The Measurement of Electromagnetic Fields in Hospital Electrotherapy Rooms

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Abstract **-** This paper presents the results of electromagnetic field measurements in some electrotherapy rooms situated in hospitals. We measured both the background fields in this special hospital rooms, and the field near the therapy units in the 40 Hz ÷ 500 MHz frequency range. The authors considered many electrotherapy units situated in different hospitals with a view to making comparisons between some rooms and some apparatus of the same type.

I. Introduction

In a hospital environment there are a very large number of electromagnetic field sources. It is important to have knowledge of the electromagnetic fields generated by medical devices or those to which medical devices are exposed to in their working environment for their design and the layout of [1], [2], [3], [4]. The medical devices that apply magnetic or electric energy for diagnosis or treatment are some of the most important intentional sources of electric and magnetic fields. In this paper we endeavour to provide some data on the electromagnetic environment in electrotherapy rooms. We measured the fields at various distances from the electrotherapy units used in different operating modes and the background fields in the rooms with the apparatus switched off and then switched on.

II. Measurement results

We measured the electric and magnetic fields in many electrotherapy rooms situated in different hospitals. Two basic electrotherapy apparatus were considered: the magneto-therapy units (low frequency magnetic fields) and the short wave therapy units (radiofrequency electric fields).
First we determined the background magnetic and electric fields (electrotherapy units in off or stand-by mode) in some points of the rooms, and then we made measurements with the therapy devices in working mode. We also measured the fields in the immediate neighbourhood and at various distances (0,5 m, 1 m, 2 m) from the electrotherapy devices (magneto–therapy units, shortwave therapy units).

A. Magnetic fields in the rooms for electrotherapy with magneto-therapy units

As far as the magneto-therapy units are concerned, we measured the magnetic fields in the centres of the two coils (abdomen and head) with apparatus in two operating modes, and the magnetic fields in some points of the rooms. For the low frequency, we measured B using a uniaxial magnetometer (ELF 01 magnetometer, made by Terraflux Control Iasi) and an active magnetic field sensor connected to a Fluke 43 Power Quality Analyser. The second instrument, made and calibrated by the authors, permits the time domain measurements and the harmonics representation of the fields (40 Hz - 200 kHz frequency range).

Table 1
The values of B for the electrotherapy rooms having magneto-therapy units

Apparatus	Measurement places	Operating modes	
		Sedative	Arrhythmic
Magneto therapy 1	Centre of room 1	0,78 μT	1,2 μT
	Centre of the coil for the abdomen	238 μT	234 μT
	Centre of the coil for the head	377 μT	318 μT
Magneto therapy 2	Centre of room 2	7,81 μT	
	Centre of the coil for the abdomen	311 μT	
	Centre of the coil for the head	565 μT	
Magneto therapy 3	Centre of room 3	0,28 μT	
	Centre of the coil for the abdomen	44 μT	
	Centre of the coil for the head	47 μT	

The results of the measurements for three magneto-therapy units situated in various rooms are given in Table 1. The 50 Hz background magnetic fields in these rooms with the apparatus switched off range from tens of nT to hundreds of nT.

B. Electromagnetic fields in the rooms for electrotherapy with radio frequency wave

In some electrotherapy rooms with radio frequency wave, we measured the electric and magnetic fields near the short wave therapy units and the electromagnetic environment in these special rooms.

We measured the electric and magnetic fields using a near-field probe set ETS, EMCO, model 7405 and the IFR 2398 Spectrum Analyzer (Frequency range: 9 kHz to 2,7 GHz; Amplitude measurement range: +20 dBm to -105 dBm).

The Spectrum Analyzer displays the power level in dBm, and for a 50 Ω input impedance, the voltage measured from the probe is:

$$U_{dB\mu V} = P_{dBm} + 107 \tag{1}$$

The field amplitude is obtained by adding the probe performance factor to the voltage measured from the probe:

$$E_{dB\mu V/m} = U_{dB\mu V} + PF_{dB} \tag{2}$$

First we determined the electromagnetic environment (the short wave therapy units switched off). Thus, with the Spectrum Analyser in "full span" (9 kHz to 2,7 GHz) we observed the maximum electric field around of 100 MHz, where there are some local broadcasting stations.

These electric fields, generated by the external radio stations and displayed by the Spectrum Analyzer in the 90 MHz ÷ 105 MHz frequency range, are shown in Fig. 1.

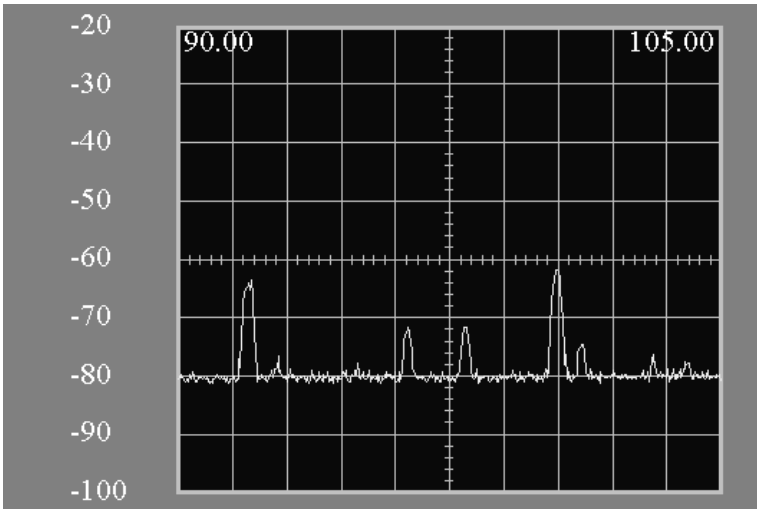

Figure 1. The electric fields ("maximum hold" trace) in the electrotherapy room, generated by external radio stations

The maximum values ("Max Hold" mode) and the average values ("Average" mode) of these electric fields are shown in Table 2.

Table 2
The maximum and average values of the electromagnetic environment in one electrotherapy room (generated by broadcasting stations)

Frequency	Maximum values		Average values	
92,01	100,6 dBμV/m	0,107 V/m	97,07 dBμV/m	0,071V/m
96,36	90,97 dBμV/m	0,035 V/m	86,4 dBμV/m	0,02 V/m
97,95	92,1 dBμV/m	0,04 V/m	83,53 dBμV/m	0,015 V/m
100,41	99,83 dBμV/m	0,098 V/m	95,28 dBμV/m	0,058 V/m
101,16	88,52 dBμV/m	0,027V/m		

Figure 2 shows the maximum electric fields ("Max Hold" trace) in the 100 kHz ÷ 500 MHz frequency range, obtained by rotating the 904 E Field Ball Probe in a point situated at about 1 meter distance from the unit's electrodes (shortwave therapy unit, working at medium power).

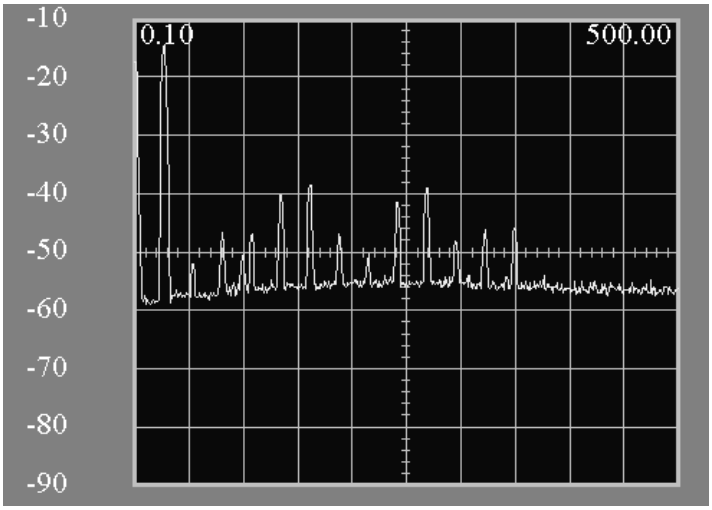

Figure 2. The electric field in the electrotherapy room generated at one meter by the short wave therapy unit ("max. hold" trace)

Table 3 presents the maximum ("max hold" mode) and the average values ("average" mode) of the electric fields at about 1 meter and 2 meters distances from the electrodes of the shortwave therapy unit. We also measured the electric fields near some shortwave therapy units, working at the medium power and situated in different electrotherapy rooms. The results are summarized in Table 4.

Table 3
The maximum and the average values of the electric fields at 1 and 2 meters from the electrodes

Frequency	Maximum values		Average values	
	E at 1 m distance	E at 2 m distance	E at 1 m distance	E at 2 m distance
27,1 MHz	78,7 V/m	62,3 V/m	7,08 V/m	1,41 V/m
54 MHz	0,63 V/m		0,14 V/m	0,09 V/m
80,1 MHz	1,6 V/m	0,83 V/m	0,16 V/m	0,11 V/m
107,1 MHz		0,57 V/m		
134,1 MHz	1,11 V/m	0,93 V/m	0,2 V/m	0,13 V/m
160,1 MHz	1,25 V/m	1 V/m	0,11 V/m	0,1 V/m
187,1 MHz	0,4 V/m	0,37V/m		0,05 V/m
213,1 MHz	0,29V/m	0,2 V/m	0,04 V/m	
240,1 MHz	0,79V/m	0,48 V/m	0,06 V/m	0,03 V/m
267 MHz	0,22 V/m	0,2 V/m	0,05 V/m	0,06 V/m
321 MHz		0,17 V/m		0,03 V/m
347 MHz	0,24 V/m	0,2 V/m	0,03 V/m	0,03 V/m

Table 4
The maximum and the average values of E at about 1 meter from the electrodes in some electrotherapy rooms

Measurement place	Apparatus	Observations	Maximum values of E	Average values of E
Electrotherapy Room 1	Apparatus 1.1	Measurement 1	147,37 V/m	25,11 V/m
		Measurement 2	84,72 V/m	17,78 V/m
		Measurement 3	141,25 V/m	
Electrotherapy Room 2	Apparatus 2.1		36,69 V/m	
	Apparatus 2.2		33,88 V/m	
Electrotherapy Room 3	Apparatus 3.1		78,7 V/m	7,07 V/m
		Electrodes on patient	143 V/m	3,98 V/m

We also made measurements of the electric field in the middle of Electrotherapy Room 2, where two short wave therapy units are working.
The maximum values of the electric fields in this point (centre of the room) situated at about four meters from the electric field generators are presented in Table 5.

Table 5
The maximum values of E in the centre of Electrotherapy Room 2

Frequency	27 MHz	107 MHz	134 MHz	160 MHz	240 MHz
E values	11,94 V/m	1,02 V/m	0,97 V/m	0,96 V/m	0,56 V/m

Even at longer distances than 2 meters from the short wave therapy units, the electric fields generated can exceed the electromagnetic compatibility limits (3 V/m, which is the immunity level for medical devices).

III. Conclusions

The electromagnetic environment differs from one electrotherapy room to another, depending on the dimensions of the room and the electrical generators layout.

The 50 Hz magnetic induction in the electrotherapy rooms increases about 10 ÷ 100 times, when the magneto-therapy units work. Nevertheless, only in the immediate neighbourhood of the coils the magnetic induction exceeds the maximum allowable levels recommended by ICNIRP for general pubic exposure (100 μT for 50 Hz frequency).

In what concerns the radio-frequency electric fields in the electrotherapy rooms:
- With the Spectrum Analyzer in "maximum hold" mode, the values of the fields are overestimated, especially when the probe is rotated for determining the maximum field vector. Nevertheless, this mode permits a rapid detection of the electric fields.
- When the shortwave therapy unit is switched off, the RF electric fields in these rooms are due to the external broadcasting station, having small levels (about tens of mV/m).
- If the shortwave therapy units are switched on, the levels of the electric fields in these electrotherapy rooms exceed the electromagnetic compatibility limits (3 V/m), and in the immediate neighbourhood of the electrodes, the electric fields can exceed the maximum allowable levels recommended by ICNIRP for general public exposure (28 V/m in 10 MHz ÷ 400 MHz frequency range).

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References

[1] Nelson R. M., Howard Ji., "Electric and Magnetic Fields Created by Electrosurgical Units", *IEEE Trans. on Electromagnetic Compatibility*, 41, 1, pp. 55-64, 1999.
[2] Fernandez M., Quilez M., Silva F., "Near field EMI Measurements in Medical Environments", *Int. Symposium on Electromagnetic Compatibility*, Zurich, 2001.
[3] Bare D. W., "Medical Product EMC", *IEEE Int. Symposium on Electromagnetic Compatibility*, pp. 494 – 498, 2004.
[4] David V., Buchholtzer l., Lunca E., Nica I., "Preliminary Measurements of Electromagnetic Environment in Hospitals", Buletinul Institutului Politehnic din Iasi, XLVIII (LII), 5B, pp. 797 – 801, 2004.