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LOCATION OPTIMALITY EVALUATION OF TRACK RADIO STATIONS IN SERBIAN RAILWAY NETWORK

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***Abstract** – The main goal of this paper is to present implementation railroad radio-station communication system in exploitation conditions. Installation of this system has been done during the reconstruction railway in location Rakovica –Resnik. For the purpose of this project is necessary to be done install a railroad radio-station for communication between the dispatcher BG train and the locomotive. One of the demands from costumer was that the base radio station needs to be implemented in the existing system and that meet with the required criteria for coverage of the railway by radio signaling 95% in the space and time. This paper presenting the comparison of the results obtained by calculations with results obtained by measurements made on the location. Parallel with comparison it will be done influence of the newly installed radio-station on the already existing system. This paper also shows solving prediction predicting the strength of the electric field which occur during project of implementation any radio-system.*

Keywords – Railway, radio station, installation, measurement.

1. INTRODUCTION

Locomotive Radio Dispatching System (LRDS) sheme is shown in Figure 1. is of great significance for security of railway transport and provides continuous duplex communication, by speech or coded commands, between moving locomotives and dispatching center, in the 460MHz (0,7 m) band. This system can integrate railway divisions for maintenance and arrangement services into one system. Also, it is open to public switched telephone network. The LRDS improves railway transport efficacy and is of great importance for security and safety of railway system. [1-4] The demand for multimedia communications, which operate with excessive speed using extremely large-sized wireless mobile community, has massively risen. [5, 6].

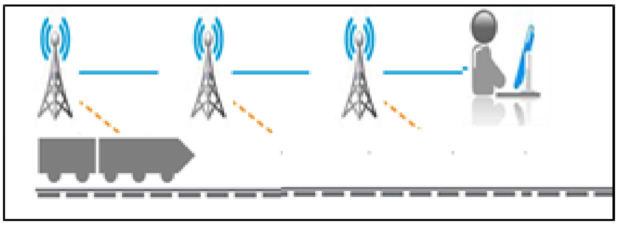

Fig.1. Functionality of Radio-Dispatcher System

The main goal of this paper is to present implementation railroad radio-station communication system in exploitation conditions. Installation of this system has been done during the reconstruction railway in location Rakovica –Resnik. [3] For the purpose of this project is necessary to be done install a railroad radio-station for communication between the dispatcher BG train and the locomotive. One of the demands from costumer was that the base radio station needs to be implemented in the existing system and that meet with the required criteria for coverage of the railway by radio signaling 95% in the space and time. [5,6]

For the needs of the railway reconstruction project in the section G -Rakovica-Resnik, it is necessary to implement the new radio-stations for the existing system in order to enable communication through the RD system in this part of the railway line, while meeting the required criteria for covering the railroad with a radio signal of 95% in space and time. In this paper we dealt with the comparison of the results obtained with theoretical calculations with actual measurements made on the ground. It will also be taken into account by measuring the impact of the newly installed radio station on an already existing system.

When designing any radio system, two basic

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problems are solved:

- Determination of the coverage area, which are the geographical zones in which the fixed radio transmitters provide sufficient strength of the electric field for the quality work of the radio receiver.
- Determination of the interference area, i.e. the minimum distance between radio transmitters operating on the same or adjacent radio channels with the permissible level of interference.

2. PROCEDURE FOR COVERING THE RADIO FIELD

As it is known from the theory of electromagnetic wave propagation, the magnitude of the electromagnetic field decreases according to the hyperbolic law by the distance of its source.

At a frequency band with of 0.7 m, it is not possible to achieve a homogeneous electromagnetic field. It could only be achieved in terms of optical visibility and in a space without reflections (Figure 2). However, due to the topography of the terrain, these conditions cannot be realized. In the case of a radio dispatch system, due to this reflection, is an important factor is that for the large number of sections they are the only way to make radio connections.

According to the laws of interference, there is a distribution of the field of maximum and minimum with a distance of about λ / 2, as can be seen in the finely explained flow of the hyperbolic propagation curve. When driving through this field, the antenna voltage changes depending on the field strength distribution. The difference between the maximum and the minimum field strength will be even greater if there is a higher proportion and number of reflections and can be up to +15 db. The range of a single station is thus limited to areas where the receiving voltage is greater than 1.9 V + 0.2 V, which is designated as a systemic range. (Figure 1).

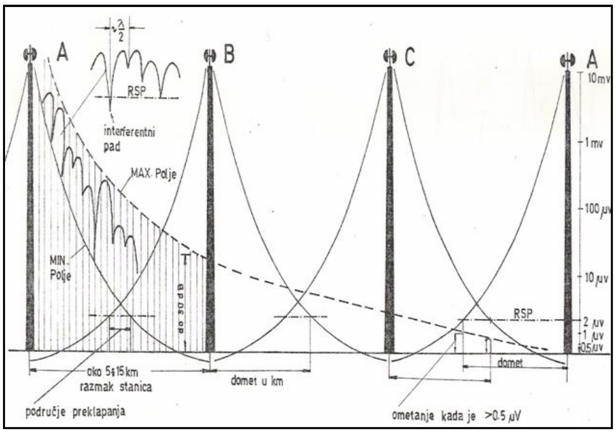

Fig .2. Procedure for covering the radio field

Theoretical calculations of the location of the radio stations are performed on the basis of the curves of the CCIR(ITU-R) for the UHF area.

Already after 35 km of probability by radio signal falls from 95% to 5%, and omissions in crossing the range, interference will occur in this area if the CCIR(ITU-R) protection value exceeding 8 dB is exceeded according to the minimum value of the useful signal. Based on this, it is only after 35 km that it will be possible to install a radio station with the same transmitting frequency.

In the area of one RD section, only three of the same shipping frequencies are used, f3, f2, f4, and again f3, f2, f4 etc. When locomotives go from the coverage area of a one radio station to the coverage area of the second, auto-switching the receiving frequency to the device in the locomotive. The receive frequency f1 is the same on all radio stations of one RD section.

For the purpose of project realization, it was necessary to determine the location for installing equipment, antenna pillar and the necessary infrastructure in order to get the coverage of the radio fields as good as possible. The total length of the track to be covered is L = 7,428 m.

Fig.3. Display of geographic locations

By analyzing the terrain and the distance between the endpoints, it has been found that this part of the track can be covered with just one location by placing the appropriate equipment (Figure 3).

The indicative position of the measured location of the antenna pillar would be in the coordinate point N: 44043'46.25; E: 20026'01.13 ".

Functioning of the system must be reliable with QoS marked as 95% coverage in space and time. Therefore, the radio field level, which depends on locations of antennas and radio waves reflection patterns, must exceed the requested value 1,9 μV + 0,2 μV throughout the coverage area, making the issue of antenna locations very important. We assume that the antenna locations include directions of radio beams, i.e. azimuth and elevation, as main factors of radio coverage. Hence, the optimality of location includes the optimality of radio beam azimuth.

3. THEORETICAL DETERMINATION OF THE LOCATION

For the preliminary and theoretical measurement, the Radio Mobile software is used, in which the necessary parameters are entered. First, the values of the base radio station are defined, such as the output power, the characteristics of the antenna system (height, amount of antenna and characteristics of the antenna itself), location as the angle of the antenna orientation, which is determined in relation to the endpoint for the necessary direction.

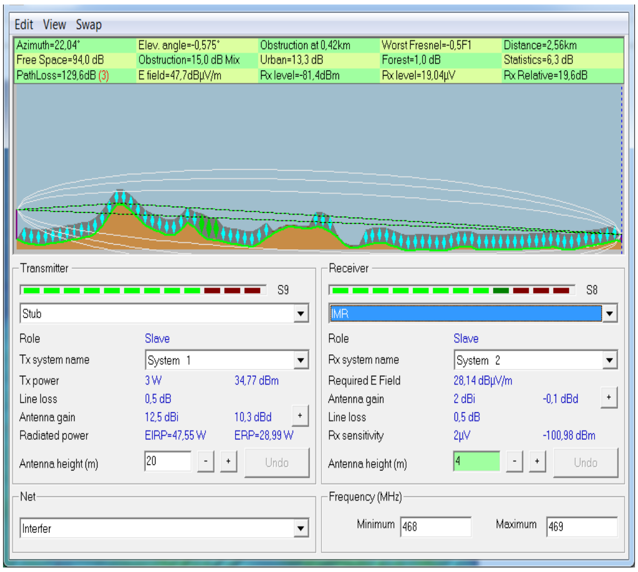

Fig.4. View the look of the measurement software with the results and the given parameters from the proposed location to Rakovica

Then, a mobile radio station (a radio station located in a locomotive) is defined, which we will call System 2. For measurement in multiple locations the defined parameters for this system remain the same, only changes the location where it is, and these are the extreme points of coverage and points without optical visibility that need to be covered.

The more defined measuring points this will result in more accurate results (Figure 4 and Figure 5). Each point is checked in two directions.

By analyzing the obtained results, we confirmed that with the proposed locations ensures the coverage of the radio-signal will be with satisfaction strength in 95% of time and space.

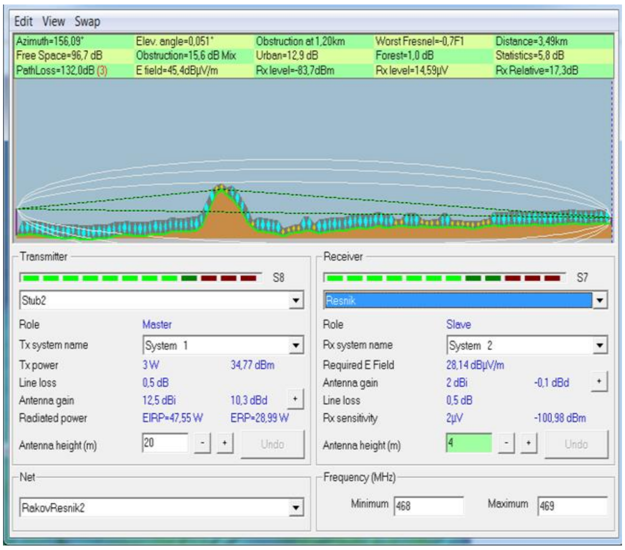

Fig.5. View the look of the measurement software with the results and the given parameters from the proposed location to Resnik

Based on these results, the installation of antenna system and equipment is planned as a simulation and measurements will be made to check the operation of the system in real time and space.

4. MEASUREMENTS IN THE FIELD

On the kilometer position 11+000. After raising the antenna, the direction of the antennas has been carried out in the following directions:

- direction towards Resnik, azimuth is 156^0
- the direction towards Rakovica, azimuth is 20^0.

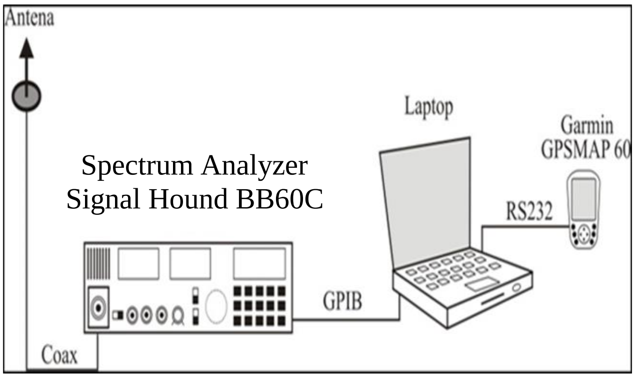

Fig.6. Measuring configuration

The frequency at which the measurement was performed is 467.775, which is the transmit frequency f1 on the 63 channel. Measuring configuration is shown on Figure 6.

To generate the signal, the FESA 2010 radio station will be used, the power of the FESA radio station is set to level 3, which is 6 W, while the following devices are used as the measuring receiver:

The origin measurement software (Figure 7) can currently measure the signal value in just one frequency, but to have a full picture or all three frequencies in order to compare and determine the overruns. So we created for these measurements, the software for the measuring instrument so that for every 3 seconds it takes the value of the electromagnetic field for the same frequency f1, f2, and f3. At the same time the time of the printing of the value is taken of the geographical position data (Table 1).

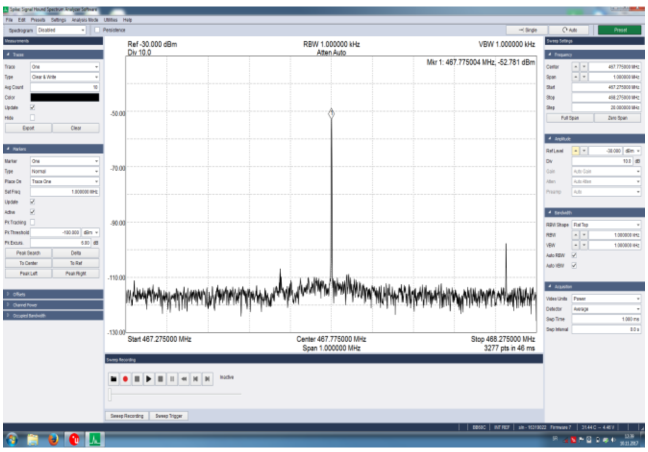

Fig.7. Measurement software

Tab. 1. Measured values

Latitude	Longitude	F1 Level	F2 Level	F3 Level
44,7076	20,44615	-92,86358	-108,5662	-106,1546
44,707833	20,44605	-85,55351	-108,0218	-107,034
44,707983	20,445983	-84,20929	-107,3461	-105,1124
44,70815	20,4459	-83,14652	-107,9842	-105,3148
44,7083	20,44585	-83,36789	-108,682	-106,3908
44,70845	20,445817	-85,80376	-107,4513	-106,6894
44,708583	20,445783	-85,45592	-108,0835	-106,1983
44,7087	20,44575	-88,33687	-107,6387	-106,9722
44,708817	20,445733	-79,18292	-108,3198	-106,5086
44,708933	20,445717	-81,05209	-107,8416	-106,6388
44,70905	20,445667	-79,89371	-107,6748	-107,5934
44,70915	20,445633	-81,0747	-108,0791	-106,4525
44,709317	20,445583	-82,92093	-108,4029	-106,7745
44,709433	20,445567	-83,31532	-108,0732	-106,8971
44,70955	20,44555	-87,46712	-107,8856	-104,8159
44,709667	20,445533	-82,84109	-108,9202	-106,4467
44,709767	20,445517	-78,76736	-106,9898	-107,525
44,709883	20,445483	-78,57267	-107,8336	-105,8001
44,709983	20,445433	-91,16868	-108,7121	-107,3579
44,7101	20,4454	-94,28963	-108,2239	-107,6675
44,710217	20,445367	-88,78308	-107,9427	-107,4158
44,710333	20,445317	-88,26634	-108,734	-107,7473
44,71045	20,445283	-82,28362	-107,9592	-105,996
44,710567	20,445233	-78,9172	-108,0901	-107,4489
44,710683	20,445183	-76,13741	-108,7153	-108,0772
44,710783	20,44515	-71,34742	-108,328	-106,6834
44,71095	20,445083	-76,88191	-107,9134	-106,2601
44,711067	20,44505	-76,00262	-108,1935	-106,9485
44,711183	20,445017	-73,72744	-108,449	-106,7313
44,7113	20,444983	-72,49283	-107,8883	-106,7678
44,711417	20,44495	-70,97686	-108,6883	-107,0591
44,711533	20,444883	-73,54751	-107,1313	-106,7266
44,71165	20,444833	-76,45788	-108,0191	-105,508

Spectrum Analyzer: Signal Hound BB60 C that is connected to a PC via a USB interface. Also, the spectrum analyzer is connected to the antenna through which the signal from the interface is received. Signal reading is done in dBm units using the Spike v3.1.10 software.

GPS receiver, in order to determine the current position, the "in-block LEA-6H", connected to the computer via the USB interface. Also, the GPS receiver is connected to an active antenna via which the GPS receiver receives signals from the GPS satellite. Reading the current position is done using the u-Center v6.01 software.

After the measurement is done, the data is inserted into the diagram Figure 8. Each frequency is colored in a different color to make it more transparent. In this diagram to the left, the value of the signal strength while the time is marked at the bottom. Blue is marked frequency f1, which is a new location. This diagram shows that there is no exceeding the range with the next location with the same frequency.

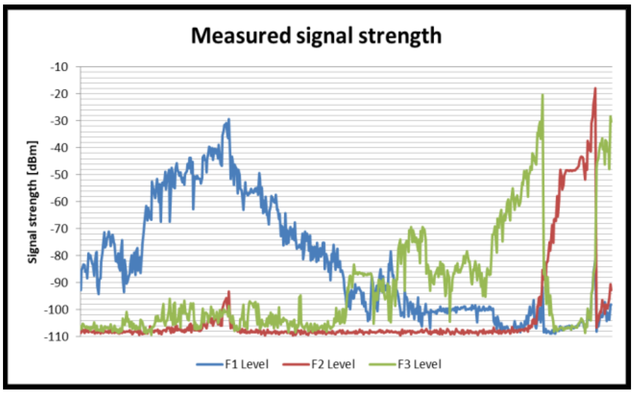

Fig. 8. Diagram of measured values

5. CONCLUSION

Earlier, with paper-edged devices, which have Serbian railway it was possible to measure only one frequency and these measurements lasted for days.

The analysis of the results was also difficult, because for each measurement on one frequency on the paper strip it was very difficult to compare the overlap. In this way, it is much faster and easier to measure, because with only one movement of the rail vehicle you can get a complete picture of the whole system very quickly and reliably!

In this paper we analyzed optimality only for one, although the most versatile topographically, section of the whole radio covered railway network. We decided to apply such methodology in order to formulate the method for analysis. Nevertheless, the LRDS has been passed continuous improvement over years of its exploitation, since its beginning on 1982, we still find a room for rising of its performance. This work gave us an impetus to do so relying on more exact basis which will be the theme for our further research.

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