Motivating Younger Students by Using Engineering Graduation Projects to Facilitate their Work

Joaquim Oliveira
School of Technology: Electrical Engineering Dep.
Polytechnic Institute of Castelo Branco
Castelo Branco, Portugal
joliveira@ipcb.pt

José Salvado
School of Technology: Electrical Engineering Dep.
Polytechnic Institute of Castelo Branco
Castelo Branco, Portugal
jsalvado@ieee.org

Abstract—**This paper addresses a way to motivate freshmen students benefiting from the work of term students in graduation projects. The application of concepts from digital electronics and analog telecommunications systems can reinforce cooperation of students at different levels on a positive way and strength skills. This can also be used as demonstrative experiences to attract prospective students to electrical engineering courses. The experience of a cooperative work with graduation projects is presented and how it can facilitate younger students work and thus contribute for their motivation and skills. The graduation projects used are briefly presented and some results are shown and discussed.**

Keywords- Antenna measurements; computer aided instruction; cooperative work; graduation projects; electrical enginnering education

I. Introduction

Younger engineering students often face some difficulties with working methodologies, namely on how to take the maximum from individual and team work within the time slot available to accomplish the tasks. This is more noticeable at laboratory classes when a plan of sequential actions needs to be designed, discussed and performed within the group. Besides social and personal relationship factors – students often do not know each other very deeply at early stages – this is also due to a natural lack on basic technical background, skills and confidence, regarding their freshmen status. Although collaborative work and project groups are good learning methodologies [1], usually there is a diverse function within the team. Some students tend to assume a passive attitude while others, probably facing the same difficulties, try harder and focus on the main objectives. However, without a proper guidance and clear focus, both tend to become unmotivated, either by the apparent increase on workload due to the sense of missing results, or by the non-perception of what is really important, which is typical at early stages, as a consequence of a lack on non critical analysis and non critical thinking.

To keep or improve motivation, the idea of very difficult piece of work to accomplish or repetitive and useless tasks should be avoided, especially in cases that require a large amount of measures as is the case in antenna measurements. Rather, the adoption of a systematic approach and a focus on the meaning and importance of each step are of great importance. Some key factors that contribute to student's motivation are: a clear idea on the applicability of the concepts and a focus on "how and why it happens" or "how it works". Simple examples are computer internal architecture, the use of software to control the hardware, namely on using the computer peripherals (e.g. signal generation). Another key factor to increase motivation is the knowledge and the applicability of some graduation projects made by senior colleagues. Regardless its complexity, it may give to younger students the sense that they are also capable of doing the same or even better and in that way increase self-esteem.

The main objective of this paper is to describe a collaborative work experience with engineering graduation projects and how it is useful for freshmen students. These can serve as aiding tools on facilitating their work at laboratory classes, and enrich their skills on using a multidisciplinary approach. The paper is organized as follows: section II presents the motivations of this work, the graduation projects are described in section III, the collaborative experience in section IV and in section V we present a summary with the main contributions.

II. Motivation

The motivation for this collaborative work started in two main branches: one in the field of telecommunications and the other one in digital electronics. Two years ago (approximately) the authors decided to take advantage from the work of senior students on graduation projects to facilitate the performance of freshmen. Thinking on its use for didactic purposes on laboratories it was also decided to introduce some new features and increase their motivation with specific applications. Both were first proposed carried and supervised separately by the authors and at a later phase improved and connected in order to enrich multidisciplinary application of concepts.

A. Antenna Measurements

The Telecommunications Laboratory (Lab-T) at the Superior School of Technology of the Polytechnic Institute of Castelo Branco (EST-IPCB) supports the Telecommunications courses of the bachelor degree (3-year) on Electrical and Telecommunications Engineering. The Lab-T is equipped with several didactic kits and test equipment and supports, among others, the practical and laboratory classes of Electromagnetic Waves, Propagation and Antennas. The later is a second year, second semester course, studying subjects related to antennas

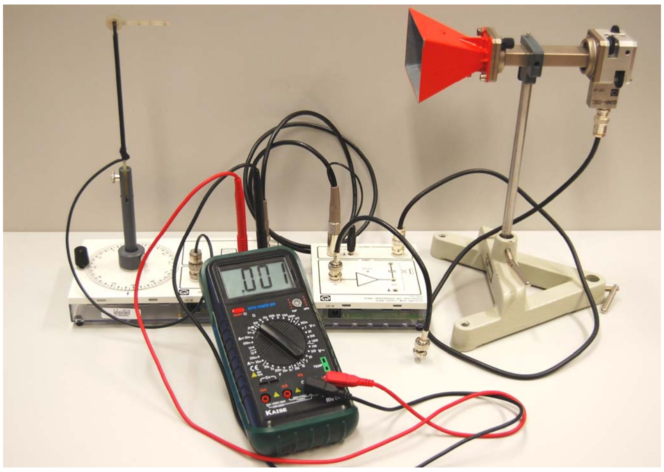


Fig.1. View of the main components of the MTS 7.6.5 antenna measurements station: TX antenna (right) supply and amplifier (middle) and RX antenna (left) with a Yagi structure.

in several different types and configurations [2]. One of the most common experiments carried at the Antennas course is the evaluation of the radiation pattern of linear antennas. For that purpose students use a Leybold–Didactic MTS 7.6.5 kit (the older version) shown in Fig. 1. The complete measurement station consists of emitting and reception terminals and a set of absorbing mats (not shown in figure). The emitting terminal comprises a horn antenna fed by a Gunn oscillator, which operates at 9.4 GHz, whose power supply is modulated, that is to say that the emitting electromagnetic power is modulated, by a 1 kHz square wave. The reception terminal consists in a small $\lambda/2$ dipole test antenna mounted in a rotating plate, with a 360º degrees scale graduated in 5º degree steps, where λ is the wavelength. The $\lambda/2$ dipole reception antenna can be augmented to form a dipole with λ , $3\lambda/4$ and 2λ and the influence of reflector and/or director parasitic elements of antenna arrays with different configurations can also be studied.

The MTS 7.6.5 station supports the study of the radiation pattern of antennas, both on the plane of electrical field or the magnetic field (i.e. horizontal or vertical polarization) or the free space attenuation tests. The first is performed putting the reception antenna at one fixed distance from the emitter and collect data of the voltage (rms value) for several angular orientations within 0º and 360º. The attenuation test consists on collecting data of the voltage values for several distances of the receiving antenna from the emitter. In both tests, the all process was originally operated manually, i.e., the positioning of the reception antenna, the adjustment of its orientation on the rotating plate, the measures, etc. To complete the experiment students had to introduce all data in a spreadsheet software application (e.g. Microsoft Office Excel or Open Office Calc).

Under these conditions, the average amount of time spent to perform a complete radiation pattern experiment is around 30 minutes per group of students, thus allowing up to 6 groups to take measures in a 3-hour session in laboratory. Even for groups of 4 students this represents significant restrictions if one considers the average number of students per class which is around forty, each semester. With these factors in mind, it became clear the need for some significant improvements and for a system for the automation of the MTS 7.6.5 measurement station, capable of collecting data and perform measures from a test setup. Moreover, the objectives and technical requirements were suitable for a 3-year graduation project.

B. *Instrumentation Electronics and Computer Organization*

The study of computer based instrumentation requires knowledge of computer architecture and organization, its peripherals, I/O addressing and programming skills, besides the knowledge on the operation of the devices. One can study each subject in a separate way and use specific didactic kits for each subject: the operation of Analog to Digital Converters (ADC) and Digital to Analog Converters (DAC) devices, PC internal buses, peripherals and I/O ports, etc.

The major advantage of this approach is the management of the laboratory due to the use the didactic modules in a complementary way by splitting the class in two turns. When the first half uses the ADCs module, the other half uses DAC, and so on. This way only the half of equipments are needed to accomplish with required tasks at laboratory classes. Although the Electronics Lab at EST-IPCB has several didactic modules to help teaching these subjects, they are in general poor in modularity and flexibility, not easy to interconnect and some require an external control unit.

As there were some obsolete PCs with Windows®98 operating system it was decided to use them for supporting units at laboratory classes in an integrated environment as

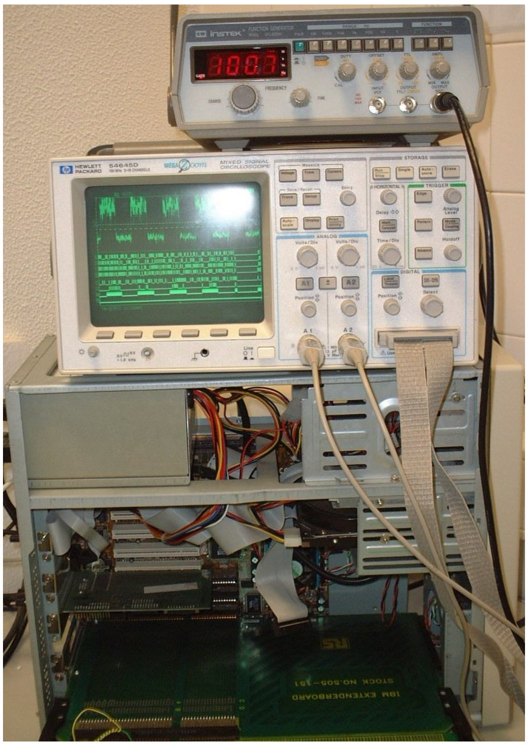


Fig. 2. The integrated environment station: a PC (Windows 98®) with an extender board on the bus (E-ISA), a data analyzer and a frequency counter.

shown in Fig.2, and considered a good alternative solution for the students work and for future expansion on functionalities.

III. GRADUATION PROJECTS AS AIDING TOOLS

Based on the motivations described above, and pursuing previous work on trans-disciplinary projects [3], the authors proposed and supervised two separate graduation projects to help students at laboratory classes, both requiring hardware/software skills. One project aimed the automation of the antenna measurement station. The other project aimed to help the study of computer architecture and organization, also the practical demonstration of some electronic devices commonly used on instrumentation electronics, using simple and typical applications such as signal generation and data acquisition on a PC via the parallel port.

A. Graduation Project I: Automation of the MTS 7.6.5

The tasks involved in this project include the design of the interface electronic circuits, motor driving, signal conditioning and the assembly and testing of a prototype [4]. The automation system for the MTS 7.6.5 antenna measurement consists of a PC acting as central and control unit, and other functional blocks as depicted in Fig. 3 a). The software application running at the PC controls the stepper motors on the receiver platform, acquires data from the conditioning envelope of the receiver signals through a parallel port and controls all the processes.

The emitter block consists on a power supply of the Gunn oscillator that allows to varying, the -9 V_{dc} medium supply voltage, between -7.5 V_{dc} and -10.5 V_{dc}. This variation can be obtained by a 1 kHz internal square wave oscillator or by external signals (e.g. voice) as depicted in Fig. 3 b), and the radiated power varies proportionally to these. The receiver block consists in a test antenna with a rectifying diode connected for envelop detection (amplitude demodulation), an amplifier with a gain of 1000, and two distinct circuits: one for radiation pattern measurement and the other one for the external signals transmitted by emitter. Finally, an interface circuit samples the signal and converts it to digital with 8-bit words (sample and hold device - S/H and analog to digital converter - ADC) as shown in Fig. 3 c). There is also a circuit for amplifier and loudspeaker to listen the recovered signal when one uses a voice signal at the emitter. The test antenna is mounted in a small platform with wheels, able for translational and rotational movements, actuated by stepper motors for positioning: displacement and rotation. It is possible to place absorbent mats to mitigate any interference due to reflections when measuring the radiation pattern, or to study the influence of these interferences.

Fig. 4 presents a detail of the receiver antenna mounted on the mobile platform and the electronics card for interface and drives for the motors and Fig. 5 shows a snapshot of the software application where it is noticeable an example of antenna radiation pattern and on the left, the values of the voltage measured and acquired for that test. The remaining buttons are for configuration and for test setup. The application also has the possibility to export data in Microsoft Excel (or compatible) files format for further processing.

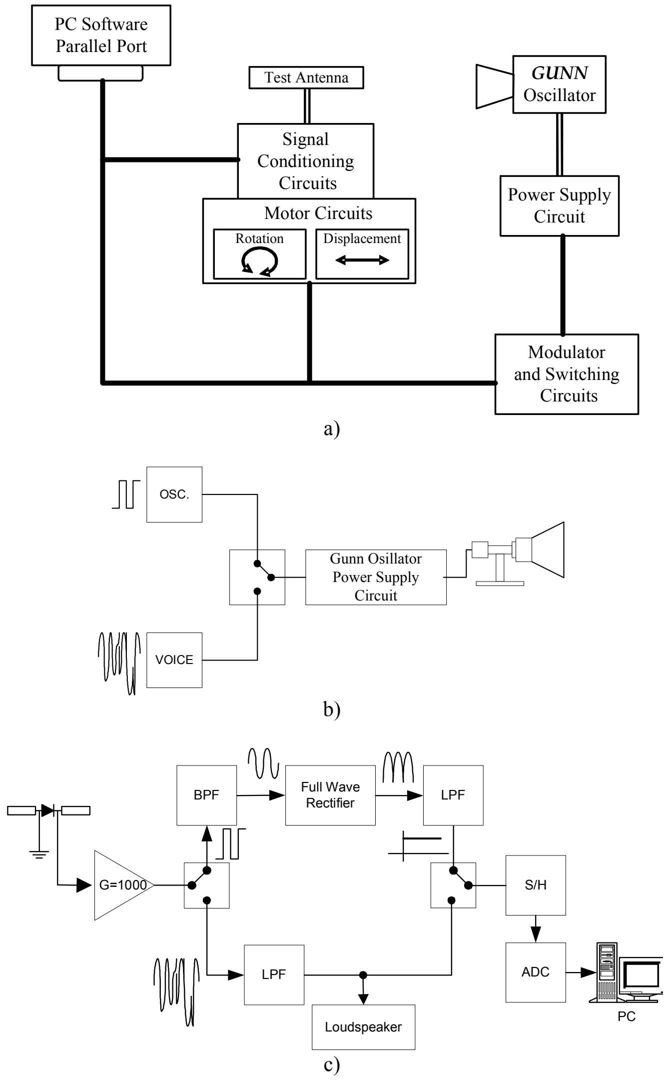


Fig.3 Automation system for the MTS 7.6.5: a) scheme of principle; b) block diagram of the transmitter end and c) block diagram for the receiver end.

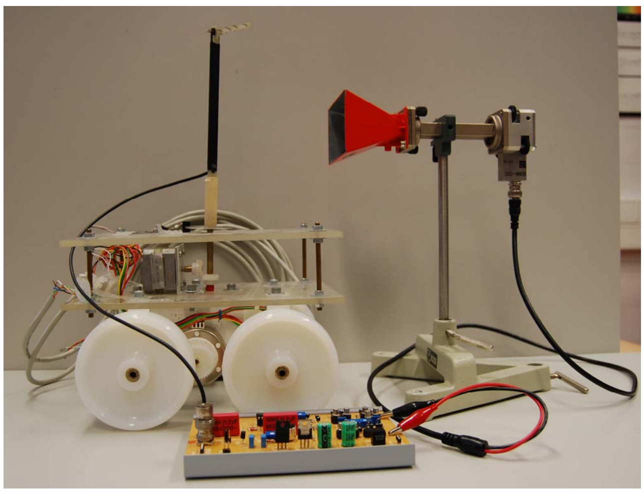


Fig.4. Final assembly: mobile platform with receiver antenna mounted and electronics circuits for motor drives and signal conditioning.

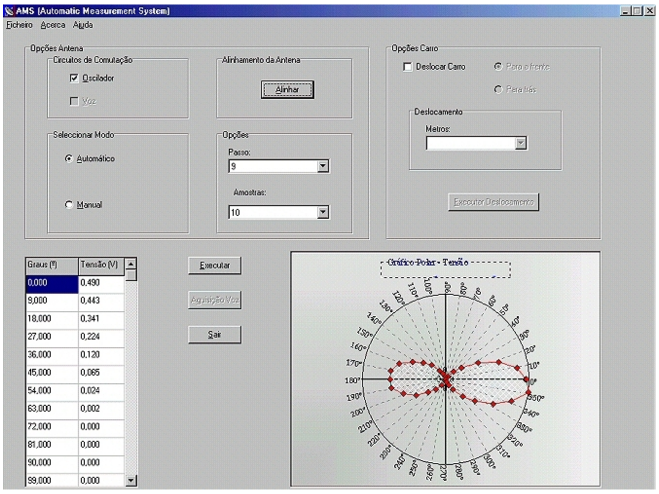


Fig.5. Snapshot of software application: A^{2}MS (Automatic Antenna Measurement System).

B. Graduation Project II: PC Based Signal Generation

This project aimed to help students to study computer architecture and organization, namely for subjects on the operation of internal buses, peripherals, I/O ports, and computer instrumentation electronics devices such as ADC and DAC and also how software interconnects with hardware. For didactic purposes the E-ISA 32-bit [5] bus was chosen and some obsolete PCs with Intel Pentium IV processor and Windows®98 operating system were used. On the other hand, the signals generators available at the laboratories had mainly a bandwidth up to 2 MHz which was one additional objective: the possibility for low cost signal generators for frequencies above 5 MHz for the three standard signals: sinusoidal, square and triangular waves. The block diagram of the signal generator card is depicted in Fig. 6. The core of the system is the MAX038 Signal Generator IC (manufactured by Maxim Integrated Products, Inc), associated to a DAC IC to control digitally the frequency of oscillation and the duty-cycle. The output frequency is determined by a reference current injected in pin I_{IN} (using a DAC device) and one external capacitor C_{OSC}. For a given current and capacitor it is possible to have an additional adjust on the output frequency within a 70% span through a voltage signal provided by another DAC output. The duty-cycle is also programmable from a voltage, the output amplifiers gains are defined by digitally controlled potentiometers and even the waveform selection is made by changing two bits.

The tasks related to the graduation project consisted on the design of a prototype card to fit into the E-ISA bus whose final prototype assembly is shown in Fig. 7 a) [6]. The hardware module is 16-bit addressable within the range 0300h and 031Fh and fully controlled by a software application with windows-like interface. The software controls two fully independent channels and generates two separate signals, as shown in Fig 7 b) and c). The results obtained exceeded the initial specifications for each channel, allowing the generation of signal within a frequency range from 1 Hz up to 10 MHz, a variation on duty-cycle from 10 to 90%, linear variation on amplitude from 1 to 13 V_{pp}, and the possibility to add a DC component to the signal.

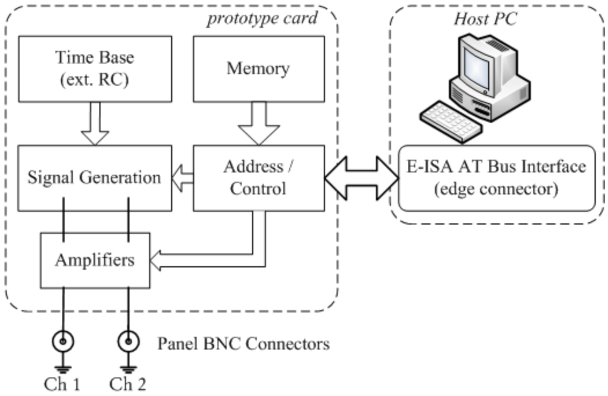
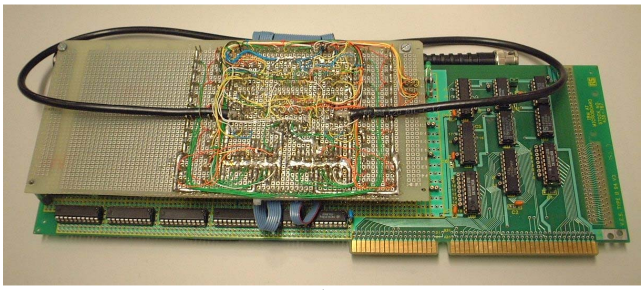
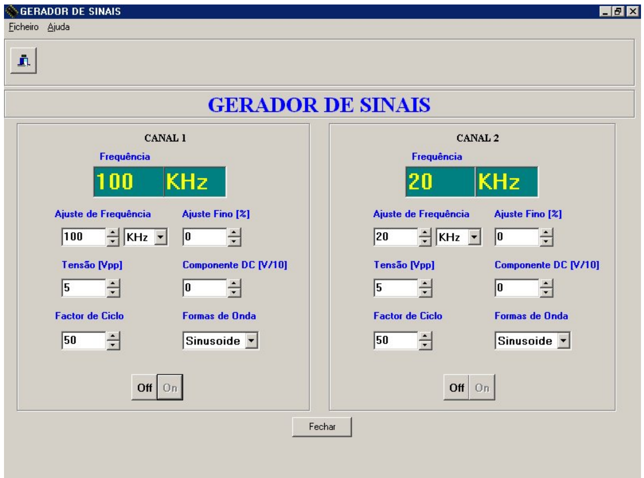


Fig. 6. Conceptual block diagram of the signal generation system.



a)



b)

Fig. 7. The PC based signal generator: a) prototype of the hardware assembly to fit into the E-ISA PC bus and b) snapshot of the application that controls both channels.

Besides its use as signal generator, this prototype help students to study all the steps involved on signal generation process, the organization of the memory spaces on the PC, and the functioning blocks of the hardware prototype card. In order to accomplish with the didactic purposes and facilitate the study of computer architecture, the hardware card can be fitted on an E-ISA bus extender board, in a similar way as that presented in Fig 2. With this solution it is possible to analyze signal activity and data on the computer bus while signals are being generated.

IV. Collaborative Work Experience and Results

The results when carrying both graduation projects were very good as there was a great commitment from the term year students on finding solutions and testing different approaches. One should also point the enthusiasm and good expectations from freshmen students, especially on how it facilitates their work on measuring antennas; also the perception of digital systems, memory spaces, I/O addressing and instrumentation devices, from the practical point of view. Moreover, the PC based Signal Generator can be connected to the Automated Antenna kit system as external signal source thus forming a fully automated test station using a single computer to control all the processes. Although there are commercial solutions available, we preferred this approach not only because of economical reasons, but also due to technical and pedagogical aspects. We consider it as an added value as we gain flexibility on introducing test points on significant stages of the measurement chain; also because we have deep knowledge of the systems and so forth have conditions to improve its functionalities.

The automated antenna measurement system allows a significant cut on time spent with manipulation and repetitive tasks thus avoiding the sense of boring or false useless procedures. As the sequential tests are previously defined and performed automatically, it also avoids errors on measures of voltage signals. With this system the time spent on performing tests was reduced around ~50% thus achieving a significant speed up gain in laboratory classes making possible up at least 10 groups per 3 –hour session. Is also allows an easy way to produce reports on the experiments, namely on graphics, since data is automatically stored in spreadsheet type files. Thus, it is possible to test the behavior of a microwave link under different conditions, and various types of modulating signals and frequencies.

The gain on time to perform these measures and the improvements on accuracy are reflected in a better quality of the radiation pattern. Also provides extra spare time to further analyze the results and interconnect practical results and theoretical concepts, thus leading to better reports on the subject. Besides the use as supporting units to laboratory classes the system is also used for experimental presentations to prospective students at secondary level, in order to attract them to electrical engineering field. Some basic experiences on computer organization and I/O and also on the fundamentals of analog telecommunications are presented and discussed with attendees. The one that most frequently get attention and interest involves a voice signal that modulates a carrier generated by the PC signal generator and transmitted through the microwave link and hear it at the loudspeaker.

The opinion of the students is important in the context of any process within the learning process, so we evaluated their opinions on the degree of satisfaction with the proposed approach. We conducted a brief enquiry with five simple question in what students have to give a rank to its significance within the range from 1 to 5: 1 (very poor), 2 (poor), 3 (fair), 4 (strong) and 5 (very strong). We collected anonymously the answers of twenty (20) freshmen students to the following questions:

Q1 – "Contribution of this approach to enlarge the scope of the learning in general in a multidisciplinary way";

Q2 – "Importance to the laboratory class with the speed up and improve of the accuracy of the measurements";

Q3 – "Significance to the laboratory work by the ease of use while avoiding the sense of repetitive and boring tasks";

Q4 – "Importance of computer based measurement systems and its concepts in the course";

Q5 – "Contribution to the particular and specific objectives of the course and to the overall skills".

The results shown in table 1 indicate that the majority of students consider this approach significant in terms of benefits both, to facilitate their work and to strengthening their specific and overall skills. The results in cases of "no opinion" or "no answer" were considered not significant.

At the present there is some work in progress with the objective to upgrade the interconnection of the systems and to add new functionalities, namely the use of USB for communication between the mobile platform and the host PC and the possibility to convert it in a remote lab experience. This way some new subject will be included in the multidisciplinary approach, namely the TCP/IP protocols and services supported on the Web. Students are also being asked to contribute with their ideas, as privileged users, about current functionalities, new aspects and new features that they think are important to include in future releases.

V. Summary

This paper describes an interconnected work experience with two engineering graduation projects and how it can benefit freshmen students as demonstrative of theoretical concepts and also on facilitating their work at laboratory. Both projects form a fully PC based automated test station, namely an Automated Antenna measurement KIT as well a signal generated system.

The experience was very positive as students felt involved with solutions and improvements to the learning process. It also contributes to their skills and expertise on strengthening its concepts in telecommunications and digital electronics. The results obtained are much better compared to the original measurement system and procedures, because it saved time and improved accuracy of the radiation pattern. Another point that deserves to be mentioned is the enthusiasm and expectations from freshmen students, especially on how it could facilitate their work on measuring antennas; also the perception of

Table 1. Results of the enquiry concerning the importance of this collaborative work to the role of the students.

	1	2	3	4	5	No Opin.	No Ans
Q1	0%	0%	15%	35%	45%	0%	5%
Q2	0%	0%	5%	40%	55%	0%	0%
Q3	0%	5%	10%	35%	50%	0%	0%
Q4	0%	5%	30%	35%	20%	5%	5%
Q5	0%	5%	30%	40%	15%	5%	5%

digital systems, memory spaces, I/O addressing and instrumentation devices, from the practical point of view. This system is also used to some demonstrative experiences to attract students to electrical engineering courses.

References

[1] Calvin S. Kalman, *Successful Science and Enginnering Teaching in Colleges and Universities*, Anker Publishing Inc, Bolton Massachussets, 2007, pp.53–96, ISBN: 978-1-933371-16-0.

[2] Constantine A. Balanis, *Antenna Theory: Analysis and Design*, 2nd Ed. John Wiley & Sons, 1997, ISBN: 978-047159-26-84.

[3] J. Oliveira, J. Salvado, "Engineering Graduation Projects in a Transdisciplinary Approach," *Proc. of CEE'05 1st International Conference on Electrical Enginnering*, Coimbra, Portugal, 10-12 October 2005, ISBN: 972-99064-3-2.

[4] A. Nobre, N. Aguiar, Sistema de Medida Automático para o KIT de Antenas, *Graduation Project Report* (in Portuguese), EST-IPCB, Castelo Branco, Portugal, 2001.

[5] Hans-Peter Messmer, *The Indispensable PC Hardware Book*, 3rd Ed, Addison-Wesley, Harlow, UK, 1997, pp.549–566, ISBN: 978-0-201-40399-4

[6] J. Ribeiro, D. Carvalho, SIGAS: Sistema Integrado para Geração e Aquisição de Sinais Suportado em Computadores Pessoais, *Graduation Project Report* (in Portuguese), EST-IPCB, Castelo Branco, Portugal, 2002.