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## THE ELECTROMAGNETIC FIELDS NEAR A MICROWAVE OVEN ~ MEASUREMENT AND ANALYSIS

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**ABSTRACT:** The issue of electromagnetic fields emitted by different types of devices is currently a very hot topic. Extensive research is being carried on in this field mainly regarding the impact of these emissions on the human body. This article focuses on measuring and analyzing the electromagnetic field of a microwave oven that are most commonly used in our neighbourhood and residential environments. The microwave oven is a commonly available appliance that does not transmit data but still radiates signals in the unlicensed 2.45 GHz band. The microwave oven causes also an unintentional interference for wireless fidelity (Wi-Fi) communication signals. At the end of the article is devoted attention the reference levels for occupational exposure and exposure of the general public were determined by International Commission on Non-Ionizing Radiation Protection (ICNIRP). This reference levels or exposure action values were also included into the Slovak legislation. The reference levels are intended to be spatially averaged values over the entire body of the exposed individual, but with the important condition that the basic restrictions on localized exposure are not exceeded.

**Keywords:** electromagnetic field, device, electric field strength, microwave oven

### 1. INTRODUCTION

As described in the document [3], microwaves are electromagnetic waves and their frequencies (wavelengths) are in the range from 300 MHz ( $\lambda = 1$  m) up to 300 GHz ( $\lambda = 1$  mm). Regarding wavelengths as typical spatial dimensions, we realize that microwaves do not have dimensions of  $\mu\text{m}$ , as might be expected from the misleading ‘micro’ in their name. After international conventions, microwave ovens at home or in restaurants operate at frequencies of about 2.45 GHz, i.e.  $\lambda = 12.23$  cm. Microwaves are generated in a magnetron which are powered trough a waveguide into the cooking chamber. This cuboids chamber has metallic-walls and so acts as a Faraday cage. The front door, made of glass and the light bulb cavity are both covered by metal grids. The holes in the grids are small compared with the wavelength of the microwaves and the grid acts just like metal plate. Showing a typical microwave oven is presented in Figure 1.

The residential microwave oven has one magnetron tuned to approximately 2.45 GHz (the commercial uses two magnetrons) and typically radiates across the entire Wi-Fi spectrum. This device emits electromagnetic high-frequency power that, when operating at the same time and in close to Wi-Fi devices, can cause data loss and even connection termination. [1]

Signal of a microwave oven at residential buildings, in the switch ON, is similar to a Frequency Modulated (FM) signal with a frequency-sweep, as is possible seen in the spectrogram in Figure 2. In the figure it seen two transient signals, which exist in each period. One is at the beginning and one at the end of switch ON cycle of microwave oven. The transient signals are broadband, with power spectral densities extending up to 60 MHz in bandwidth. The frequency-sweep of

microwave signal is mostly for less than half of the 60 Hz time period, typically 5÷6 ms. During the frequency-sweeping, the radiated signal can be characterized as an FM signal but with varying power levels, suggesting that the latter property means that it is an Amplitude Modulated (AM) mode. Thus a combined AM-FM waveform will serve as a basis for the frequency-sweeping part of the signal. [2, 4, 5, 7]

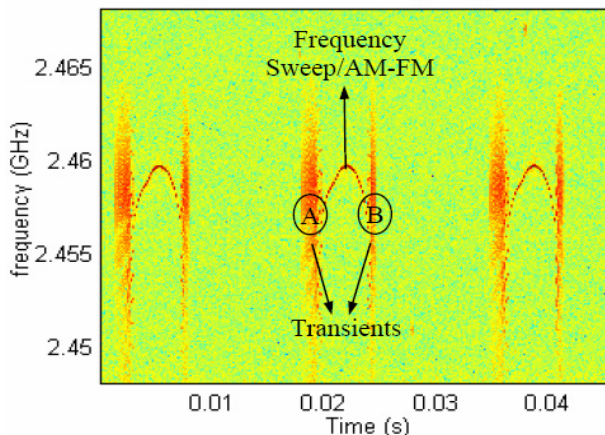
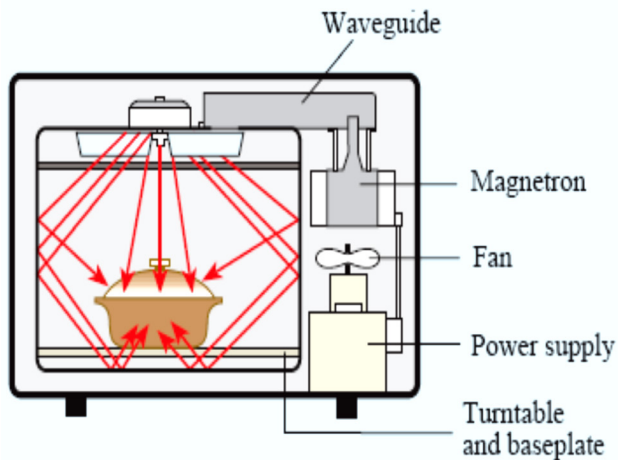


Figure 2. Spectrogram of typical microwave oven signal [2]

Figure 1. Typical microwave oven [3]

## 2. EXPERIMENTAL MEASUREMENTS AND METHODS

For measuring was used spectral analyzer Narda SRM 3006 with isotropic probe 3502/01, whose measuring range is within  $0,14 \cdot 10^{-3} - 160$  V/m. Frequency range of probe is from 420 MHz to 6 GHz. Measurements of the electric field strength have been made in the frequency area of microwave oven. The parameters of the microwave oven are as follows: input voltage 230 V, input frequency 50 Hz, input power 1200 W, output power 700 W and operating frequency 2.45 GHz. On the microwave oven was set the working mode in the maximum level (High level). Microwave oven was placed on the table and its center was located at the height of 1.0 m above the floor.

Electric field strength measurements, was carried out on five sides of microwave oven, at a distance of 0.2 m, 0.5 m, 0.8 m and 1.0 m from the front door, rear wall and side walls as well as at a distance of 0.5 m and 1.0 m from the upper wall. Measuring probe, for all measurements was placed at 1.1 m and 1.5 m above floor level.

Measuring analyzer was set in the following parameters: resolution bandwidth (RBW) 3 MHz, video bandwidth (VBW) 300 kHz, measurement range 4 V/m and range of frequency bands from 2.3 to 2.6 GHz.

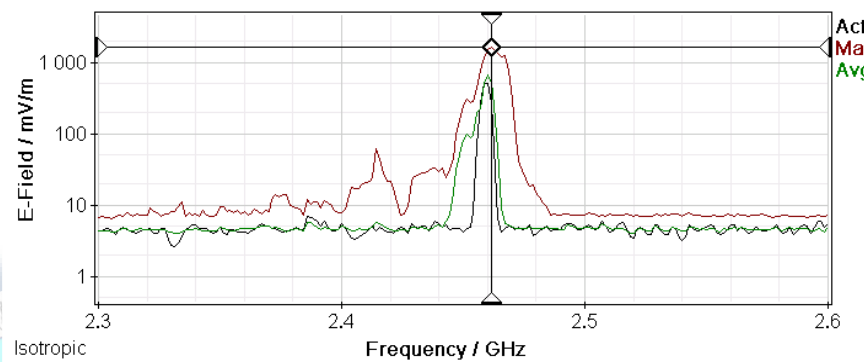
Measured values were reading and displayed on the analyzer at the mode “Max Hold”. In the microwave oven was, at the measuring time, embedded glass of drinking water with a bulk of 0.2 liter.

As a first step has been identified frequency of microwave oven in spectrum mode. The highest values of the electric field strength were in the range of frequencies 2.454 to 2.464 GHz (see on the Figure 3).

## 3. MEASUREMENT RESULTS

Measurement results are shown in the following tables and graphs. Table 1 and graph 1, shows the results of electric field strength measurement from the side microwave oven (side, where it is located magnetron). Table 2 and graph 2, shows the results of measurement from the front of the microwave oven (door). Table 3 a graph 3, shows the results of measurement from the back side.

Battery:	Ext. Power Freq:	2 461.46 MHz	Ant:	3AX 0.4-6G	SrvTbl:	1_MTEL_9
Service:	Srv_0007 Max Pk:	1.646 V/m	Cable:	SRM 1.5 m	Std:	ICNIRP GP



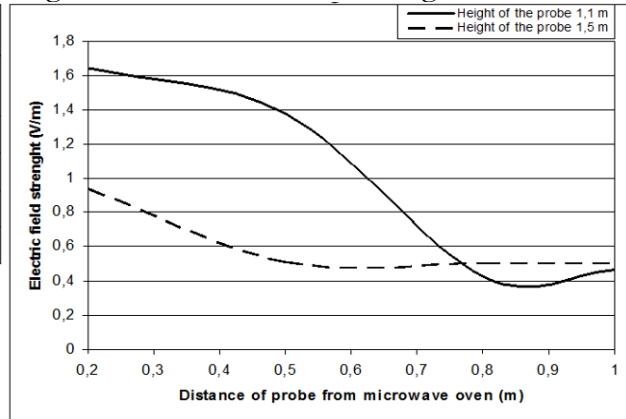
Isotropic Spectrum					
Fmin:	2.3 GHz	Fmax:	2.6 GHz	Sweep Time:	257 ms
MR:	4 V/m	RBW:	3 MHz	Progress:	<div style="width: 100%;"></div>
		VBW:	300 kHz	No. of Runs:	12 833
				AVG:	4

Figure 3. Spectrum analysis

Table 4 and graph 4, shows the results of measurements from the opposite side of the magnetron. Table 5 and graph 5 shows, the results of measurements from the top of the microwave oven. Microwave oven was placed on the table and its geometric center was located at the height of 1.0 m above the floor.

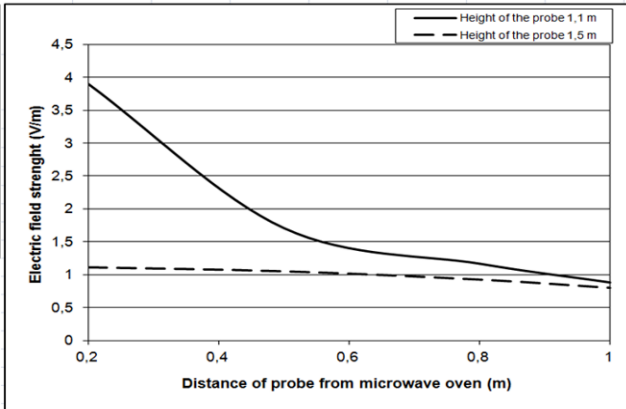
**Table 1.** Graph 1 Results of electric field strength measurements from the magnetron side

Distance from the microwave oven [m]	Electric field strength (V/m)	
	Height of the probe 1,1 m	Height of the probe 1,5 m
0,2	1,646	0,941
0,5	1,380	0,510
0,8	0,427	0,507
1,0	0,468	0,503



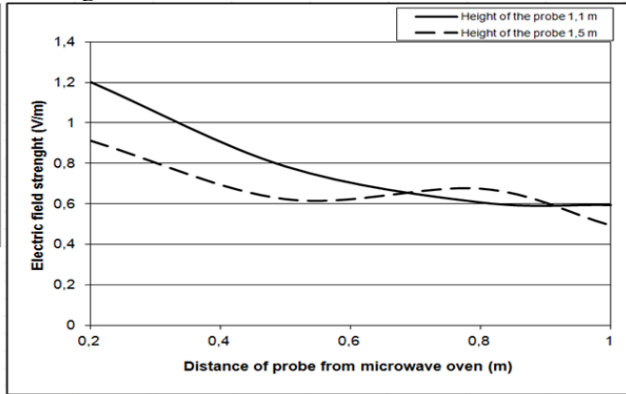
**Table 2.** Graph 2 Results of electric field strength measurements from the door side

Distance from the microwave oven [m]	Electric field strength (V/m)	
	Height of the probe 1,1 m	Height of the probe 1,5 m
0,2	3,893	1,106
0,5	1,707	1,048
0,8	1,168	0,925
1,0	0,883	0,805



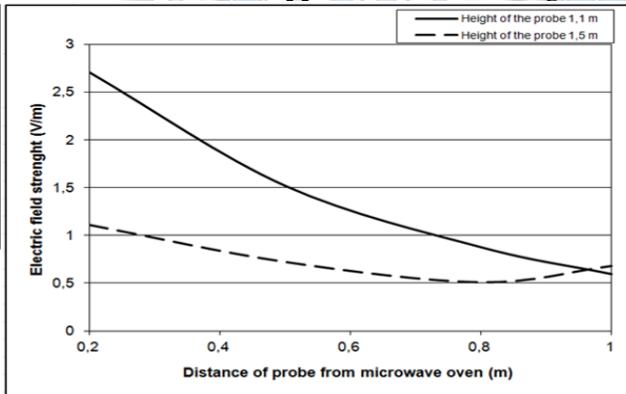
**Table 3.** Graph 3 Results of electric field strength measurements from the back wall

Distance from the microwave oven [m]	Electric field strength (V/m)	
	Height of the probe 1,1 m	Height of the probe 1,5 m
0,2	1,201	0,910
0,5	0,785	0,621
0,8	0,608	0,673
1,0	0,595	0,491



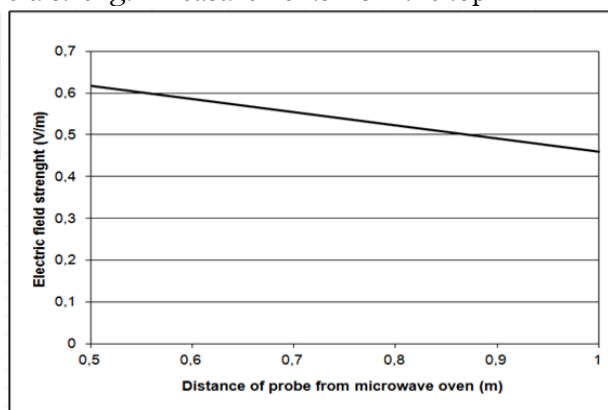
**Table 4.** Graph 4 Results of electric field strength measurements from opposite side of the magnetron

Distance from the microwave oven [m]	Electric field strength (V/m)	
	Height of the probe 1,1 m	Height of the probe 1,5 m
0,2	2,708	1,107
0,5	1,519	0,722
0,8	0,876	0,511
1,0	0,594	0,680



**Table 5.** Graph 5 Results of electric field strength measurements from the top

Distance from the microwave oven [m]	Electric field strength (V/m)
0,5	0,617
1,0	0,459



#### 4. CONCLUSION

In many cases, members of the public are unaware of their exposure to electromagnetic field. The general public comprises individuals of all ages and of varying health status, and may include particularly susceptible groups or individuals. Individual members of the public cannot reasonably be expected to take precautions to minimize or avoid exposure. These considerations are the basis for the adoption of more stringent exposure restrictions for the public than for the occupationally exposed population. [6]

For the identified frequency of 2.45 GHz is reference level (action value) under ICNIRP and Slovak legislation 61 V/m for general public. Although the measured values of electric field strength, with reference values based on the law do not constitute risk, but it should be better, to reduce time of electromagnetic fields exposure emitted by microwave oven. Much research in this area do not yet have precise conclusions, on what actually causes radio frequency electromagnetic field, and what are the potential consequences for human health at long term exposure.

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