MODELLING OF STREET RADIO LINKS AS MICROWAVE MULTIPORTS AT WORK OF SYSTEM WiMAX IN THE CONDITIONS OF THE CITY

Strelnitskiy A.A., Tsopa A.I. and Shokalo V.M.

Kharkiv National University of Radio Electronics, Kharkiv, Ukraine
E-mail: multimedia@kture.kharkov.ua

Abstract

The approached method of calculation of attenuation of radio-waves along street wave channels with the help canyon radio waves propagation (RWP) models and the Microwave Office packet of applied programs has been developed. The comparative analysis of the results of calculation and experiment for a case of WiMAX system operating in the central area of Kharkiv has been supplied.

Keywords: modelling, attenuation, multi-terminal circuit, dispersion matrix, transmission line.

1. INTRODUCTION

From uniform positions of the theory of circuits the approach to modelling of wave ducts of city streets (architectural constructions) is offered at calculation of attenuations of signals in radio links with technologies WiMAX.

Existing models of calculation of radio links with technologies WiMAX consider some mechanisms of a radio propagation. One of them is RWP on wave ducts of architectural constructions (WCAC). Authors switch on wave ducts of city streets In this concept. Known models WCAC are insufficiently effective owing to the big time expenses for calculations. The purpose of the given work consists in boosting of efficiency of models WCAC at the expense of their representation in the form of multiterminal circuits.

2. THE MAIN PART

The main standings of the offered approach enclose the following. It is considered that the spherical wave radiated by the base station extends along streets as a number of locally plane waves. The further approach consists in representation of a homogeneous linear WCAC piece as a piece of an equivalent two-wire line with losses on which a T-wave extends. Wave resistance of such line without counting losses equals characteristic free space resistance Z_0. As a result line pieces are easily represented by dispersion matrixes and attenuation of radio-waves can be calculated by means of the Microwave Office packet.

The proof for this statement is being carried out on

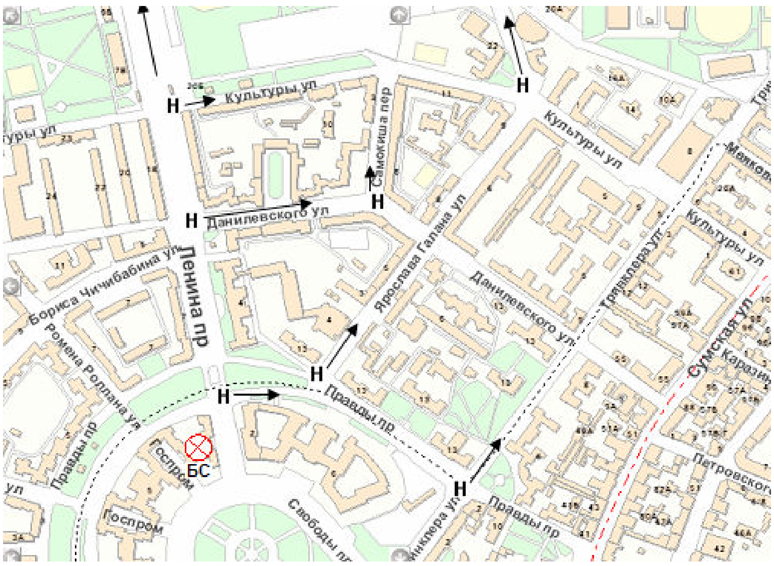

Fig. 1. The map of the area of measurements (БС is base station site).

the basis of a joint analysis of the results of the calculation and the experiment of radio-waves attenuation having WiMAX system operating along the streets of one Kharkiv districts (see fig. 1). In detail the procedure and results of such experiment have been published in [1].

Let's consider the offered method on an example of Lenin avenue model. In the model developed for calculation the piece of street of length r_i is represented in the form of a piece of the equivalent range lossless line of length r_i. The line was cascaded with a variable attenuator considering losses of propagation $L(r_i/r_0)$, where – r_0 is the standard distance [2] relative to which attenuation calculation on the current distance r_i is carried out.

The dispersion matrix of the four-terminal circuit equivalent to a cascade connection of the lines and the attenuator looks in the following way:

$$\left[S(r_i)\right]=\begin{bmatrix} 0 & \sqrt{L\left(\frac{r_i}{r_0}\right)} \\ \sqrt{L\left(\frac{r_i}{r_0}\right)} & 0 \end{bmatrix} e^{-i\beta r_i}. \qquad (1)$$

The matrix is recorded in the assumption that the four-terminal circuit is corresponded to characteristic resistance of free space and mutual, and $\beta = 2\pi/\lambda$, where λ is operating wave length.

The example of the circuit of streets junction used for calculation of attenuations along Lenin avenue in the Microwave Office packet of applied programs is shown on fig. 2 ($l = r_i$ is a piece of line of length r_i; $\mathrm{AT}(m,n)$ are the attenuators (m is the street number, n is a serial number of an attenuator for a street with number m); ИМ is a power meter). The circuit is excited by three sources of local plane waves from Romen Rollan and Yaroslav Galan streets and Lenin avenue.

For determination of signal levels S in points r_i of Lenin avenue attenuations $L(r_i/r_0)$ calculated on the following formula were subscribed to the attenuator AT (1,1):

$$L(r_i/r_0)=(D_1-\Delta G_1)+(D_2-\Delta G_2)+\frac{\Pi(r_i/r_0)}{\Pi_{\max}},[dB], \qquad (2)$$

where D_1 is directive gain of base station antennas, D_2 is directive gain of the client adapter antennas; ΔG_2, ΔG_1 are adjustments considering variation directive gain in the preset direction calculated following the method [3]; $\frac{\Pi(r_i/r_0)}{\Pi_{\max}}$ is relative density of power stream calculated with the help of RWP canyon models.

On fig. 3. the sketch of a canyon wave channel is shown. A is a transmission point, B is a reception point. Street width is d, distances from the transmission point

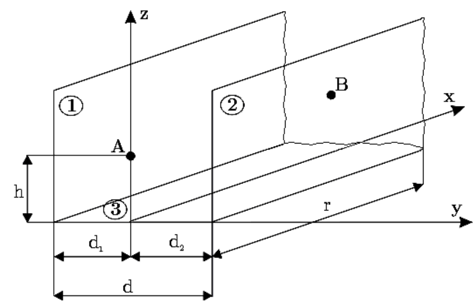

Fig. 3. Street wave channel model.

to lateral surface are d_1 and d_2, heights of the receiving and transmitting antennas are equal and $h \gg \lambda$.

In point B there is a directional antenna of client adapter WiMAX with directivity factor D2. We consider that a locally plane wave is transmitted from point A. It is caused by d1 and d2 being much bigger than λ. The street is presented in the form of three reflecting planes. On fig. 3 numbers 1 and 2 show reflective surface with parameters ε1, σ1which are peculiar to walls of the street architectural constructions (ε1,2=2..15, σ1,2=0,002..0,01). Approximation when modelling consists in the fact that the street building is considered solid. The reflective surface 3 models a carriageway with parametres of the surface ε_3, σ_3 (ε_3=2..5, σ_3=0,001..0,02).

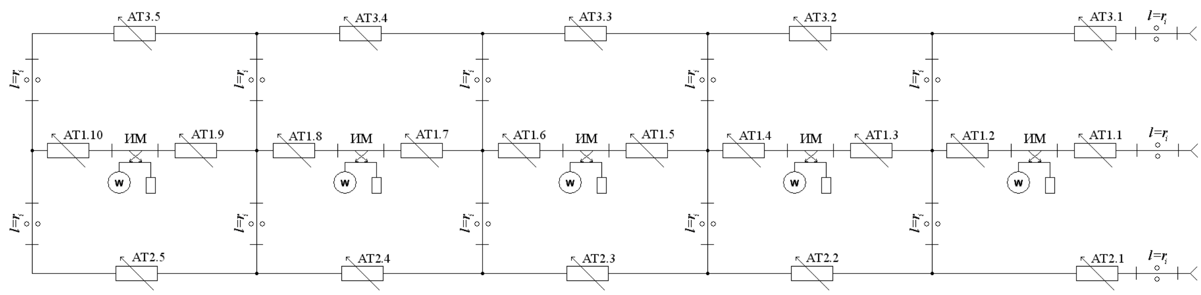

Fig. 2. The circuit for calculation of attenuations along Lenin's circular (m=1 – Lenin's avenue, m=2 – street Romena Rollana, m=3 – Yaroslav Galana's street).

Another approximation when modelling the street wave channel is application of Rayleigh criterion. At use of reflective tractability this measure is applicable within a field essential to reflexion only at small glancing angles. It corresponds to oblique incidence (far-field region) of a beam on the boundary. In this connection we consider that for distance r the far-field region requirement is satisfied, and the direct and reflected beams in the receiving point are parallel.

For these approximations and the case of vertical polarization the following ratios were obtained:

$$E(r_i) = \frac{1}{r_i} \cdot \left(1 + R_{\text{B}} \cdot e^{-\beta \cdot r_i} + R_{\Gamma} \cdot e^{-\beta \cdot r_i} + R_{\Gamma} \cdot e^{-\beta \cdot r_i}\right) \cdot e^{-\beta \cdot r_i}, \quad (3)$$

where R_B is reflectivity factor at vertical polarisation, R_Γ is reflectivity factor at horizontal polarisation;

$$\Pi(r_i / r_0) = \frac{1}{2} \cdot \frac{\left|E(r_i / r_0)\right|^2}{120\pi}. \quad (4)$$

Similarly, attenuations of all other attenuators AT (2, n) and AT (3, n) were calculated. Thus, power meters in the lines simulating streets 2 and 3 were excluded and propagation losses on all the length of corresponding pieces were attributed to the attenuators.

Comparative data of the results of the calculation on the supplied method and experiment is resulted on fig. 4–7.

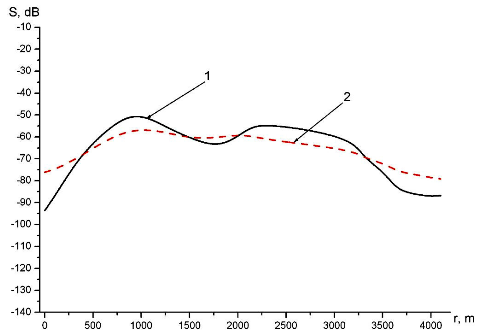

Fig. 4. Attenuation of signal along Lenin avenue (1 – experiment, 2 – calculation).

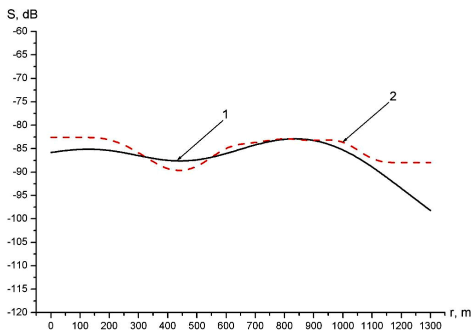

Fig. 5. Attenuation of signal along Lenin street (1 – experiment, 2 – calculation).

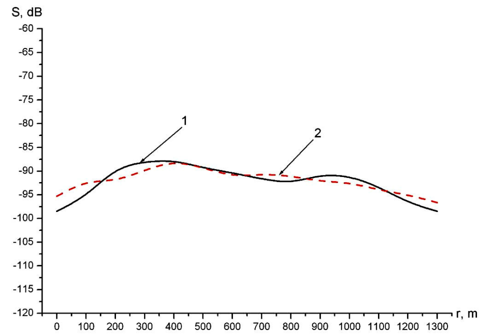

Fig. 6. Attenuation of a signal along Danilevskaya street (1 – experiment, 2 – calculation).

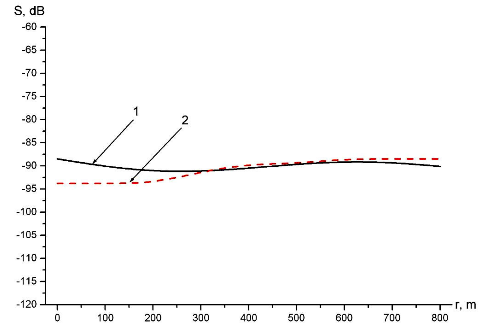

Fig. 7. Attenuation of a signal along Novgorodskaya street (1 – experiment, 2 – calculation).

It is not difficult to notice that the theoretical curves correspond well to the experimental ones.

3. CONCLUSION

The possibility of forecasting of attenuation in street radio channels on the basis of their representation in the form of microwave multi-terminal model has been proved.

REFERENCES

1. Strelnytskyi A.A., Strelnytskyi A.E., Tsopa A.A., Tsopa A.I., Shokalo V.M. Experimental researches of wideband connection wireless access system WiMAX by streets waves channels distribution signals. The fourth International Conference "Ultrawideband and Ultrashort Impulse Signals", Sevastopol, the Crimea, Ukraine, September 15-19, 2008. - p. 116-118.
2. Bernard Sklyar. Digital communication. Theoretical bases and practical application, 2-nd issue.: Translation from English - M: the Publishing house "Williams", 2003. 1104 p.
3. The recommendation MSE-R RG. 4-95.