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Title: Electromagnetic theory: Electromagnetic pulse in the laboratory

Authors: Guzmán-Tinajero, Pedro, Hernández-Gómez, Víctor Hugo and Castro-Fuentes, Aide

Facultad de Estudios Superiores Cuautitlán UNAM ACR-9145-2022 0000-0002-2297-7758 251228
Facultad de Estudios Superiores Cuautitlán UNAM S-6575-2018 0000-0001-9315-5869 122247
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ECORFAN-México, S.C.
Park Pedregal Business. 3580, Anillo Perif., San Jerónimo Aculco, Álvaro Obregón, 01900 Ciudad de México, CDMX,
Phone: +52 1 55 6159 2296
Skype: ecorfan-mexico.s.c.
E-mail: contacto@ecorfan.org
Facebook: ECORFAN-México S. C.
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INTRODUCTION

The Facultad de Estudios Superiores Cuautitlán (FESC), part of the Universidad Nacional Autónoma de México (UNAM), is an important academic center located in the municipality of Cuautitlán Izcalli, State of Mexico. It was inaugurated on April 22, 1974 and has been in existence for more than 50 years. It now has 17 degree programs and has approximately 18,000 students enrolled.

In the curriculum of the Telecommunications Systems and Electronics Engineer (ITSE), taught at the FESC of the UNAM is the subject of Electromagnetic Theory, located in the fifth semester of the career and marked as a theoretical and practical subject (therefore includes a laboratory), has 10 mandatory credits, so it is of great importance in the training of future engineers.

INTRODUCTION

For the scope of this article, we will focus on Electromagnetic Pulses generated in the laboratory through voltage variations such as those produced by the Van De Graaff Generator.

The problem we wanted to attack was the general ignorance of our students about the EMP phenomenon and the importance that it has in the proper functioning of electronic devices today

The contribution of this experiment is the realization of a controlled EMP, as well as the design and measurement of the basic circuit to raise the voltage, all this is visually attractive to students and motivates them to deepen the subject.

For all of the above, we developed a laboratory practice called: “Passive circuits and electromagnetic pulse”, which has already been included in the manual of laboratory practices of the Physics Department of the FESC UNAM.

METHODOLOGY

For the elaboration of this work, first, theoretical research was carried out that included basic elements of the Electromagnetic Theory subject, the programmatic contents approved by the H. Technical Council of the Faculty, and the quality guidelines according to the ISO 9001:2015 standard. We worked with several academics from the Electromagnetic Theory faculty to distribute the work equitably.

Considering that Maxwell's equations pertain to the interaction between electric and magnetic fields, we decided to include an experiment with the necessary characteristics to make it engaging for students while simultaneously demonstrating the relationship between these fields

For this project we used the Van De Graaff Generator of the Physics Laboratory, FESC, which works with the friction of the band on a roller and the induction of charges to the generator shell, see Figure 1, to produce a controlled EMP that allowed the students enrolled in the Electromagnetic Theory course to observe the effect of the same on electronic devices.

Box 1

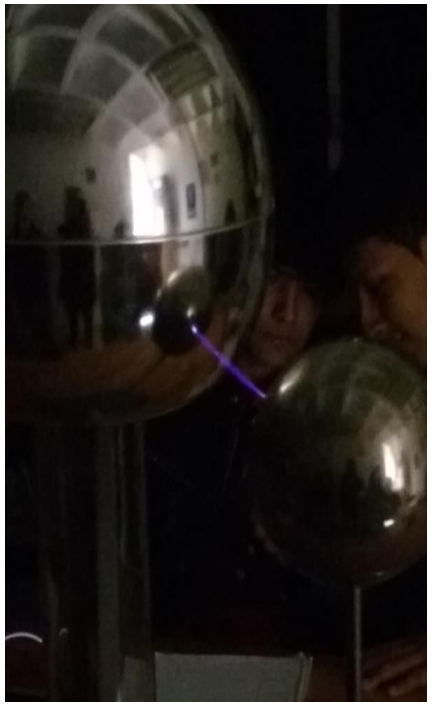

Figure 1
Van De Graff generator.
Source: Own Elaboration

METHODOLOGY

Compared to other techniques (such as nuclear), the PEM generated by the Van De Graaff Generator is of low power, which allows students to understand and measure it more safely.

We also built a passive oscillator circuit with laboratory elements (Capacitive-Inductive circuit) and accompanied it with a Diode to produce the effect of voltage growth in the capacitor. See Figure 2

We consider it important to mention that, although we could have worked with a power transistor, to make the experiment more didactic we used a basic button switch.

By using the basic switch, we were able to allow the students to interact with the circuit and demonstrate the relevance of the operating frequency in a practical and didactic way.

Box 2

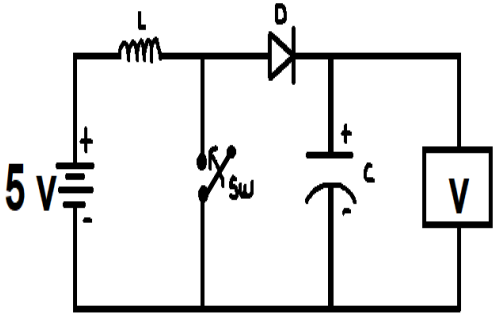

Figure 2
Wiring diagram.
Source: Own Elaboration

METHODOLOGY

The Laboratory of the Physics Department of the FESC is certified under the ISO 9001-2015 standard, which is why when introducing a new practice it was necessary to comply with certain organizational guidelines.

According to Departamento de Física (2024), the structure of each of the practices of the manual for the Electromagnetic Theory laboratory, consists of 8 main elements, see Table 1.

The proposed practice complied with these guidelines and additionally, being a product of a collegiate work, it could be integrated to a UNAM program called: Program of Support to Projects for the Innovation and Improvement of Teaching (PAPIME for its acronym in Spanish), which indicated additional elements to be considered, which was fulfilled in the drafting determining the final structure of the document.

Box 3

Table 1

Structure of the practice

1.	Portada
2.	Conocimientos previos
3.	Objetivos
4.	Fundamentos teóricos
5.	Cuestionario Previo
6.	Material y equipo
7.	Desarrollo
8.	Conclusiones

Source: Own Elaboration

METHODOLOGY

For the electromagnetic pulse part, the Van de Graff and a basic calculator were added, the students were asked to place a certain level of band velocity to generate sufficient charge and then at different distances to measure the impact of the electric field on the electronic device. As can be seen in Figure 4.

The final work consisted of 15 pages, including the cover page. Its name was: Practice 3. Passive circuits and electromagnetic pulse. It was presented to a pilot group of teachers for their observations and later to a pilot group of students to evaluate its impact.

Box 5

LABORATORIO DE TEORÍA ELECTROMAGNÉTICA

DESARROLLO:

I. PULSO ELECTROMAGNÉTICO

a) Conecte el Generador Van De Graaff, asegurándose primero que se encuentre descargado y con su valor mínimo (la perilla debe estar toda a la izquierda), coloque la esfera de descarga aproximadamente a un metro de separación.

b) Encienda su calculadora, coloque en la pantalla de la misma un valor cualquiera diferente de cero y acérquela al generador Van De Graff sin tocarlo, como se muestra en la figura 3.2

Figura 3.2. Generador Van de Graff y calculadora
Fuente: Claustro de Teoría Electromagnética

1. ¿Qué sucede en la calculadora? Explique.

Trabajo realizado con el apoyo del Programa UNAM-DGAPA-PAPIME PE103424

PRÁCTICA 3.- CIRCUITOS PASIVOS Y PULSO ELECTROMAGNÉTICO SEMESTRE 2024-2
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Figure 4

Electromagnetic Pulse Experiment

Source: Own Elaboration

RESULTS

During the development of the study, a significant understanding on the part of the students concerning the concept of electromagnetic pulse was observed. This finding suggests a deep understanding on the part of the students about this phenomenon, which indicates remarkable progress in their learning.

In addition, the teachers participating in the study were able to develop and strengthen their didactic skills by incorporating new tools and strategies to improve the teaching of the Electromagnetic Theory course. This pedagogical adaptation can be considered an important achievement for the teaching team, as it allows them to offer a more enriching and effective educational experience to their students.

Regarding the students' understanding of the operation of a voltage booster circuit, the results showed a satisfactory level of comprehension. This ability acquired by the students suggests an improvement in their knowledge and skills in the field of electronics and telecommunications engineering.

CONCLUSIONS

The results obtained in this study provide a clear view of the positive impact that the lab session had on students' learning and the professional development of teachers. From these findings, several important conclusions can be drawn:

Effectiveness of the pedagogical approach: The lab session was effective in enhancing students' understanding of fundamental electromagnetics and electrical circuit concepts. The integration of theory with hands-on practice enabled a deeper and more meaningful comprehension of the studied phenomena.

Teacher development: The results indicate that the participating teachers were able to strengthen their didactic skills and adapt their pedagogical approach to offer a more enriching learning experience. This aspect is crucial to improve the quality of teaching and learning in the classroom

CONCLUSIONS

Practical application of knowledge: Practice allowed students not only to understand theoretical concepts but also to apply them in practical situations. This is essential for developing practical skills and fostering critical and creative thinking in students.

Fulfillment of objectives: It was confirmed that the objectives set for the practicum were satisfactorily achieved. Students were able to observe and apply electromagnetic phenomena, while teachers were able to strengthen their course with new tools and approaches.

In summary, the results highlight the importance of educational practices based on experience and active interaction with content, both for students' learning and for teachers' professional development. These findings can serve as a basis for future research and the continuous improvement of academic programs and teaching in general.

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