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Evaluation of EMF Exposure from Digital Terrestrial Television Transmitters

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***Abstract* – This study presents results of a preliminary survey of the RF electromagnetic fields (EMFs) originating from digital terrestrial television transmitters. In situ-measurements of DVB-T2 signals were conducted in the city of Iasi, Romania, and its rural vicinity, where a 180 meters tall guyed mast for FM-/TV-broadcasting is installed. The measured *E*-field levels were found to be well below the exposure limits recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) for the general public.**

***Keywords* – EMF exposure, DVB-T2 transmitter antennas, in-situ measurements**

I. INTRODUCTION

The transition from analogue to digital terrestrial television (DTT or DTTV) is a process in various stages of implementation around the world [1]. In the European Union (EU), DTT represents the most widespread platform for TV reception, reaching over 100 Million households – 250 million viewers [2].

DVB-T (*Digital Video Broadcasting – Terrestrial*) is the DVB European-based consortium standard for the broadcast transmission of digital terrestrial television. It transmits compressed digital audio, digital video and other data in an MPEG transport stream, using the coded orthogonal frequency-division multiplexing modulation (COFDM). DVB-T was first published in 1997 and first broadcast in 1998, in the UK [3].

Although Romania started DVB-T broadcasting in 2005, it was only experimental. In 2012, the Romanian authorities decided that DVB-T2 (*Digital Video Broadcasting – Second Generation Terrestrial*) will be the standard used for terrestrial broadcasts, as it allows a larger number of programs to be broadcast on the same multiplex (MUX). On 17 June 2015, the analogue terrestrial television was switched off, with the exception of the main public TV program (TVR1), which will continue to be broadcast strictly in the VHF band until the end of 2016 [4].

At the end of 2015, free-to-air DVB-T2 broadcasts on MUX1, provided by the state-owned Radiocom, were available for about 56% of the population [5]. In such a context, we initiated a measurement campaign of the RF electromagnetic fields originating from DVB-T2 transmitter antennas, first in the city of Iasi and its rural vicinity. To our knowledge, no study has tried to evaluate the in-situ DVB-T2 exposure in our country.

II. RELATED RESULTS IN THE LITERATURE

A number of studies concerning – at least partially – the RF exposure from DVB-T systems were published over the past decade, with the migration to DTT in the European countries.

In Germany, extensive exposure measurements were performed at more than 300 points in two DVB-T starting-areas, Munich and Nuremberg. At 200 locations in residential areas, measurements before and after the switchover were carried out to determine a possible change of exposure situation. Additional measurements along defined lines and inside buildings were also performed [6, 7].

In Belgium, The Netherlands and Sweden, measurements of DVB-T signals were carried out in the framework of a common survey of the RF electromagnetic fields from emerging wireless communication technologies. According to this study [8], which was published in 2012, the exposure ratios from DVB-T (if present) were the highest except GSM.

A study from 2013, [9], deals with the electromagnetic field exposure from a DVB-T transmitter in the urban environment of Zagreb. Measurements of electric field were performed at several key locations and compared to theoretical calculations of the present field.

There are also several studies and reports concerning the evaluation of the RF exposure from DVB-T, e.g. [10], but all of these show that the RF exposure levels are generally well below the exposure limits recommended by ICNIRP [11]. This is also true in our case.

III. MEASUREMENT METHOD

Like its predecessor, DVB-T2 uses the OFDM modulation scheme [12], which divides the available bandwidth into a large number of closely spaced subcarriers and transmits data in parallel streams. The signal bandwidth can be either 8 MHz (in the UHF band) or 7 MHz (in the VHF band). Currently, the DVB-T2 transmissions occur in the UHF band, relayed from a number of transmitters located at high sites around the country.

In order to measure such emissions, we adopted a frequency-selective method based on a SPECTRAN HF-60105 V4 spectrum analyzer (1 MHz – 9.4 GHz) in conjunction with a calibrated BicoLOG 20300 antenna (20 MHz – 3 GHz), both from Aaronia AG (Fig. 1). After extensive investigations, taking into account the characteristics of the DVB-T2 signals with respect to the performances of the spectrum analyzer, the following settings were established for assessing the DVB-T2 exposure: RMS (Root Mean Square) detector, resolution bandwidth *RBW* = 5 MHz, video bandwidth *VBW* = 50 MHz (FULL), sample time *SpTime* = 250 ms (sweep time *ST* about 750 ms, as reported by the MCS Spectrum Analyzer Software), frequency span of 20 MHz, with the center frequency (CF) of the spectrum analyzer equal to the CF of the DVB-T2 signal.

Fig. 1. Instrumentation used for the survey

At each selected location, MAX HOLD measurements were taken with the antenna oriented in three orthogonal directions, at a distance of 1.5 m above the ground or floor, for a sufficiently long time to allow the trace to stabilize. During the investigations, a minimum distance of 0.5 m was maintained between any object and the antenna [13, 14].

All readings indicated by the spectrum analyzer (power in units of dBm) were recorded and converted to *E*-field strength levels, in units of V/m, by taking into account the antenna factor and power losses in the connecting coaxial cable [15, 16]. Then, the total *E*-field at each location was calculated with the formula [17]:

$$E_{tot} = \sqrt{E_x^2 + E_y^2 + E_z^2}\,, \qquad (1)$$

where E_x, E_y and E_z represent the three orthogonal readings.

The specified accuracy of the HF-60105 V4 spectrum analyzer is ±1 dB (typically), but higher deviations are possible especially when approaching the so-called noise floor or the maximum sensitivity of the instrument [18].

IV. RESULTS AND DISCUSSION

DVB-T2 exposure measurements were performed at 80 locations: 62 – in different areas of the Iasi city, 18 – in the surrounding of the "Pietraria" transmitter, a 180 meters tall guyed mast for FM-/TV-broadcasting at Pietraria, a village near Iasi. Fig. 1 shows the position of the transmitter and considered measurements locations on the map. Most of the measurements were taken outdoor, in the period March 2016 – April 2016.

An overview of the VHF and UHF frequency bands at a measurement location is shown in Fig. 3. At the moment, only a DVB-T2 signal is present in the UHF band, on channel 25 (506 MHz CF). Other two multiplexes will be broadcast in the UHF band until the end of May 2017, so we expect an increase in total RF exposure associated with this technology.

Fig. 2. Indication of the measurement locations on the map (yellow marker: E < 0.1 V/m; black marker: E > 0.1 V/m)

The highest *E*-field level recorded during the survey was 0.382 V/m, which represents 1.24% of the exposure limit (30.93 V/m at the frequency of 506 MHz). It was measured in the proximity of the "Pietraria" transmitter, at a ground distance of about 150 m (location "1" on the map). The highest *E*-field level measured in the urban environment was 0.096 V/m (location "2" on the map), which accounts for 0.31% of the limit.

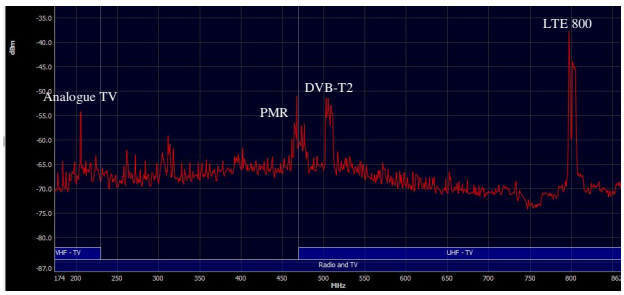
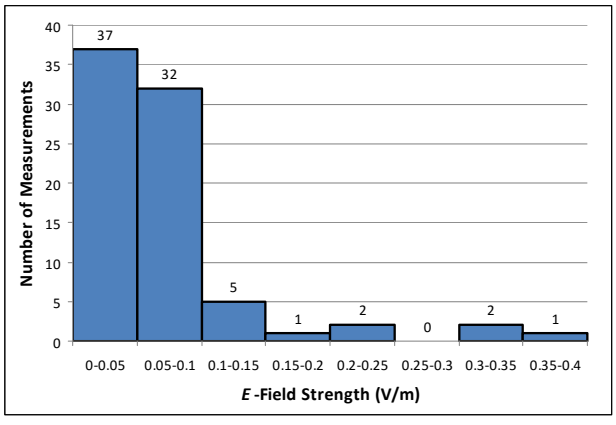


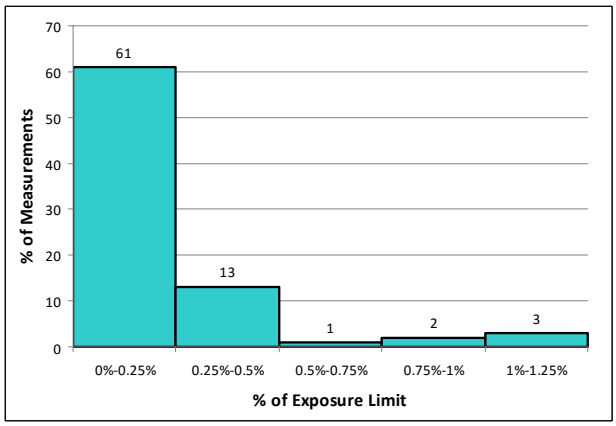
Fig. 3. Overview of the VHF and UHF frequency bands

Fig. 4.*a* illustrates the general distribution of the survey results in terms of *E*-field strength. The overwhelming majority of the results are below 0.1 V/m (0.32% of the field strength limit), whereas the average and median values are 0.072 V/m (0.23% of the limit) and 0.056 V/m (0.18% of the limit) respectively. In percentage terms, 61% of the recorded *E*-field levels are below 0.25% of the ICNIRP exposure limit, whereas 13% of the readings are in the range from 0.25% to 0.5% of the limit (Fig. 4.*b*).

At a first glance, the obtained results are comparable to those reported for DVB-T in the literature. For instance, in [7], the maximal exposure concerning the power density is 6.5 mW/m^2 (corresponding to 0.24% of the ICNIRP reference levels), whereas our maximum value is 0.39 mW/m^2 (corresponding to 0.015% of the ICNIRP limit, 2.53 W/m^2). In [8], the maximal and average exposure values reported for Analogue TV / DVB-T are 1.65 V/m and 0.09 V/m respectively. As we can see, these levels are somewhat higher than our results, but we measured only a single channel.



a)



b)

Fig. 4. Distribution of the recorded data: a) number of measurements as a function of E-field strength; b) percent of measurements as percent of ICNIRP exposure limit

Regarding the main factors influencing the DVB-T2 exposure, this greatly depends on the distance from the transmitter and terrain irregularities. The buildings and other obstructing structures in the urban environment have also a strong influence on the DVB-T2 exposure, causing not only a significant reduction in the EMF levels, but also a very complex spatial distribution.

V. CONCLUSIONS AND FUTURE WORK

According to the measurements performed for this survey, the *E*-field levels from DVB-T2 transmitter antennas were found to be well bellow the exposure limits recommended in the ICNIRP guidelines. The highest *E*-field level was 0.382 V/m, which corresponds to only 1.24% of the exposure limit, whereas 74% of the measurements were below 0.5% of the limit.

Future research will be focused on the influence of different factors on the DVB-T2 exposure. For instance, one limitation of our study was that most of the measurements were taken outdoor, at the ground level, so further investigations might be necessary to characterize the indoor exposure, especially in tall buildings that are in the direct line-of-sight of the transmitter. Also, we expect an increase in the total DVB-T2 exposure with the release of MUX2 and MUX4, until the end of May 2017.

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