SYSTEM OF MEASURE AND REPRESENTATION OF ELECTROMAGNETIC EMISSIONS

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Abstract: Due to the vertiginous increase of the electromagnetic emissions of the modern communication systems and to the affected population's concern, it becomes necessary a more exhaustive control of this type of contamination. There are available different measure devices that make a characterization of the received emissions, but most does not discriminate between the contributions from different systems. Therefore, you cannot identify the systems responsible for the excessive measured levels. Of all the studied devices, the one that better it fulfils the expectations it is the spectrum analyzer, that it allows to characterize the received emissions, separating the different bands of the spectrum, and isolating the frequencies that don't perform the existent norm. To control the spectrum analyzer we have developed a software program that makes the measures according to the procedure exposed in the standard. Finally, another program processes and it represents the results of the measures. In addition, this application can calculate the theoretical level of radiation of different communication systems by simulation approximations and then, to compare with the measurement levels and with the reference level.

1 INTRODUCTION

People demand every time a bigger mobility of the systems of communications that they use in their daily life. To satisfy this demand, different technologies have appeared in the last times based on the propagation of the electromagnetic waves that it has relegated the cable to a second plane. As examples of these technologies, we can mention the mobile telephony (GSM, UMTS …), the wireless networks (WiFi, Wimax), the communication through Bluetooth, etc… The most attractive case has been in the entire world the exponential grow of the use of the mobile telephone.

The problem of the expansion of the wireless systems is the increase of the emission levels that it can be considered harmful if it surpasses certain exposure levels. To this physical problem, it is necessary to add the visual and psychological impact in the population that it is caused by the antennas of base stations. All of this has produced an effect of rejection in the population. Although they do not want to lose the comforts that offer them these new systems, they want to be sure that they do not represent a danger for their health, demanding a more restrictive control of the emissions levels produced for these systems.

To respond to this concern they have been developed a series of recommendations and standards that they regulate the maximum levels of emissions that will tolerate (ICNIRP, 1998). In spite of this effort, the population does not have knowledge from the levels to those that is exposed, and neither have they known the levels to which the exhibition can be harmful. Even those titled capable to characterize this emissions they find several problems in identifying the source of emissions that is surpassing the acceptable levels.

To solve these problems, we have developed a system able to make a complete characterization of the completely conflicting spectrum, using the hardware and software resources to obtain accurately measurement, representation and estimation of the emission levels.

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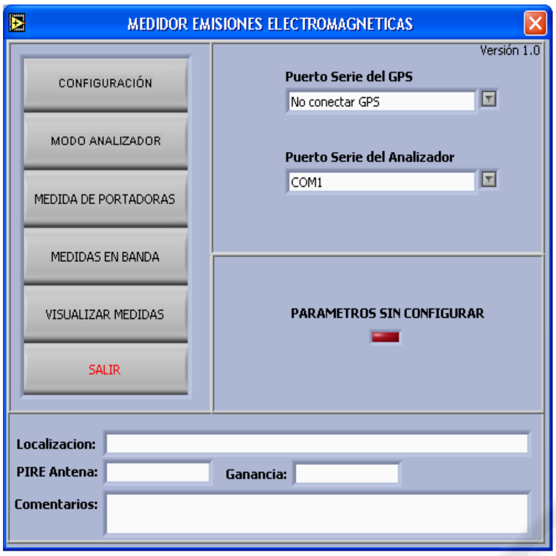
2 CAE PROGRAM

Spectrum Analyzer control (CAE) is a software application that allows the user to make different types of measures. This program controls a Spectrum Analyzer and a GPS by the serial ports. To carry out these measures the user has a series of utilities, created for each one of the measure options.



The program is divided in five modules:

<u>Configuration</u>: This module helps the user through the process of configuration of the antenna factor and the lost of the cable.
<u>Analyzer mode</u>: The program sends commands to the analyzer in real time, and the user can select the frequencies that he wants to measure, showing the results in a program window in the same way that they would be seen in the analyzer.
<u>Carrier measurement</u>: It makes a temporal characterization of a number of carriers selected by the user. For this application, we use the span zero mode of the spectrum analyzer.
<u>Band measurement</u>: This is the most significant module for the estimation of emissions level. It has two measure methods, one quick, but of less reliability and another that requires more time but whose results are more precise.

Figure 1: Application main window

Each one of these applications saves the obtained data with a certain format, in some cases attaching the obtained graphs. So the user can check the measures in any moment.

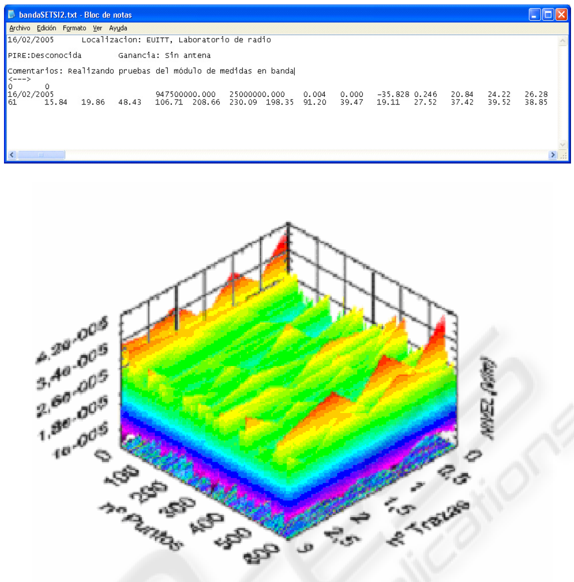


Figure 2: Text and graphical format of data

Each one of the text files contains the position provided by the GPS, as well as all the data obtained in the realized measure. Additionally, we can send de captured data to a remote monitoring system (Ruiz et al., 2005) using a mobile data communication system as GPRS.

2.1 Jump in Frequency

This approach has been developed by the necessity of making reliable measures, similar to accurately in the broadband systems, such as isotropic probes and field meters. We have made several measures that have demonstrated that they should not take all the points captured by the analyzer to make the field calculations and received power. To know what frequencies it is necessary to use and which it is necessary to discard we use the following equation:

$$Jump = \frac{Rate \cdot RBW}{Span} \cdot N^{o}\ points \qquad (1)$$

where *RBW and Span* are the resolution bandwidth and the span of spectrum analyzer respectively and *Rate* it is an adjusting parameter.

With this equation, we obtain the jump that we make when we select the frequencies band that will be analyzed

3 MODELEM PROGRAM

MODELEM is an application developed in MATLAB to Model the Electromagnetic Emissions. It is very intuitive and easy use software with a series of graphic interfaces. The user can do different actions related with Coordinates change, antennas radiation diagram, propagation models, transmission systems and projects. A project consists on calculating the levels generated by a transmission system and to make a graphic representation.

Moreover, the measurements done with the software CAE can be represented in MODELEM to compare the similitude between the theoretical calculus and the measurement values. If the GSP was connected when the measurement was been, the coordinates are used to do the representation. However, if the GSP was not connected, the coordinates should be introduced manually. Then a map can be superimposed at the measured levels.

So this program has different functions: represent measures, simulate theoretical levels and compare both with the security reference levels give by the standards.

3.1 Representation of measures

The first of these functions allows the user to process the data obtained in the measure. To complete the representation we can add a map.

Figure 3: Representation of measures and map.

3.2 Diagrams of Radiation

Besides the representation of measures, the MODELEM can simulate the levels radiated by a series of systems transmitters.

To make the simulation, the user has to introduce the data of the transmitters, and the horizontal and vertical radiation diagram of the antennas. One of the most complicated task is calculates the diagram in three dimensions.

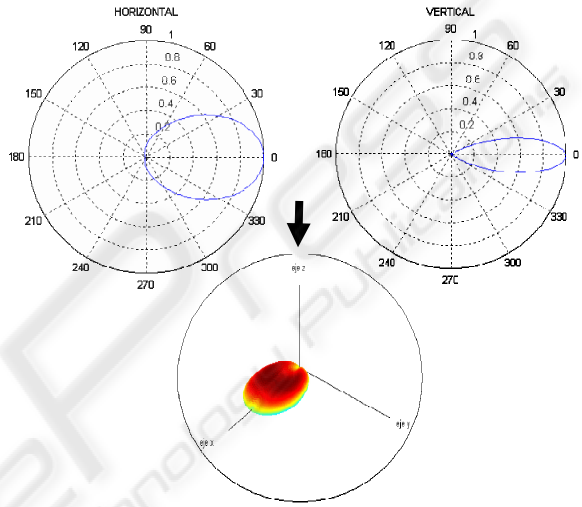


Figure 4: Radiation diagram of the antenna

3.3 Radiation models

To obtain the emitting levels we can use different propagation models: theoretical models, (Free Space, Flat Terrain), empirical models (UIT-R, Okumura Hata, etc) or models based on Ray-tracing and Ray-launching. It is necessary to consider some specific circumstances such as the number and location of the different emitting sources, the high range of frequencies, etc.

One accurate and not excessively complicate model to estimate the level of emissions is proposed in (Herradon et al., 2002). This is a two-slopes model with a Rayleigh factor for multipath propagation.

$$
\begin{aligned}
S &= \sum_{k=1}^{N} \frac{EIRP_k}{4\pi d_k^{n_1}} F_k(d_k,\theta_k,\varphi_k) \qquad (d_k \le bp_k) \\
S &= \sum_{k=1}^{N} \frac{EIRP_k}{4\pi d_k^{n_2}} \frac{bp_k^{n_2}}{bp_k^{n_1}} F_k(d_k,\theta_k,\varphi_k) \qquad (d_k \le bp_k)
\end{aligned} \tag{2}
$$

where EIRP, equivalent isotropic radiated power, d distance from the source and $F(\theta,\phi)$ the relative radiation pattern. The model above mentioned is only appropriate in far-field conditions. The most common accepted definition for far-field in communications is d = $2D^2/\lambda$, where D is the largest dimension in the antenna, λ is the wavelength and both must be in the same units. However, in emitting measurements it can be considered that the field is almost formed from d= λ.

3.4 Results

In figure 5 the emitting levels produced by a typical 3-sector base station for mobile communications with PIRE = 1 KW are shown. In this case we use the free space expression as propagation model.

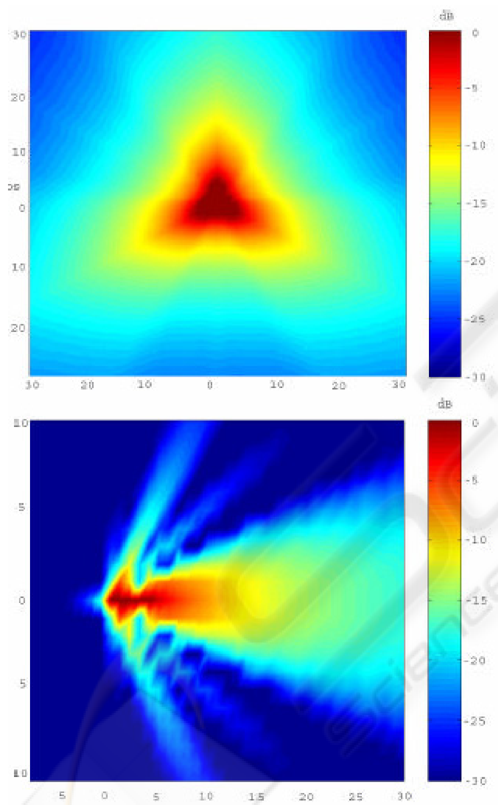


Figure 5: Power density levels, in horizontal and vertical plane, relative to Reference Levels

Considering the application of the before models, we have been carried out some approaches for different environments, and they was compared with measurements carry out with the CAE program. The results are very closed when we adjust the propagation model.

An area corresponding to a big city with a high number of emitting stations appear in figure 6.

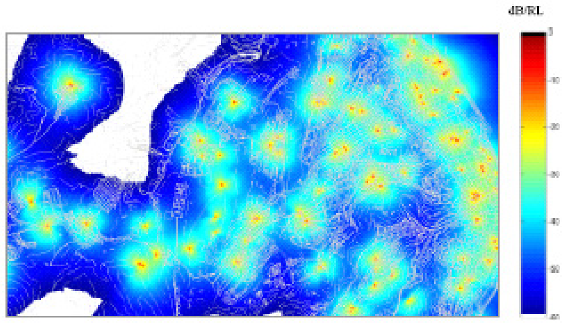


Figure 6: Simulation of emitting levels in a city

4 CONCLUSIONS

We had developed a system that allows any user to make a study of the electromagnetic emissions of a interest area.

The program CAE help to the user in the process of realization of measures. Allowing the user to make different types of measures, and saving the results for their later study.

In the program MODELEM, the user can do a simulation of emission levels, including antennas radiation diagrams, propagation models, several transmission systems, etc. The user can check if the levels obtained in the measure coincide with the obtained ones in the theoretical simulation

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