more, used by a network at fixed network topology); in considered case SNIR values may be increased (intranetwork EMC may be improved) by network optimization, daily dynamic radio-frequency resource redistribution between BS, etc.).

5) Results of simulation are illustrating the obvious fact, that changing of BS antenna height without appropriate changing of network structure and topology, influence on intrasystem EMC and cellular communication quality quite ambiguously. Increase of BS antenna height in some cases can improve intrasystem EMC and cellular communication quality on ground floors, but also can reduce to its obvious degradation on the top floors. Therefore, BS antenna height is a parameter that must be optimized in specified conditions.

6) It is inexpedient to use BS EIRP levels in voice communication mode, that are greater than 43-45 dBm on urban areas of simulated type, because it does not lead to the essential improvement of cellular communication quality, but it can be a reason of increased intensity of electromagnetic background on considered populous areas.

IV. CONCLUSION

The results given above testify to the following.

1) At high requirements of comminication quality on considered urban area (at probability of service failure no more than 1-2%) the absolute values of MS useful signal in modern cellular networks at voice communication mode are connected with communication quality rather poorly; quality of intrasystem (intranetwork) EMC is quite determinative, and it is defined by comparative levels of intranetwork interference and by the corresponding distribution of SNIR values on an receiver inputs of an indoor MS set.

2) The BS EIRP levels 53-58 dBm in frequency GSM channels used by cellular operators on urban areas, are essentially overrated and really dangerous for urban population. These levels can be reduced up to 43-45 dBm without any appreciable degradation of cellular voice communication quality. Usage of so overestimated BS EIRP levels is actually a consequence of lack of understanding the influence degree of intranetwork interference on cellular communications quality. And even at BS EIRP levels 43-45 dBm, the quality of cellular communication on simulated urban area is defined basically by level of intranetwork EMC, as far as levels of intranetwork interference exceeds the level of MS receivers internal noise on 25-30 dB and more.

3) In typical urban areas of medium number of building storeys the high communication quality at BS EIRP ≥ 43-45 dBm in GSM-1800 networks can be achieved mainly by diagnostics and improvement of intrasystem EMC of cellular network and network optimization, including optimization of spatial structure and optimization of frequency sharing, but not by increase of radiated power of stationary and mobile GSM radio equipment.

4) Owing to the symmetry of processes of intranetwork interference creation by MS and BS operation in conditions of frequency multiple reuse, the poor intranetwork EMC also can be a reason of superfluous levels of MS EIRP, that essentially increases danger of the personal voluntary ecological risks caused by use of cellular communications. And as a result the superfluous EIRP levels of BS and MS can be a reason of the essential growth of the total intensity of electromagnetic background formed in frequency bands of cellular communications, and of practical impossibility of operation of cognitive, UWB or any other radio systems in these frequency bands on the secondary basis.

5) It should be expected, that the similar problem is completely typical for cellular radio networks of 3^{rd} (UMTS) and 4^{th} (LTE) generations, especially taking into consideration **1)** usual assignment of the same frequency channels ("carriers") in adjacent BS sectors of these networks, and also **2)** considerably higher BS & MS EIRP levels of cellular communications at the data transmission modes. Therefore authors intend to study this problem for other modes and generations of cellular communications at populous areas hereafter.

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