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LMAT.EMF-ELF_WEBMONIT: Extremely Low Frequency Electromagnetic Fields Monitoring System

Abstract. *Exposure to Extremely low frequency (ELF) electromagnetic fields is a matter of great concern, and is the subject of on-going research and a significant amount of public debate. To better study and inform the general public interested in this topic, it is necessary to measure the ELF electromagnetic fields. The LMAT.EMF-ELF_WEBMONIT system was developed to take measurements of electric and magnetic fields ELF at any location, and provide these readings through charts on a website.*

Streszczenie. *W artykule zaprezentowano nowy system pomiarowy do monitorowania pola elektromagnetycznego bardzo małej częstotliwości. Proponowany system LMAQT.EMF-ELF_WEBMONIT umożliwia pomioar pola elektromagnetycznego w dowolnej lokalizacji i odczyt za pośrednictwem Internetu. (**LMAQT.EMF-ELF_WEBMONIT: system monitoringu pola elektromagnetycznego małej częstotliwości)***

Keywords: ELF Electromagnetic Fields, Web-Monitoring, Measurements.
Słowa kluczowe: pole elektromagnetyczne, monitoring..

1. Introduction

The progress of our society and way of living led to the growth of energy consumption, which in turn required increased capacity production and distribution. Associated with this, the exposure to electromagnetic fields (EMF) and consequent need of monitoring, is nowadays an actual and critical issue.

Exposure to electromagnetic fields of low frequency (ELF) is a matter of great concern [1,2] in recent year's studies, in order to find out if they have harmful influences for human health. The monitoring of these fields and the risk communication to the general public and other institutions becomes then a very important issue [3].

The LMAT.EMF-ELF_WEBMONIT system was developed to allow the measurement of electric and magnetic fields ELF at any location, and to provide these readings through charts on a website in real time.

The system, to be installed at the site of interest, monitors the electromagnetic fields, and the collected information is sent to a web server.

The complete set of measurements is available on a website, showing the higher values of electric and magnetic fields and can be accessed at any time.

This paper reports the main aspects of the development of this system. It is referred to the equipment used and how they communicate with each other to send the results of the measurements to the website. The website features are also presented.

Fig. 1. LMAT.EMF-ELF_WEBMONIT system

2. Implementation

In Fig. 1 it is shown the system used to monitor electromagnetic fields in real time. This system consists of a probe capable of measuring electric and magnetic fields in the frequency range between 5 Hz and 100 kHz, a GSM / GPRS module to control and data acquisition and to transmit the measured values. The batteries that power the entire system are located inside the control box.

In Fig. 2 it is shown schematically the operation of the monitoring system, from the measurement of ELF field to the display of the measured results on the website.

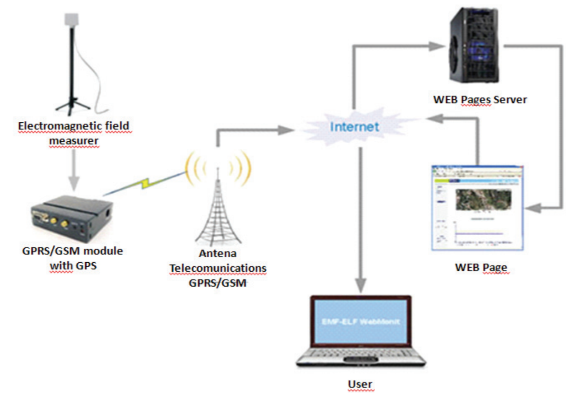

Fig. 2. Operation of the monitoring system

The GSM / GPRS module, acts as the "brain" of the system as it sets the measurement equipment and gives the orders to carry out the measurements. Once collected and validated, all data (values of electric and magnetic fields and position of the local monitoring) are sent to the server via GPRS. On the server, they are reprocessed and stored in a database. When the web page is loaded, the database is read and graphs are constructed, showing the measured values of electromagnetic fields. To give the user the perception of the location where the system is running, along with the name of the nearest town it is shown a map indicating the location of the system. Whenever new values are received, the graphics are updated automatically.

In addition to real-time monitoring it is also available for the users of the website, all previous measurements.

3. System Hardware

The electromagnetic field probe is the EHP-50C [4], from Narda [5]. This probe makes measurements of electric and magnetic field between 5 Hz and 100 kHz.

EHP50-C (Fig.3) is a small (92 x 92 x 109 mm) cube. It contains three coils and three plates arranged orthogonally to measure the magnetic and electric fields, respectively. It also has an analog-digital converter followed by signal processor and a CPU that controls all functions. It has an analogue to digital converter followed by a powerful DSP (Digital Signal Processor) analyzing the signal and a E2PROM (Electrically-Erasable Programmable Read-Only Memory) that stores calibration data. The interface has an optical output, which through the optical-RS232 converter allows interaction with a computer or other device able to control it.

Fig. 3. Electric and magnetic field probe EHP-50C

The GSM / GPRS module with GPS, EZ863-GPS (Fig.4), manufactured by GLYN, with the Telit's module GE863-GPS and is controlled via AT commands [6, 7]. This module has two SMA connectors for GPS and GSM antennas, RS-232 and I2C, a connector with 24 in/out ports and a RJ11 type connector for audio [8].

Fig. 4. EZ863-GPS module

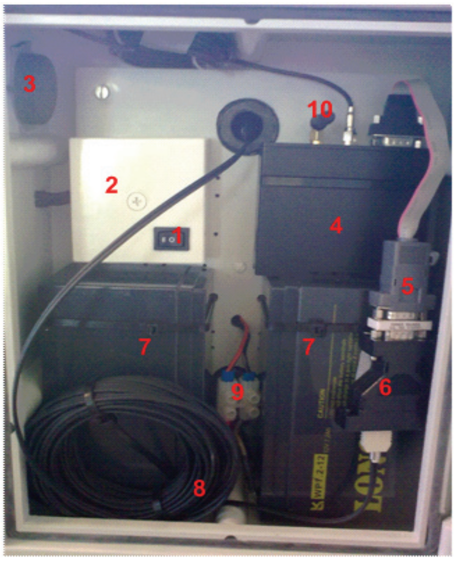

Fig. 5. Fiber glass box with the system hardware
1 - GSM/GPRS-GPS module on/off switch;
2 - Electric wiring box;
3 - GPS antenna;
4 - GSM/GPRS-GPS module;
5 - Cross RS232-RS232 cable;
6 - Optical-RS232 converter;
7 - 12V 7,2Ah battery;
8 - Fiber optic cable;
9 - Batteries terminal connection;
10 - GSM/GPRS antenna.

An important feature of this module is to be able to run programs written in python. It can be powered from 6 to 30V and has option battery that powers the module in case of failure of mains supply. These devices with the batteries are placed in a fiber glass box, with 26x31x13 cm, making the whole system easy to carry (see Fig. 5).

4. System Software, Web Server and Database

The software developed for the system LMAT.EMF-ELF_WEBMONIT, was written in python and runs by GSM/GPRS module.

After turning on the system, the module calculates its position. This may take several minutes depending on the quality of the signal received by the antenna. Once the position is calculated an SMS is sent to the system controller indicating that the system is ready to make measurements. Then the module sends a command to place the dosimeter in slave mode avoiding in order to prevent the system to send data not yet requested (see Fig. 6).

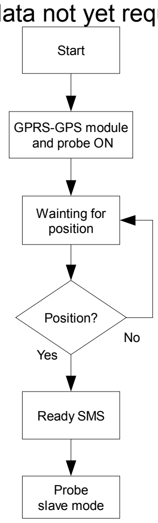

Fig.6. System software (part 1)

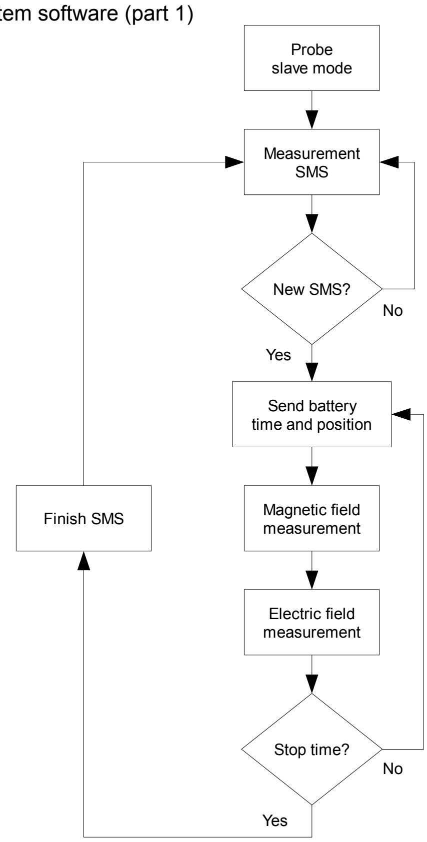

Fig. 7. System software (part 2)

After the system configuration, the module waits for a SMS with the operating period, i.e., the period of time when the system should be measuring.

After receiving the SMS with the measurement period, the first data is sent to the server. These data are the dosimeter battery level, the startup time of the measurement and position. Next, the magnetic field is measured and the values and the time at which the measurement were performed are sent to the server. The next step is the electric field measurement and again the measured values are sent to the server. This cycle (magnetic field measurement -> send -> electric field measurement -> send) is repeated until it reaches the measurement end time that was sent in the measurement's period SMS.

When the measurements are done, the system waits for a new SMS with a new measurement period and when is time for a new measurement the cycle begins (see Fig. 7).

Once the server receives and confirms the data, the byte stream is separated and processed in order to be entered in a database.

To build and manage the database it was used MySQL, a (DBMS) database management system. It is a free program, robust, fast and able to handle with no problem tables with millions of records. The created database is composed of the following entities and their attributes (Fig.8):

TABLE MEASUREMENTS

Nmed	Data	Hini	Lat	Long	Local

TABLE E

codE	Nmed	Ehora	ef1	ef2	ef3	Nef1	Nef2	Nef3

TABLE B

codm	Nmed	mhora	mf1	mf2	mf3	Nmf1	Nmf2	Nmf3

Fig. 8. Entities and attributes that compose the Database

The Table Measurement stores information about the characteristics of the measure, i.e., the date on which it was performed (Data attribute), the start time of measurement (Hini attribute), the coordinates (latitude and longitude) of location of the measurement (Lat and Long attributes) and finally the name of the nearest town from the previous position (Local attribute). The attribute Nmed is the code that corresponds to the information in each measurement (see Fig. 9).

Nmed	Data	Hini	Lat	Longi	Local
126	280909	153202	40.1657872	-8.4224583	Castelo Viegas
127	280909	163607	40.1652329	-8.4213171	Castelo Viegas
128	290909	090800	40.1637643	-8.4324314	Carvalhais de Baixo
129	290909	104008	40.1636412	-8.4322955	Carvalhais de Baixo

Fig. 9 - Table Measurement

In table E it is shown the values measured by the system. Thus, the attributes ef1, ef2, ef3 corresponds to the values of electric field measured for the frequencies f1, f2 and f3 respectively. The attributes Nef1, Nef2, Nef3 correspond to the values of the three frequencies with higher electric field. The attribute codE is the code of the measured values, the attribute Nmedia matchs the characteristics of the measurement and the attribute Ehora is the time at which the values of the electric field were obtained (see Fig. 10).

For the table B the attributes are the same as in the previous table but the values are stored for the magnetic field measurements.

codE	Nmed	Ehora	ef1	ef2	ef3	Nef1	Nef2	Nef3
1926	141	20091015	0,341111	0,302445	0,200112	51	49	54
1927	141	20091015	0,340774	0,302479	0,201023	51	49	54
1928	141	20091015	0,341955	0,302951	0,200787	51	49	54

Fig. 10. Table E

5. Web Page

In order to provide access to these measurements to the general public, it is necessary to present them in an organized, simple and intuitive way. Therefore, the graphics interface of the web page is very important. The page has the configuration presented in the Fig. 11.

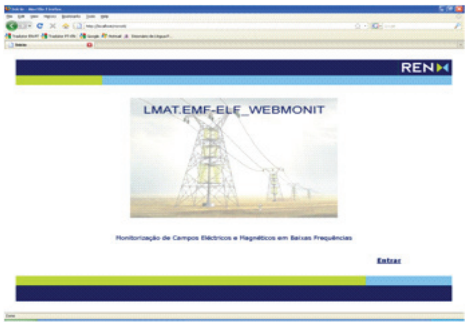

Fig. 11. Home page

Upon entering in the web page, shown in the Fig. 12, we find the most important elements relating to monitoring, the map showing the measurement location and the chart, which shows the measured values.

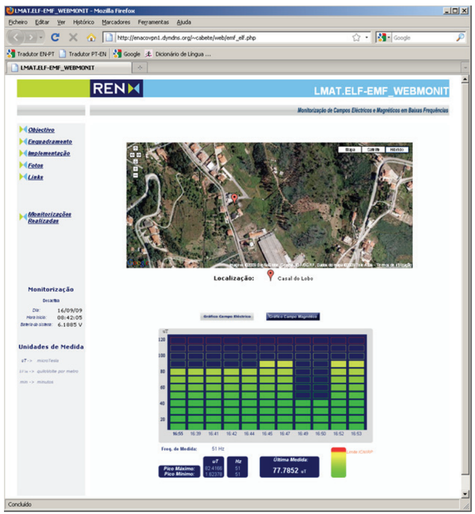

Fig. 12. Main page

On this page it is presented the measurement data that is in progress or the last measurement made. Both, the map and the chart are dynamic, i.e., they are updated automatically. When a new value is entered on the data base, the chart is immediately updated and below each bar is shown the time of the new reading. The bars are painted in different colors for a fast and simple perception of the field value, the green corresponds to a low field and red to a level above the limit set by ICNIRP, which is 5kV/m for the electric field and 100uT for the magnetic field. Along with the chart, there is also other important information such as the frequency being analyzed, that is always the frequency with the biggest electromagnetic field for that site, and also the maximum and minimum peak, as shown in the Fig. 13.

The measurements that have been already carried out can be available, through a link to a page that lets you choose the desired measurement, just by selecting the location, date and time (see Fig. 14).

For the completed measurements, the chart has a different format, since this chart shows the exact values of the electric field and magnetic field. Through the three colors, present in each bar, it is represented the three highest values of electromagnetic field and their frequencies (see Fig. 15).

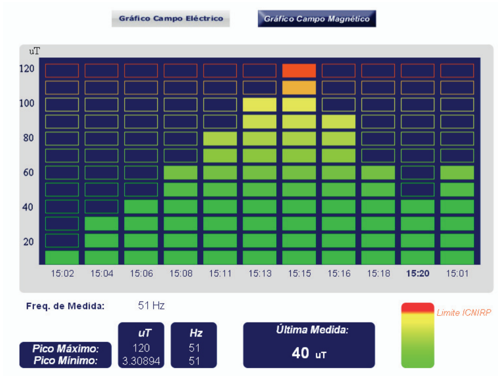

Fig. 13. Measurement in progress chart

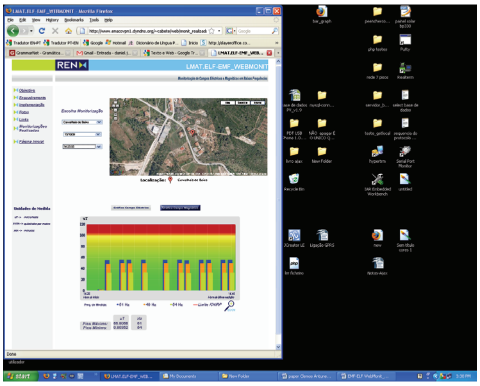

Fig.14. Completed monitoring page

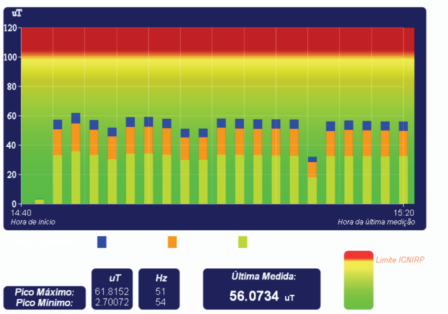

Fig. 15. Completed measurements chart

The cycle that makes the automatic update of the chart and the map, begins when the page is loaded in the browser. At that time, a function search in the database, the location of the system and returns that values to the function responsible for the creation of the map. Once the map is created it is loaded on the main page. A second later, the database is consulted to find the last value of the EHP-50C battery voltage and the corresponding value is shown on the main page. Every 5 seconds the value of the battery voltage is updated (see Fig. 16).

To create the chart, the first task is to search the database for the measured values. Once found, the values are passed to a function that generates the chart and puts it on the main page. Every second, it is checked if there are new values in the database, repeating the cycle for updating the chart (Fig.17).

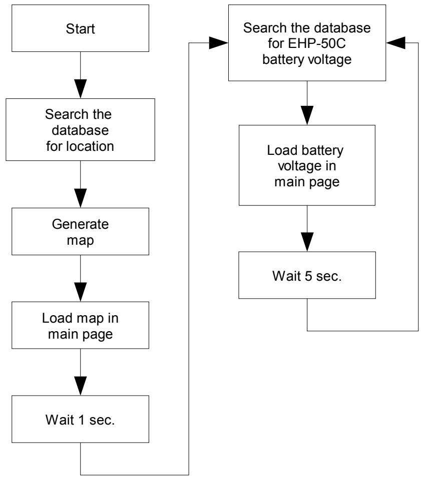

Fig. 16. Operation of the monitoring system (part 1)

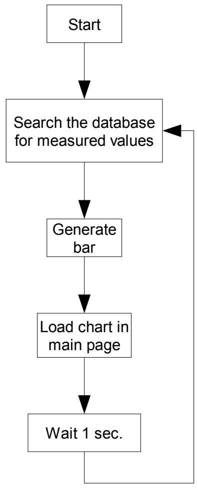

Fig. 17. Operation of the monitoring system (part 2)

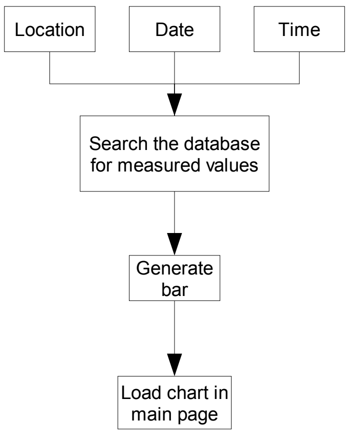

Fig. 18. Operation of the monitoring system for completed measurements chart

To view a measurement already carried out, the user, using the three boxes on the page, must identify the location, date and time of the desired measurement. Once these data are available, the database is read and the values are presented to the user. The location of monitoring is presented in a map and measurements of electromagnetic fields on graphs. Everything happens as in main page but with the difference that the update cycle of the graph and position are not repeated (see Fig. 18).

6. Conclusions

The system LMAT.EMF-ELF_WEBMONIT has been in tests in the field, and from our experience, it is a good tool to the study of electromagnetic fields of low frequencies. In addition to the measuring system, the ability to query the values measured to everyone via the Internet, makes this system an excellent platform to inform people, develop awareness, and eventually reduce anxiety and social hysteria on the issue of electromagnetic fields and the levels of electromagnetic radiation.

Acknowledgments

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