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EMF exposure assessment through an online application: time and frequency domain data acquisition and processing

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Abstract

WebNir (https://webnir.eu) [1] is an open-access web platform that exposes several applications related to the assessment of risk from exposure to electromagnetic fields (EMF) are made available. This platform is developed by the "Nello Carrara" Applied Physics Institute of the National Research Council (IFAC-CNR) within the framework of a research project financed by INAIL (Italian Workers Compensation Authority).

This paper describes the application that allows the automated processing of measurements produced by various instrumental chains operating in the time or frequency domain. The goal of these automated procedures is to perform the verification of compliance with exposure values, the calculation of various radiological protection indices and the graphical display of the source data and processing results.

Initially, the procedure refers to the most common measuring instruments, implementing specific scanning algorithms for each. Then, this approach was extended to accept more generical measurement results, potentially produced by any measurement chain, as long as they are in open format (text file or spreadsheet). In particular, for data files whose structure is unknown to the system, the user provides the import procedure with the parameters necessary for its correct interpretation.
The application also allows the calculation and representation of quantities not made available by the considered measurement chain (e.g., exposure indices, ΔB/3s variation).

1 Introduction

A web-based tool has been developed and made available to the public that allows the automated processing and the graphical visualization of measurements produced by various instrumental chains operating in the time or frequency domain [2]. If the data meets software specifications, additional processing tools allow the calculus of weighted peak indices, the visualization of the ΔB/3s variation, and other helpful information.

A relational database (RDB), managed via a web interface, stores the information needed to manage the system and the characteristics of the measurement equipment. This approach simplified the analysis process since it directly links a file type to its internal structure description and a specific instrumental chain.

The processing utilities were developed in PHP and Python3 programming languages. A bidirectional intermediate layer, the GateWay to Python (GW2Py), supports the dialogue between the web interface and the Python environment. Data is entered into an HTML page, transmitted over the network using the HTTP protocol, and made available to a Python calculus procedure (and vice versa).

Before the processing phase, raw measurement results are converted into standard formats (one for the time domain and one for the frequency domain) that are also used for processing results.

2 Application Interface

The user interface consists of two sections dedicated to the archived instrumental chains (time and frequency domains) and a section for the user file input, different for specific measurement chains and user-defined data formats. When sending data to the server, the two procedures are aligned to offer the same options to the user in the following steps.

2.1 Data Files for specific instrumental chains

The user can select a measurement chain in the archive, and the interface automatically adapts to the required parameters.

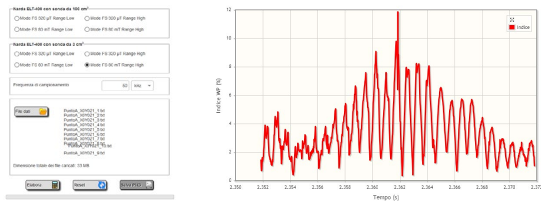

Figure 1. Interface for selecting an instrument chain from the archive, definition of measurement settings, loading and sorting of files (on left) and data plot (on right).

For example, for an instrumentation based on a Narda ELT-400 analyser, the following must be specified:

- probe type (3 cm^2 or 100 cm^2),
- instrument settings,
- sampling rate set in the acquirer connected to the analogue output.

The display and processing options are activated by sending the data to the server. These will be analysed after introducing the management of generic files, as the analysis modes do not depend on the file type.

The procedures dedicated to processing data files generated by specific measurement chains operating in the frequency domain are structured similarly to those in the time domain.

2.2 User-defined Data Files

To manage files that cannot be traced back to an instrumental chain that is not stored in the archive, it is necessary to specify the parameters that allow its correct interpretation.

Depending on the domain chosen by the user (Time or Frequency), a menu is generated to enter parameters to characterize each data item. In the time domain, one between time resolution, sampling frequency and column containing time values. In the frequency domain, integration factors and one between spectral distance, resolution bandwidth and column containing frequency values.

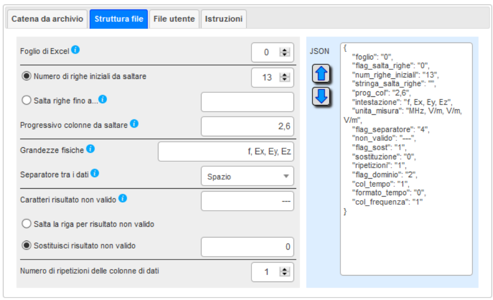

Figure 2. “File structure” tab.

At the same time, a tab called "File structure" (Fig. 2) is populated with the parameters relating to the file format associated with chosen domain. In particular, the information is given:

- whether text or spreadsheet file, and in this case the progressive number of the sheet to be considered
- the number of initial lines to be skipped (or a string contained in the last line to be skipped);
- the sequence of the columns to be skipped;
- the symbol of the physical quantities;
- the character acting as separator between the data;
- how to handle any invalid data;
- whether the columns containing the data are repeated several times.

This data can be saved and loaded from JSON objects so that it is possible to store and reuse parameters of a particular file type without referring to data in the archive or having to re-enter it manually. Users can select a list of raw data files and choose their processing order.

At this point, a procedure verifies the compatibility of the selected files with the format specified by the user (or with the selected instrumental chain). If this test passes, the files are sent to the server.

3 Visualisation of Data

When the user uploads files to the server, they are interpreted according to the specified settings. Then, two tabs are presented, one containing a summary table of the data sent and one that shows the data displaying and processing options.

The data visualization is possible in the following two modes (Fig. 3):

- all data (condensed): this mode displays data in the entire time or frequency range, but in condensed format so as not to overload the client and server with large amounts of data;
- zoom in around the maximum: only data around the maximum value are displayed, in non-condensed format.

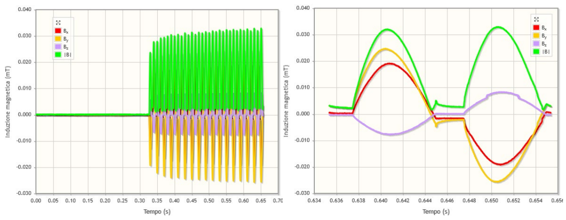

Figure 3. Condensed data (on left) and zoom in around the maximum (on right).

The user can narrow the range of interest (in time or frequency) by manually setting the desired extremes.

4 Time Domain Processing

Further options are activated if the data in the time domain include magnetic induction components. In particular, it is possible to generate a table and a graph showing the data relating to Max ΔB/3s and its trend over time (fig. 4).

A table with the data relating to the spectrum calculation and two graphs showing the trend, in continuous and discrete format are also shown.

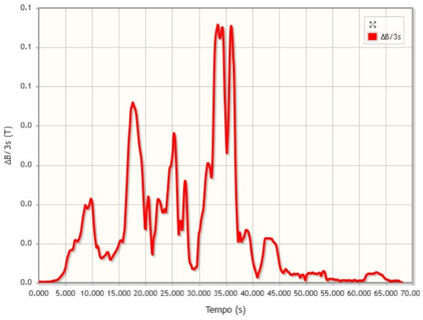

Figure 4. Max(ΔB/3s) graph.

Once the spectrum has been calculated, a new section is activated, which allows the calculation of weighted peak indices and linear spectral sum indices in the frequency domain.

5 Frequency Domain Processing

In this case, the file selection and loading options are similar to those seen for the time domain. Once the files are uploaded to the server, some summary values are displayed, like the number of spectral lines, the spectral pitch, the maximum modulus value and RMS amplitude (wideband).

Visualization options in 2 modes (condensed data and zoom around maximum) are enabled, and linear and quadratic spectral sum indices for the standards of interest can be calculated.

6 Conclusions and Future Development

A publicly available application has been described that is aimed at the needs of technicians working in the field of protection against exposure to electromagnetic fields. This application is composed by a series of automated tools that allow the determination of relevant quantities derived from raw measurement results uploaded to the server application by the user.

For some measurement chains operating in both the time and frequency domains, specific procedures have been developed that allow users to directly process their data with inputting few parameters.

Operators can also use advanced functionality to upload files obtained from a generic measurement chain, specifying its format in detail. The instrumentation database is constantly updated also using data files provided by the users.

Credits

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References

[1] M. Comelli, D. Andreuccetti, N. Zoppetti, E. Mattei, G. Burriesci, R. Falsaperla, S. D'Agostino, C. Grandi, M. Valentini, A. Bogi, N. Stacchini, R. Di Liberto, “WebNir: Web-based tools for assessing occupational exposure to Non-Ionizing Radiation”, *RAD – International Conference on Radiation in Various Fields of Research*, Herceg Novi, July 2022.

[2] D. Andreuccetti, M. Comelli, S. D’Agostino, R. Falsaperla, N. Zoppetti, “Sviluppo ed utilizzo di uno strumento web per l’elaborazione delle misure di esposizione al campo magnetico di bassa frequenza e la determinazione dell’indice di picco ponderato”, 2018, *conference proceedings in dBA2018, I rischi fisici nei luoghi di lavoro*, ISBN 978-88-940868-6-7.