EVALUATION OF THE COMPROMISING RADIATION BY ELECTROMAGNETIC COMPATIBILITY TESTS

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Prezenta lucrare propune o metodă statistică de evaluare TEMPEST a radiaţiilor electromagnetice, utilizând datele obţinute din măsurători de compatibilitate electromagnetică, efectuate în conformitate cu standardul militar MIL-STD-461F.

The paper presents a statistical method for TEMPEST evaluation of the electromagnetic radiation, based on the test data resulted from electromagnetic compatibility tests, performed in accordance with MIL-STD-461F standard.

Keywords: TEMPEST, electromagnetic compatibility (EMC)

1. Introduction

The evaluation of the compromising electromagnetic radiation, emitted by electronic equipments which handle sensitive information, is the main part of the TEMPEST problem, or reducing compromising emanations problem.

However, due to the similarity of physical phenomena implied, this kind of tests can also be seen as a part of the electromagnetic environment evaluation, made in order to reduce the compromising emanations power levels according to the limits imposed by appropriate standards.

2. Compromising emanations evaluation

2.1 Testing method

There are several methods which can be used in order to evaluate the compromising emanations, [1, 2]; these methods can be seen as different one from another, making different approaches to the same problem: the energetic approach or the informational one. In the present paper, there is proposed an energetic approach, which is, in our opinion, consistent with the EMC general approach.

The test setup (see fig. 1) is made in accordance with the method described in [1, 3].

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As EUT (Equipment under Test) there were used three LCD computer monitors, each one placed into the shielded room and on each one being made, separately and successively, the measurement procedure, generally described by the following steps:

- there is displayed a white page corresponding to the main panel of an office suite (text editing and processing part)
- there are displayed, successively, on the white background described at step 1, three letters: A, B,W.
- in each one of the above mentioned steps, there is done an automatic measurement of the monitors radiated electric field, in the frequency range 44 MHz ÷10 GHz.

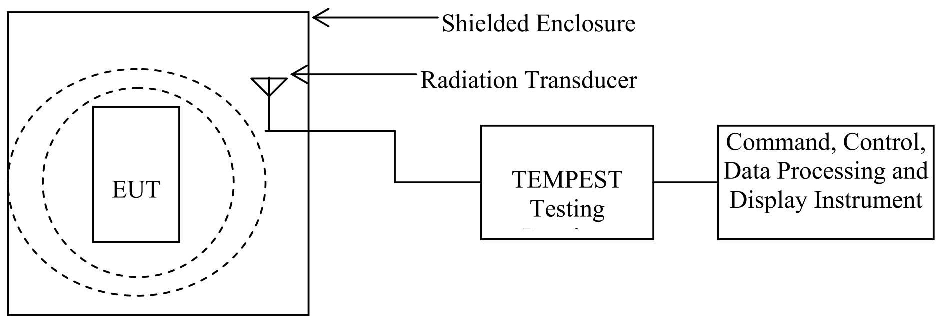

Fig. 1 The test set-up for measuring the level of the electric field radiated by the LCD monitors

2.2 Results

From all the measurements there have been collected the spectra of letters A, B, W and of the backgrounds, for three different types of computer displays. The first step oh the data processing is the noise (i.e. background) removal from the signals spectra, which has been made by simple subtraction, the results being the “noiseless spectra” (fig. 2).

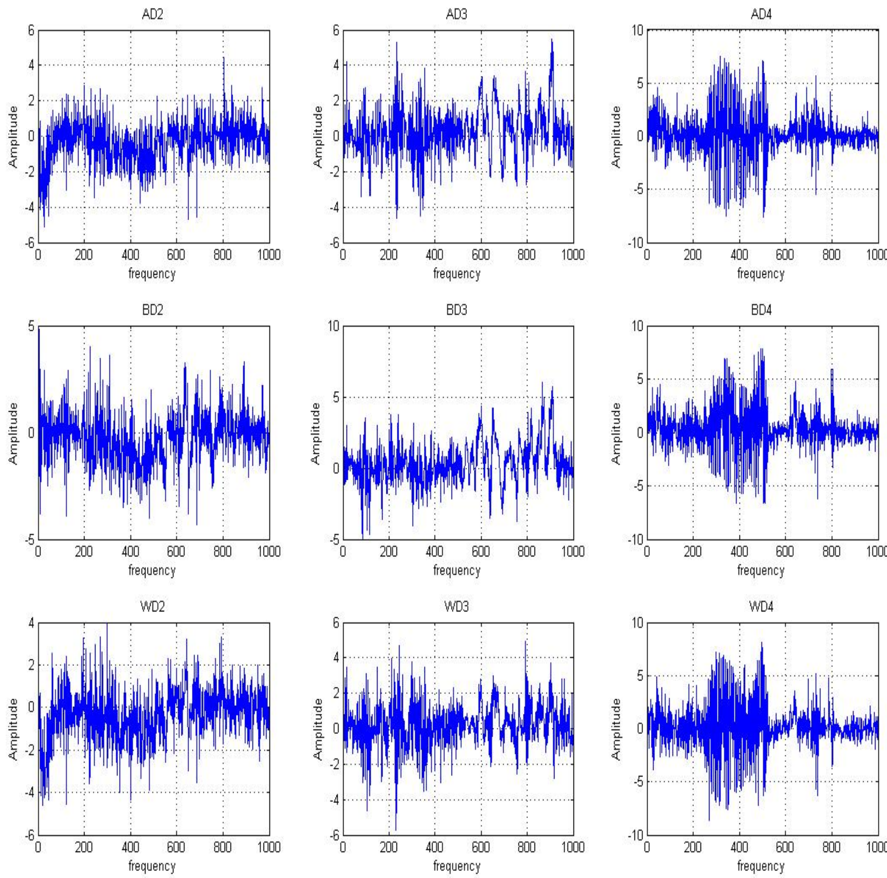

Fig. 2 The spectra of the emanated electromagnetic radiations for three computer displays of different types, on each computer being displayed three letters (A, B, W) and the background. Notation: AD2 means letter A on display 2, etc.

The main task is, now, to identify each letter from each display. In order to accomplish the task, the paper proposes a statistical approach. The first step is, obviously, to look for eventually correlations between signals spectra, which can be done by computing the correlation matrix (relation 1) and inspecting it and the correlation graphics between all the signals spectra (fig. 3).

$$RS = \begin{bmatrix} 1 & 0.0444 & 0.0462 & 0.5213 & 0.0458 & 0.1232 & 0.6365 & 0.0393 & 0.065 \\ 0.0444 & 1 & 0.003 & 0.007 & 0.6273 & 0.0926 & 0.0072 & 0.5776 & 0.0986 \\ 0.0462 & 0.003 & 1 & 0.0158 & 0.0674 & 0.579 & 0.0316 & 0.0572 & 0.5489 \\ 0.5213 & 0.007 & 0.0158 & 1 & 0.0062 & 0.0834 & 0.536 & 0.0168 & 0.0307 \\ 0.0458 & 0.6273 & 0.0674 & 0.0062 & 1 & 0.0851 & 0.0229 & 0.5026 & 0.0529 \\ 0.1232 & 0.0926 & 0.579 & 0.0834 & 0.0851 & 1 & 0.0459 & 0.0004 & 0.6365 \\ 0.6365 & 0.0072 & 0.0316 & 0.536 & 0.0229 & 0.0459 & 1 & 0.0167 & 0.0247 \\ 0.0393 & 0.5776 & 0.0572 & 0.0168 & 0.5026 & 0.0004 & 0.0167 & 1 & 0.0346 \\ 0.065 & 0.0986 & 0.5489 & 0.0307 & 0.0529 & 0.635 & 0.0247 & 0.0346 & 1 \end{bmatrix} \quad (1)$$

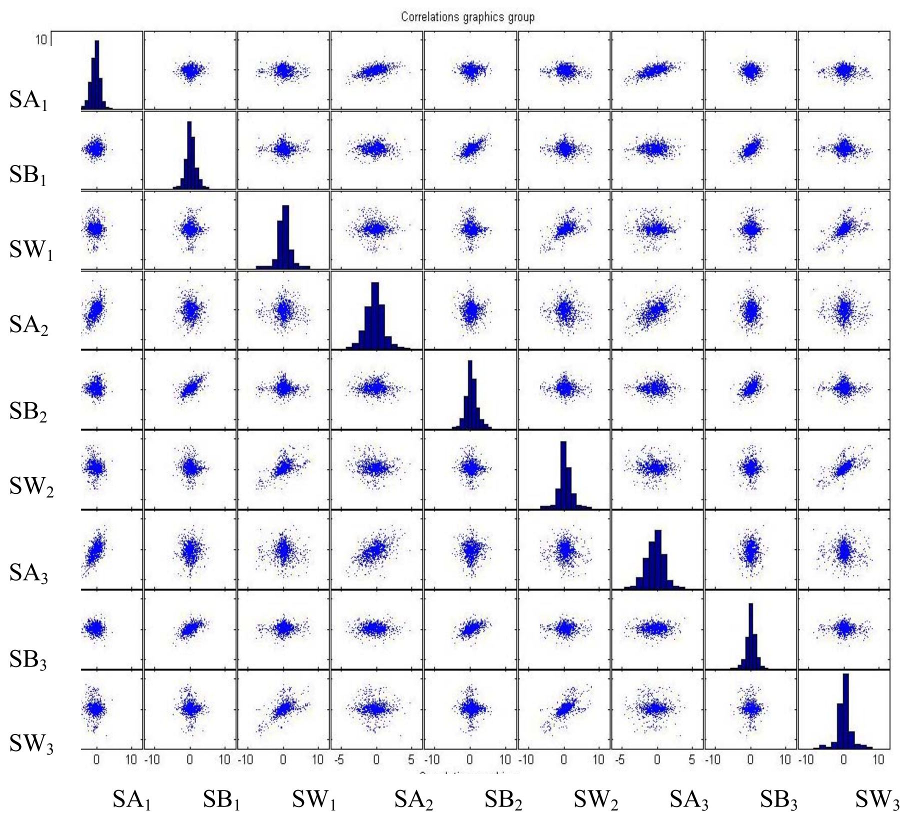

Fig. 3 The correlations between all the signals spectra in fig. 2.

In fig. 3, each element of the figure represents a correlation function, the whole figure being a matrix of graphics. Each graphic, is a correlation graphic between the spectra from the left side column and the down side line.

Since, as appearing from fig. 3 (and relation 1), the only certain fact is that there is a (strong) correlation between each signal and itself and the other signals are correlated to a certain degree, some of them week or very week, there have been made a more in depth analysis, by using the so-called boxplots [3], (see fig. 4 and fig. 5). The only difference between the plots from fig. 4 and fig.5 is the grouping: in fig. 4 there have been made a grouping by letters (i.e. the each group is made from the signals of the same letter from three displays), while in fig. 5 the grouping was made by displays (each group is made from signals from the same display).

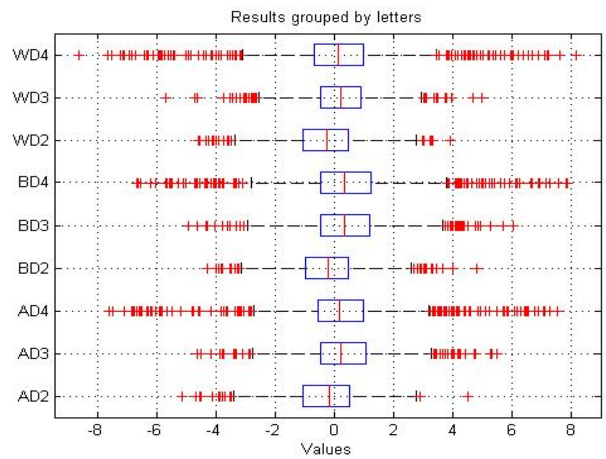

Fig. 4 The boxplots of all the signals spectra in fig. 2, grouped by letters.

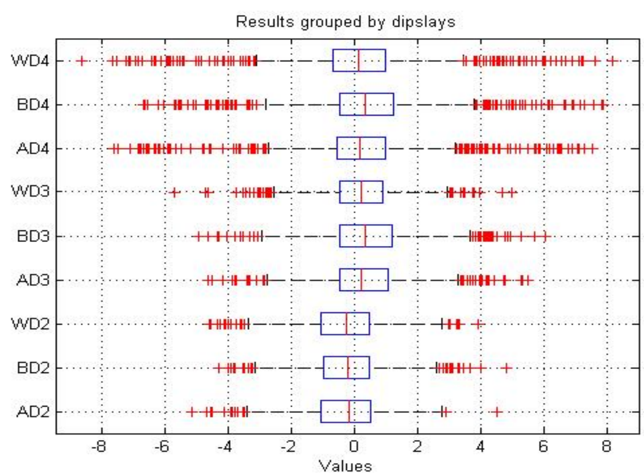

Fig. 5 The boxplots of all the signals spectra in fig. 2, grouped by displays.

The boxplots are a very synthetic representation of some statistical proprieties of the evaluated values (in our case the signals spectra): one can notice the main frequency speeding interval for the spectrum of each letter on each display. There can be also seen the median value and the percentiles for each letter on each display.

There is an obvious "display grouping" of the plots, meaning that up to this point, one can only say from which displays are the signals.

For more information, which is really needed, there has to be done another step. In our approach, this step is a principal component analysis (PCA) of the data [4]. PCA operates by obtaining, from a set of variables, of a new set that are called the principal components. The principal components are orthogonal and are ordered in terms of the variability they represent. That is, the first principle component represents, for a single dimension (i.e., variable), the greatest amount of variability in the original data set.

By applying the PCA to the set of variables represented by the signals spectra, there have been obtained the results from figures 6, 7 and 8.

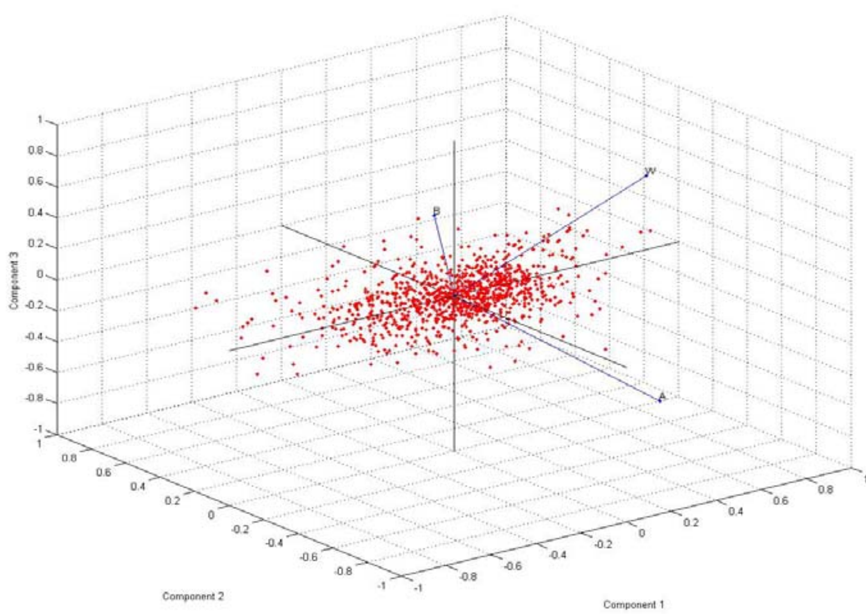

Fig. 6 The PCA plot for the signals spectra of the first display.

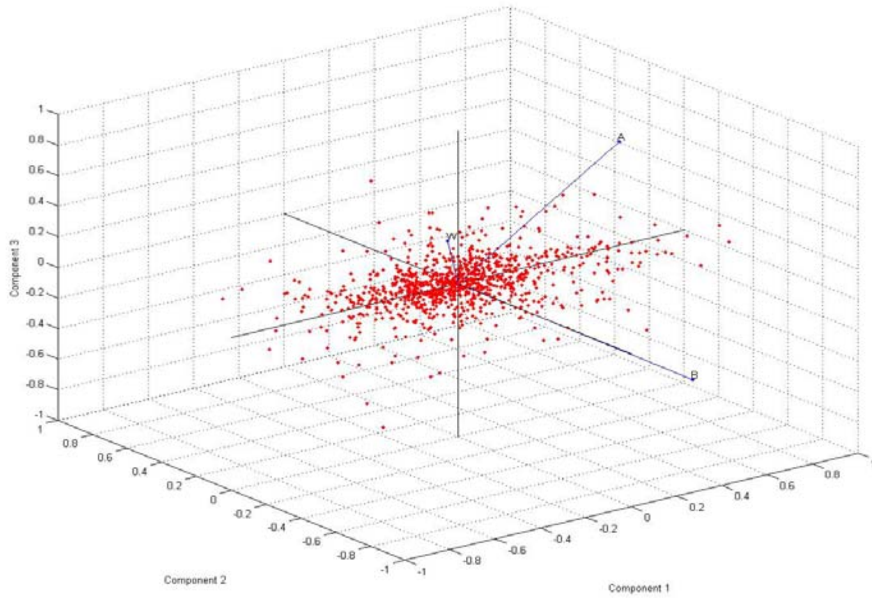

Fig. 7 The PCA plot for the signals spectra of the second display.

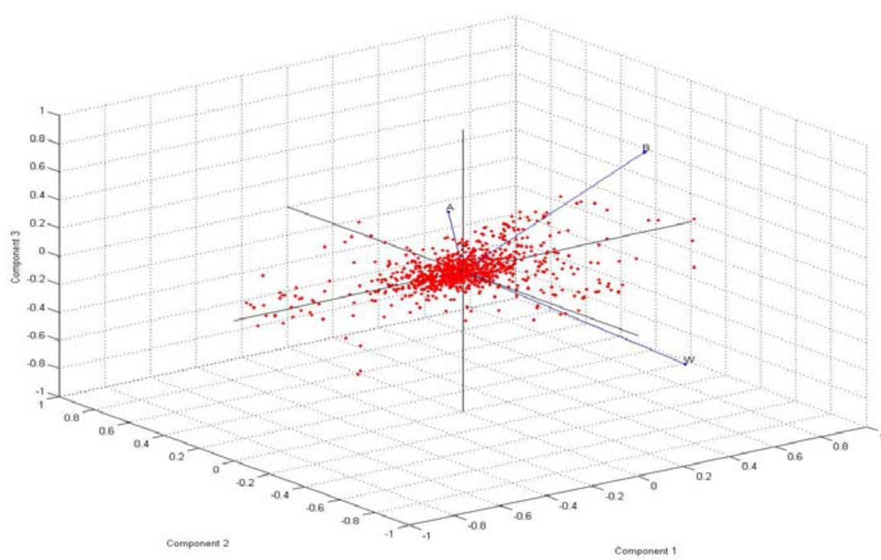

Fig. 8 The PCA plot for the signals spectra of the third display.

There is, only now, a relatively, but obvious, grouping of the signals spectra representing, for each display, different letters.

At this point, there is possible to make a distinction (identification) of the letters from the unintentional electromagnetic radiations of each display, which was, the goal of our work.

3. Conclusions

In the present paper there have been proposed a step by step procedure for the identification of the information content of the hazardous and unintentional electromagnetic radiation of some computer display.

The procedure have been validated trough tests, measurements and data processing. The important point is that the identification of the information of the radiation can be made gradually: first of all, there have to be made a spectra inspection; if, from this operation, there is no possible to make a positive identification, one has to go to the second step, i.e. correlation between spectra analysis, and, according to the identification result, to stop here or to make a statistical type "boxplot" analysis, or, even a principal component analysis of the data.

R E F E R E N C E S

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[4] *The Mathworks Inc.*, Matlab, "Statistical toolbox".