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THE STUDY OF THE ELECTROMAGNETIC WAVE PROPAGATION EMITED BY BROADCAST TV STATIONS

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Abstract – The development of the broadcast services imply prediction of attenuation of the electromagnetic wave in the propagation area propose to be covered with radio signal. For prediction it is used propagation models that try to estimate the reception power in different interest points. This paper present a study for modeling the propagation of the radio waves transmitted by a broadcast Tv station, at 200 MHz video carrier.
Keywords: prediction, propagation model, Longley-Rice

I. INTRODUCTION

Until today, it is known several propagation models that can characterize the radio wave attenuation in different frequency bands, with results that can be satisfactory in a certain applications. Here it can be reminded some empiric models like *ITU-R P.370-7* recommendation, *Wojnar* model or *Hata – Okumura* model which, although is a model used in mobile communications, can be used also for broadcast estimations, for frequencies beyond 150 MHz, but only for a flat terrain. For this study, the author has observed that the propagation model with the best results was the Longley-Rice model, but, in several cases, for the rough country, the estimation error was inacceptable and the model need certain corections.

II. PROPAGATION STUDY

The Longley-Rice model has the following input data [1]:

- carrier frequency ranges between 20 MHz and 40 GHz, but it is recommended the upper limit to be 20 GHz;
- distance: 1 km – 2000 km;
- antenna heights: 0,5 m – 3000 m;
- vertical or horizontal polarization.

Beside the mentioned parameters, the model takes into account terrain irregularity parameter, electric ground constants or climatic region influences. In addition, the model has three statistic variables by which, one can choose the confidence level for the estimation of propagation attenuation for the different conditions.

For the study and validation of the propagation model, it was necessary to make a set of measurements around the emission station. These measurements were made with mobile measurement equipment, with the receiver antenna toggled at 9 m above the ground. In every measurement point, geographic coordinates was determined by GPS system, in order to have exact position on the map, for the calculus of the distance to the transmitter, and for determination of the elevation.

These measurements are presented in figure 1.

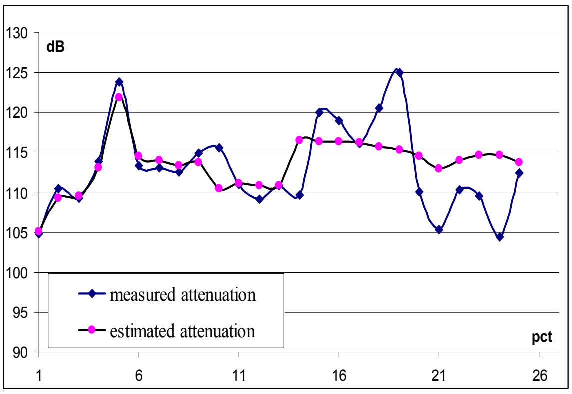

Fig.1 Experimental data representation

For every measurement point, the Longley-Rice predicted attenuation was calculated and represented in figure 1. It can be easily seen that are two categories of results: in some points has recorded small and acceptable differences between the measured and the predicted attenuation, but there is also, in several points, unacceptable differences

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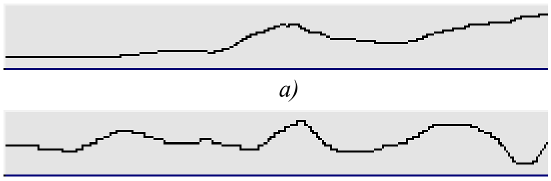
between the measurements and the calculated values of attenuation.

In order to establish the causes for these unacceptable results, the relief from the propagation path, in every situation, was analyzed. As an example, in the figure 2 are presented two propagation paths. For the first one, the results are very good, and for the second one, the predicted attenuation is bigger than the measured one.



a)

b)

Fig. 2 a) Propagation path with good results
b) Propagation path with unacceptable results

The conclusion is that, in the points with a smooth relief around the receiver, the error of prediction is acceptable. Anyway, where the relief around the receiver has big irregularities, the differences between the measurements and the prediction data are significant.

Therefore, the study reveals that the Longley-Rice model can be successfully used for broadcast predictions, but in certain situations, the model needs a correction coefficient to be added.

III. PRESENTATION OF THE EXPERIMENTAL DATA

In order to find a coefficient to improve the Longley-Rice model, a study was realised by measuring the electromagnetic field level in several points, choose to be placed on an imaginary straight line that simulate the points on a propagation trajectory. The points originally choose on the map were reached just over there where the terrain conditions and the access roads were permitted.

The position on the map for these points is presented in figure 3, and the experimental results are listed in table 1.

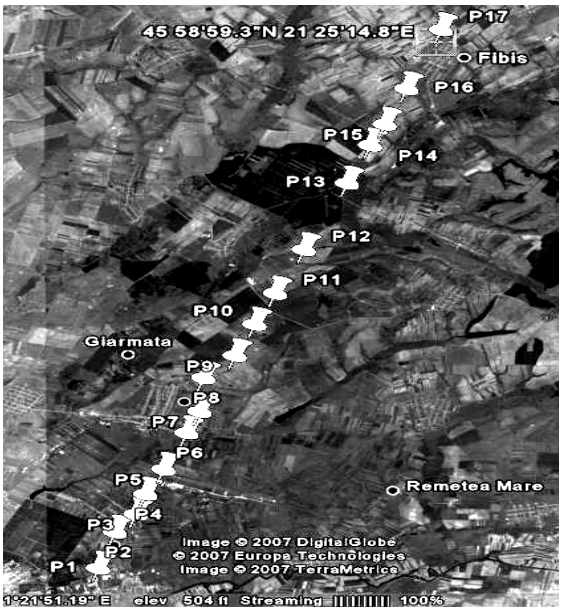


Fig. 2 The distribution of the measurement points along the propagation path

Table 1 Experimental data presentation

Pct	latitude	longitude	d[km]	angle	elevation [m]	Pr [w]	A_{mas} [dB]	LR(50,50) [dB]
1	45-46-23	21-17-19	6.427	24.6	94	7E-08	118.95	94.6
2	45-47-14	21-17-42	8.069	23.1	98	1E-07	116.35	96.6
3	45-47-39	21-18-10	9.021	24.7	102	1E-07	116.35	97.5
4	45-48-7	21-18-24	9.934	24.2	102	1E-07	116.53	98.4
5	45-48-42	21-18-49	11.14	24.5	104	1E-07	116.54	99.5
6	45-49-33	21-19-21	12.86	24.3	105	1E-07	116.64	102.5
7	45-50-3	21-19-39	13.86	24.2	119	1E-07	116.57	101.3
8	45-50-50.4	21-19-44.2	15.24	22.3	139	3E-07	112.15	102.1
9	45-51-21.4	21-20-27.9	16.5	24.1	149	1E-06	107.05	102.8
10	45-52-5.2	21-20-55.2	17.98	24	138	4E-08	121.45	112.1
11	45-52-48.7	21-21-23.5	19.46	24	126	3E-09	132.45	115.2
12	45-53-49.7	21-22-3.3	21.54	24.1	121	6E-08	119.85	113.1
13	45-55-22.6	21-23-3.1	24.69	24.1	127	3E-10	143.11	116.4
14	45-56-15.7	21-23-35.1	26.44	24	142	6E-08	119.57	115.9
15	45-56-45.3	21-23-55.4	27.46	24	151	7E-08	118.98	113.9
16	45-57-34.6	21-24-25.5	29.13	23.9	154	3E-07	112.23	114.5
17	45-58-59.3	21-25-14.8	31.95	23.8	168	8E-08	118.53	115.4

One can observe from the table that the measurement positions weren't perfectly in line, the angle measured from geographic north were between 22,3 and 24,7 degree. Also, in the table can be seen the measured power, and from here the recorded attenuation of the wave, the Longley-Rice model calculated attenuation and the elevation of the measurement point.

The graphic representation of the table 1 data is presented in figure 4. Beside the measured and calculated attenuation charts, it can be seen the chart of the propagation terrain profile for this study.

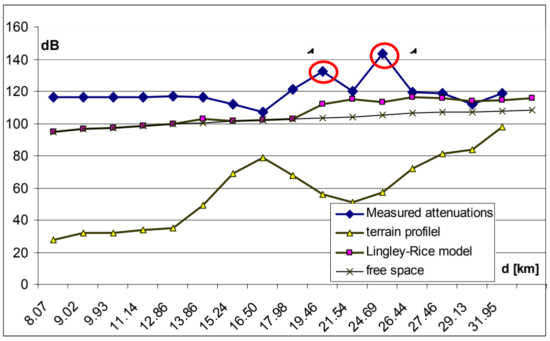


Fig. 4 Experimental data charts from table 1

About these experimental data, some important remarks can be made. First of all, the attenuation calculated by the Longley-Rice model, especially at small distances, it is identically with free space attenuation, and smaller than the measured attenuation. At larger distances from the transmitter, the attenuation estimated by the model is very close to the experimental data.

Another important observation regards the points where the measured attenuation is considerable bigger than the rest of the situations (the picks with circle in figure 3). The point mark with number 13 has the singularity to be placed behind woodland; the wood distance on the propagation path is about 1200 m. According to ITU-R P.833-4 and [2] it can be considered an excess attenuation due to vegetation, depends on the species and density of the vegetation, about 0,02 dB/m. For point 13 we have 24 dB excess attenuation and the remaining attenuation after adding this correction is A=119.11 dB, a plausible value and close to the values obtained in the vicinity points.

The most important conclusion from the study is that the attenuation measure and the one calculated by the model have significant differences that must be proofread. Also, from figure 3 charts result the existence of correlation between the terrain irregularity on the propagation path and the attenuation and a correlation between the measured and the calculated attenuation. The table 2 contains the correlation coefficients interest in this study.

Table 2. Correlation coefficients

Correlation	Correlation coefficients
meas. atten. – terrain profile	-0.067
model atten. – terrain profile	0.742
model atten. – meas. attenuation	0.485

The correlation coefficients from table 2 reveal that between Longley-Rice model and terrain profile it is a very close correlation, due to the fact that the model takes into account the propagation path influences in the propagation mechanism. The correlation between the model and measurements is only 0,485. This coefficient can be improved by adding at the Longley-Rice model a correction.

IV. NEW MODEL PROPOSED

The determinations of the correction coefficient added to the original model have started from the idea that the radio wave propagation is influenced by the receiver point relief (elevation) and also by the terrain irregularity near the receiver point. Therewith one can observe in figure 3 that the Longley-Rice model calculated attenuation doesn't pursue the measured attenuation, especially for small distances from the transmitter (distances smaller than 15 km). That supposes to introduce a coefficient that takes into account relief variation at small distances from the transmitter. When the distance grows, this coefficient must have a smaller weight because in the wave propagation the reflections, diffractions or scattering appear, and the terrain profile variations don't have a dominant influence.

The proposed mathematical relation for the correction coefficient has the expression:

$$C = \frac{\frac{dh}{dr} - k \cdot r}{r^n} \cdot 100 = \frac{100}{r^n} \cdot \frac{dh}{dr} - \frac{k \cdot 100}{r^{n-1}} \text{ [dB]} \quad (1)$$

where: h – terrain elevation convey in m;
r – distance from transmitter to measurement point, convey in km;
k, n – weights who depend on the terrain irregularity.

The purpose of the first term is to characterise the relief influence over propagation at small distances form the transmitter, and the second term decrease the influence of the first term, when the distance grow.

Figure no. 5 present the chart for the propagation model with the correction added.

The new model succeed a better approximation relative to originally model, and the improvement is reflected by correlation coefficient between the measured attenuation and the estimated one: 0,485 – the old coefficient and 0,696 – the new coefficient.

In the (1) formula, the weights *k* and *n* have the values: $k = 3{,}1$ and $n = 2{,}4$. One can observe that the distance decrease, not with the square of distance, but with a fractional power. This behaviour of the radio wave attenuation was reported also in other publications. In [4] one considered that for distances bigger than 30 m from the transmitter, the intensity of the field, at a given height vary with $1/r^n$ (*r* - distance), where *n* take values between 1,3 - for open areas and 2,8 - for dense urban areas. For calculus, average value for the weight is 2,4.

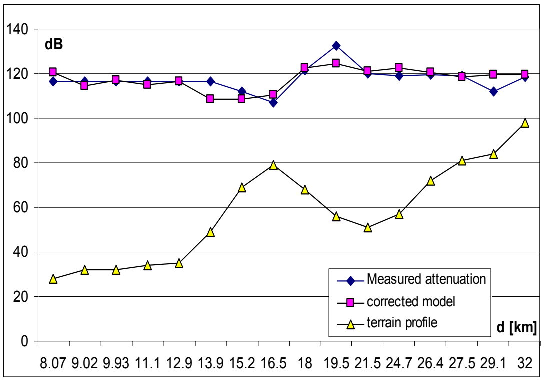


Fig 5 The propagation model after correction

V. CONCLUSION

The study reveals the Longley-Rice propagation model as a model with good estimation results, but especially at small distances from the transmitter and for the area with big irregularities, the prediction can have errors. By introduction of a correction coefficients that take into account the relief variation at small distances from transmitter, the prediction have better results, even in shadow relief region. The weights *k* and *n* from correction coefficient formula is established empiric, they have values close to the values presented in literature and it is possible to have different values for different propagation paths and different frequency.

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