Education in Data Transmission Laboratory Respecting the Principles of Electromagnetic Compatibility

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***Abstract* – The paper attempts to formulate the methodology for laboratory education of data transmission from the viewpoint of electromagnetic and spectral compatibility. The laboratory exercises are based on several measurement workplaces, which share quite modest room – for example, in a laboratory of 50 square meters there are 6 of them, including those with wireless technologies (Wireless USB, GPS, WiFi, GPRS, UMTS, CDMA via GSM and BlueTooth). All these workplaces generate electromagnetic signals to their surroundings, and thus they represent sources of strong disturbance to the neighboring ones. The disturbing signals can negatively influence the measurement results (and often they do so); of course, this is undesirable and unacceptable from the didactic perspective (since the disturbed systems do not show the proper results that, however, should be demonstrated). The paper focuses on looking for the optimum procedure and methodology to minimize the disturbances, so that the pedagogical process in the concerned laboratories can be efficient. We present examples of negative influence to specific measurement workplaces and the ways to solve the problem.**

Index Terms – Laboratory education, Wireless technologies, Electromagnetic compatibility.

INTRODUCTION

Along with other laboratories, the Department of Telecommunication Engineering at the Czech Technical University in Prague, Faculty of Electrical Engineering, operates the Laboratory of Data Transmission, which is used for education of the following fundamental courses: Means of Data Communications, Fundamentals of Data Communications, Telecommunication Technologies and Fundamentals of Measurement in Communication Technology.

These courses are – in accord with recent pedagogical trends and with the demands of the industry – focused on laboratory education.

With respect to the high utilization of the laboratory's capacity, it is necessary to set up a strict plan (time schedule) for the individual study groups, which must be respected. In practice, every study group of 18 students is divided into 6 measuring groups of 3 students. The measuring groups then perform six laboratory exercises simultaneously.

THE PROBLEM

Since the laboratory exercises are focused on the problems of data communications, an unexpected problem was identified relatively soon – the specialized measuring workplaces, installed close to each other, negatively influenced the results obtained at the other ones.

The identification of this problem was accidental in fact. The individual workplaces were set up and tested before the beginning of classes, in order to determine the typical values students should measure as well. Then the complex of all six workplaces was built, the semester began and students started their measurements.

The following technologies were used for the six workplaces: Wireless USB, GPS, WiFi, GPRS, UMTS, CDMA over GSM and BlueTooth. (It should be noticed that GPRS, UMTS and CDMA were installed in a single workplace – their simultaneous operation was not required.)

The workplaces were deployed in one room within the area of approximately 50 square meters. After finishing their measurement, students submit reports containing the measured values. Initially we did not pay attention to the fact that those values were different under (seemingly) identical conditions, but later we had to look for the reason systematically.

CURRENT STATE

The measuring workplaces were originally located within the laboratory according to Figure 1. It is apparent that the workplace for WiFi (wireless networking) is placed close to that for UMTS. But the measurement of wireless networks includes an experimental part when the transmission output of the system is changed, and the UMTS measurement includes testing of transmission speed for one or more occupied channels.

As we learned later, the wrong data were measured in the time periods when the transmission power of WiFi network was altered. The higher output power itself was not a problem – but the process of changing was. In the very instant of the change, an intensive burst noise occurred for a short time and the transmission speed of UMTS data was substantially decreased for several seconds.

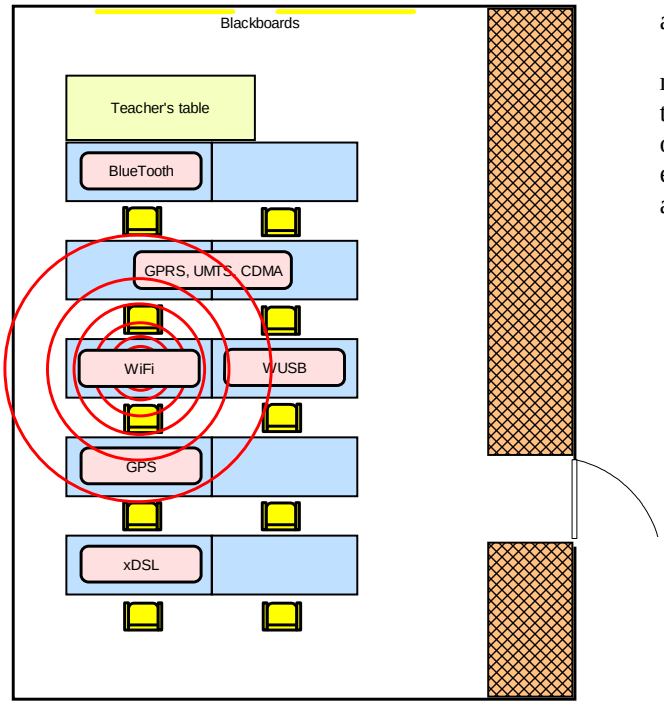

FIGURE 1
ORIGINAL ARRANGEMENT OF WORKPLACES

After multiple experiments we concluded that the laboratory operations of these two workplaces were influencing each other.

ANALYSIS

Subsequently we performed a theoretical study of spectral compatibility concerning various communication systems as well as electromagnetic compatibility in common, taking into account [1] and [2]. However, the theory did not help us discover any reason for mutual influence between the individual systems and their functions.

Then we proposed a hypothesis that the electromagnetic incompatibility of these devices was caused by the specific operational states during the experiments in laboratory conditions. We started to explore the laboratory, with the objective to ensure the electromagnetic compatibility of the students' measuring workplaces so that the measured values would be real and not distorted by undesirable emissions from other devices and systems.

SOLUTION

To evaluate the mutual influences, we chose the experimental method (as the analytical one would be too much complex). We examined the interaction of each pair of the systems in various operational states.

The experiments revealed that the most aggressive source of disturbance for other systems were the WiFi transmission units, always during the change of transmission power. We started the searching for suitable solution of this problem. We focused on spatial separation of the respective workplaces. As soon as the distance of UMTS workplace from that for WiFi exceeded 2m, the false values ceased to appear.

The testing results of other pairs of workplaces were negative – we did not get any false results. On the basis of these observations we determined the optimum configuration of all workplaces within one laboratory, ensuring the electromagnetic compatibility conditions. The resulting arrangement is shown in Figure 2.

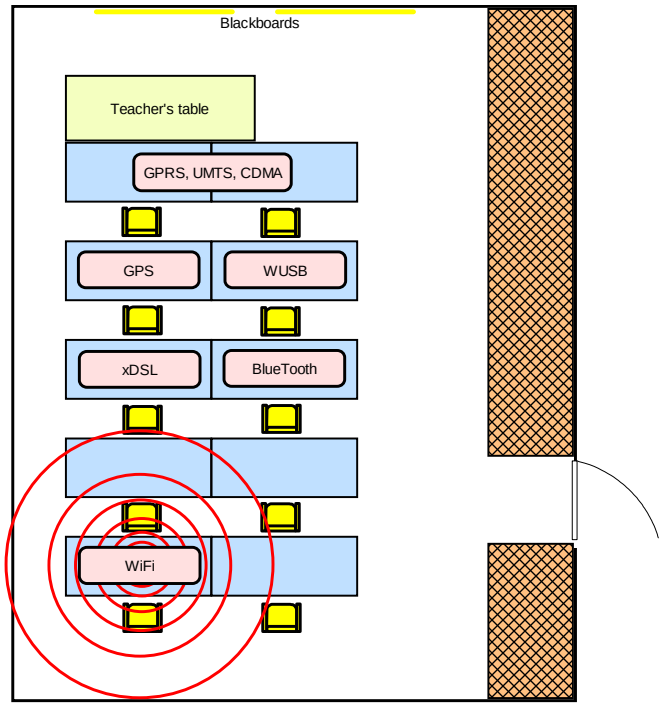

FIGURE 2
NEWLY DESIGNED ARRANGEMENT OF WORKPLACES

CONCLUSION

The strict respecting of EMC (electromagnetic compatibility) principles is the necessary prerequisite for successful operation of various electronic devices. The EMC of school laboratories is often neglected, which is a serious mistake. The purpose of this paper is to draw the attention of university teachers to possible difficulties, suggesting that EMC is not just a theoretical discipline, even for laboratory education.

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