Procedure for Incorporation of NBM-550 Measurement Results into the SEMONT Database

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Abstract— One of the consequences of the permanent increase of the electromagnetic (EM) field sources is the emergence of various systems for the remote monitoring of electromagnetic field. These systems are able to perform the continuous monitoring of the EM field in the environment utilizing the wireless sensor network technology. As a support to the authorities, to timely inform the general population on the potentially harmful effects of the long-term exposure to the EM radiation, the development of the Serbian electromagnetic field monitoring network – SEMONT has started. The SEMONT system performs a continuous EM field monitoring and presents the obtained results over its own Internet portal, playing an important role in the field of radiation protection. In order to obtain data on the high-frequency electric field strength over the area of the campus of the University of Novi Sad, the SEMONT system has recently started with initial measurements. This paper considers the SEMONT system database model supporting the measurement results incorporation, obtained by the NBM-550 handheld instruments.

I. INTRODUCTION

The increasing number of electromagnetic (EM) field sources enforces the safety problem both for the human health and the environment [1]. In order to raise the awareness of the general population about unhealthy and possibly dangerous effects of the long-term exposure to the EM radiation, the research team has started the development of the Serbian electromagnetic field monitoring network – SEMONT [2], [3].

Based on the technology of the wireless sensors network, the SEMONT system is able to continuously acquire information about the current EM field level over an open area utilizing spatially distributed sensor nodes, as shown in Fig. 1.

![Figure 1. Basic concept of the SEMONT system.](image)

Additionally, the SEMONT system performs the exposure assessment of the general population according to the Serbian legislation [4], [5] and the recommendations of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) [6].

The results of the continuous monitoring and the exposure assessment are presented as daily curves over the publicly available Internet portal of the system [2]. Besides that, the system also allows for the creation of the EM field register that contains a long-time history overview over a particular area [7], as shown in Fig. 2.

![Figure 2. Feature of the long-time history overview.](image)

In order to validate the system functionality, initial test measurements have been carried out over the area of the campus of the University of Novi Sad. Some details about those measurements have already been presented in some previously published papers [8], [9], so at this occasion they will be omitted, since the focus of this paper is the measurement results incorporation into the SEMONT centralized database.

Therefore, this paper briefly presents the SEMONT system database model and its Internet portal organization. The Section 2 introduces the basic concept of the SEMONT database and describes the Internet portal organization, while Section 3 presents the measurement results incorporation into the database. Section 4 brings the conclusion of this paper.

II. THE EM FIELD REGISTER DATABASE MODEL

This section presents a brief reintroduction of some prior published details [7], [10], aiming to introduce readers to the EM field register database model of the SEMONT system.

Dedicated Internet portal of the SEMONT system is intended for the presentation of the EM field measurement results to the general population. During the incorporation of the results into the system database, the following should be taken into account:

- Locations, where the measurements are performed,
- Measurements itself, and
- Sensor elements that have been applied.
On the particular location several different measuring campaigns can be carried out, utilizing different sensor elements. Therefore, the logical organization of the register elements [7] is presented in Fig. 3.

![Image of logical organization of the register elements]

Figure 3. Relationship between the register elements.

It can be seen from Fig. 3 that each Location can have several different Measurements. Also, the particular Measurement can have several associated Sensor elements [7]. These three elements with their attributes are the foundation of the SEMONT system database model.

More details about the SEMONT database model have already been presented in some previously published papers [7], [10]. The focus of this paper is to describe a possibility of the database model to incorporate measurement results into the system. The Internet portal of the system is designed to allow the full history overview for a long-time period presenting results in the form of graphs and tables. Additionally, the Internet portal provides information on the SEMONT network features, its technical specifications, several application examples for the low-frequency and the high-frequency field monitoring, and finally, the measurement results [2].

III. INCORPORATION OF THE MEASUREMENT RESULTS

In order to perform the first systematic testing of the EM pollution on the high-frequency route of the student population on the campus of the University of Novi Sad, the research team began the initial measuring campaign [8]. The campaign was performed over the area of the campus utilizing the handheld equipment for the high-frequency electric field strength measurement.

A. Measuring campaign

Measurements were conducted at ten carefully chosen locations that cover places most crowded with students on the campus. The measuring procedure over the particular location consisted of two parts:

- First, preliminary field scan was performed over the measurement grid, in accordance with relevant standards regarding the measurement of EM fields [11]-[13], in order to determine spatial distribution of the field strength and to find the grid point with the local maximum of the field strength, the so-called hot-spot.

- In the second phase of the measurement, the continuous monitoring of the field strength was carried out at the hot-spot, observing maximal and averaged field values. Continuous monitoring during the time period of 4 hours was performed in order to determine the electric field fluctuation during that time period [8].

Since the implementation of the wireless monitoring stations and sensor elements of the SEMONT monitoring system is still in the phase of development, in this measuring campaign the Narda NBM-550 broadband field meter [14] with the EF 0691 high-frequency electric field probe [15] was applied. Some of the basic parameters of the applied probe are given in Table I.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency range</td>
<td>100 kHz to 6 GHz</td>
</tr>
<tr>
<td>Measurement range</td>
<td>0.35 V/m to 650 V/m</td>
</tr>
<tr>
<td>Linearity</td>
<td>±0.5 dB (2 to 400 V/m)</td>
</tr>
<tr>
<td>Frequency sensitivity</td>
<td>±1.5 dB (1 MHz to 4 GHz)</td>
</tr>
</tbody>
</table>

Although the NBM-550 broadband field meter is a handheld instrument, it has the same functionality as the SEMONT monitoring stations, and can be utilized for the EM field monitoring [8].

B. Methods of incorporating the measurement results

Since initial measurements were performed by utilizing NBM 550 handheld measuring equipment, there are two possible solutions for incorporation of obtained results:

- **Automatic approach** – provides the transmission of the measurement data, stored in the instrument internal memory, to the SEMONT system database, utilizing the connection instrument – laptop and GSM network.

- **Manual approach** – it means to download the measurement data to the PC and their incorporation into the database using the specially developed software interface, the so-called Parser, as depicted in Fig. 4.

![Image of incorporating the results into the SEMONT system]

Figure 4. Incorporation of the results memorized in the instrument.

The software interface, used for the data parsing, enables the authorized personnel to incorporate the meas-
measurement results through the protected administrative part of the SEMONT Internet portal.

Unfortunately, since the SEMONT network is still under development, implementing the wireless monitoring stations and sensor elements, utilizing of the handheld equipment is not very efficient from the standpoint of the data incorporation. At the final phase, in the fully developed system, the measurement data from the sensor nodes will be automatically, wirelessly and remotely collected and stored into the system database.

C. Database model – table relationship

As stated in the previous section, for each particular Location, numerous Measurement campaigns can be carried out, utilizing a number of different Sensor elements. Consequently, database models of the EM field register of the SEMONT system were realized as depicted in Fig. 5 [7].

There are several tables as an integral part of the database model. The Measurements_Sensors block, describing the particular measurement, presents the central part of the database. For each Location there can be several different Measurements, so the relationship between these tables is the “1:*” type. Also, one Measurement can apply several different Measurements_Sensors, as shown in Fig. 5.

The Sensors table contains basic attributes about a sensor element associated to Measurements_Sensor and applied for an individual Measurement. All other tables also contain their own attributes [7] and here these details will not be mentioned. The attention will be focused on the Measurement_Results table.

The Measurement_Results table is a part of the database intended for the incorporation of the results using the software interface. The data file containing the results of a particular measurement is incorporated after selecting one of the incorporation methods described in Fig. 4 and written into this table. Additional information about the performed measurement, such as a serial number, a measurement date, a battery status and the local temperature are also placed into this table.

D. NBM-550 file format

On the particular location, the measurements were performed every 6 minutes during 4 hours a day. While performing the broadband monitoring, the instrument records the averaged field values and also the peak value during the time interval of 6 minutes, in the applied probe frequency range [14]. On applying the handheld equipment in this initial measuring campaign, the measurement results were incorporated using the manual approach, described in Fig. 4.

One of the file formats that contains the measurement results obtained by the NBM-550 is the XLS (Microsoft Excel Spreadsheet) and it is shown in Fig. 6. This file is downloaded to the PC in the process of the results incorporation to the database.

As it can be seen from Fig. 6, beside some basic instrument parameter settings, the file contains data columns with the averaged and the peak electric field values for the corresponding instant of time.

E. NBM-550 results – manual incorporation

The columns containing the averaged and the peak electric field values are extracted from the NBM-550 XLS file utilizing the Parser and are incorporated into the system database, as depicted in Fig. 7. The Parser software module is available via the SEMONT internet portal administration page and it is available only to the authorized personnel.

Electric field values mentioned above were written into the “e_rms_avg_w” and “e_peak_w” fields of the Measurement_Results table, because the measurements were carried out with the NBM-550 field meter in the wideband frequency range.
F. Future development

Generally, in the fully developed SEMONT system, utilizing specially designed sensor elements [16], the broadband monitoring of the electric field will be possible in four frequency ranges (wideband, GSM 900, GSM 1800 and UMTS 2100), as shown in Fig. 8. Therefore, the Measurement Results table contains fields with data about the averaged field values and the peak values for each frequency range.

It should be mentioned that there are also fields that contain data about the magnetic field values, since the utilization of the sensor elements capable to perform the monitoring of the low-frequency field is planned in the future [16], as shown in Fig. 8.

G. Web Technology used for the realization

Utilizing the PHP programming language and its special CakePHP application development framework [10] is crucial in the realization of the SEMONT Internet portal. Besides that, the centralized database relies on the MySQL server, while the protected administrative part of the portal is provided by utilizing the Web Content Management System (WCMS).

The implementation of the Google maps technology provides the presentation of the measurement results, displayed using the charts realized with the open source iPlot library for the PHP. The utilization of the jQuery and AJAX web development techniques provides the smooth changes of the page content, since it is expected for this SEMONT web page to be the most visited one.

IV. CONCLUSION

The SEMONT system is a unique system at the national level and its accompanying Internet portal presents a significant support for the local authorities in their efforts to take a systematic care of the potential unhealthy effects of the non-ionizing radiation.

The system is designed for the automated, remote and continuous EM field broadband monitoring in the environment and is the most suitable solution for a constant supervision of the EM field strength, as well as for the global exposure assessment of the population.

In this paper, the SEMONT system database model as a support for the incorporation of the NBM-550 measurement results into the system was introduced. In order to present the database model organization, the initial measuring campaign was carried out over the area of the campus of the University of Novi Sad. The high-frequency electric field measurement results, obtained with the handheld equipment during this measuring campaign, were incorporated into the database using the manual approach.

The organization of the database model tables and the procedure for incorporating the results into them demonstrate the functionality of the SEMONT monitoring system and its publicly available Internet portal.

ACKNOWLEDGMENT

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REFERENCES

[13] Basic standard to demonstrate the compliance of fixed equipment for radio transmission (110 MHz — 40 GHz) intended for use in wireless telecommunication networks with the basic restrictions or the reference levels related to general public exposure to radio fre-quency electromagnetic fields, when put into service, SRPS EN 50400:2008 (2008).