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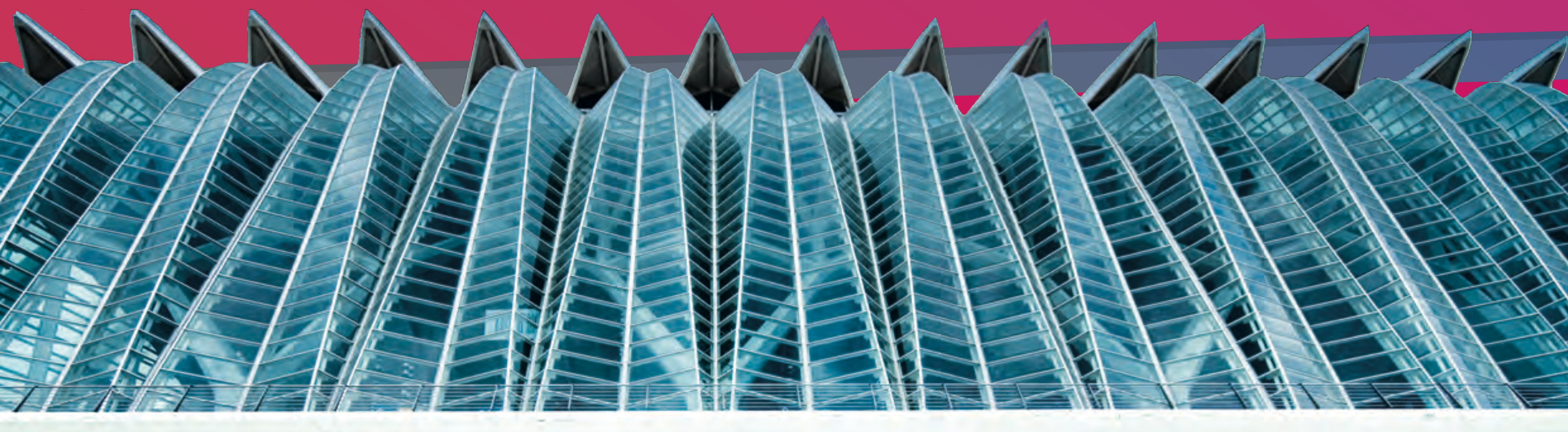

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A CONCEPTUAL MAP ABOUT ALTERNATING CURRENT CIRCUITS

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Abstract

Teachers are deeply concerned on how to be more effective in our task of teaching. We must organize the contents of our specific area providing them with a logical configuration, for which we must know the mental structure of the students that we have in the classroom. We must shape this mental structure, in a progressive manner, so that they can assimilate the contents that we are trying to transfer, to make the learning as meaningful as possible. In the generative learning model, the links before the stimulus delivered by the teacher and the information stored in the mind of the learner requires an important effort by the student, who should build new conceptual meanings. That effort, which is extremely necessary for a good learning, sometimes is the missing ingredient so that the teaching-learning process can be properly assimilated. In electrical circuits, which we know are perfectly controlled and described by Ohm's law and Kirchhoff's two rules, there are two concepts that correspond to the following physical quantities: voltage and electrical resistance. These two concepts are integrated and linked when the concept of current is presented. This concept is not subordinated to the previous ones; it has the same degree of inclusiveness and gives rise to substantial relations between the three concepts, materializing it into a law: The Ohm, which allows us to relate and to calculate any of the three physical magnitudes, two of them known. The alternate current, in which both the voltage and the current are reversed dozens of times per second, plays an important role in many aspects of our modern life, because it is universally used. Its main feature is that its maximum voltage is easily modifiable through the use of transformers, which greatly facilitates its transfer with very few losses. In this paper, we present a conceptual map so that it is used as a new tool to analyse in a logical manner the underlying structure in the alternate current circuits, with the objective of providing the students from Sciences and Engineering majors with another option to try, amongst all, to achieve a significant learning of this important part of physics.

Keywords: Active Learning, University Teaching, Conceptual Map, Electric Circuits.

1 SIGNIFICANT LEARNING

All teachers at any educational level are keen in improving their teaching practice and transforming the classroom into a space of construction and creation of knowledge to be more effective in their teaching task. To do this, we must know what we are teaching and how students learn [1].

If a constructivist approach is adopted [2-4] the contents of our specific subject should be organized providing them with a logical configuration, for which it is necessary to know the mental structure of the students who are in the classroom. Which means that they must acquire the skills that allow them to logically relate the concepts that have been designed or selected by the teacher. Why is this done? The answer is clear: to make the meaningful learning, as meaningful as possible.

The term "significant learning" [5-6] is used as opposition to merely repetitive-rote learning in which it doesn't relate or it is made arbitrarily, what it is to be learned with the knowledge that the student possesses. This nonexistent or arbitrary relation allows knowledge that is acquired in a nonmechanical form endure over time [3]. The previous knowledge play an important role to make learning

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meaningful. Ausubel summarizes this in the epigraph of his work as follows: "The most important factor influencing learning is what the learner already knows. Ascertain this and teach accordingly "[3].

Ausubel also notes that meaningful learning occurs when new content is related with the previous knowledge that the students have and when this knowledge acquires a new meaning in the student's learning. One can say that meaningful learning has two crucial features:

- When the student has a favourable attitude to learn. Which means he is motivated to do it and by this he will provide his own meaning to the content that is transmitted and he assimilates it.
- When knowledge is potentially significant from both logical organization of the content of the discipline, and from the student's own psychological structure. From the logical organization of the discipline, it is understood that the content is consistent, clear and organized. From the psychological structure of the discipline, it means that the student possesses the various previous knowledge necessary to anchor the new learning into the existing knowledge in their mind.

For Ausubel to learn it isn´t to copy or to reproduce a reality, the concepts overturned by the teacher, is something more elaborated: "To learn is to build". The learning exists when a student is able to develop a personal representation (specific for every student) of the learning content. This approach involves the development of the content in order to understand and this is made possible from the experiences, interests and previous knowledge. When this process occurs, it is said that learning is significant [3]. This learning is not always easy; but it is real and effective and it persists over time.

For the task to be effective we need to have a summary, this is an initial epitome [1] in which we are provided of an overview of those contents that are going to work later in detail. This epitome must contain the most fundamental ideas and have a hierarchical summary to be effective structure. One can say that the epitome summarizes the essential content (and therefore minimum) that the student must acquire in connection with a subject or a teaching unit of our curriculum development

2 LEARNINGS

This learning process can take several approaches:

- Subordinate learning.
- Superordinate learning.
- Coordinated learning.
- Generative learning.

These new concepts must be engaged logically if it is desired for learning to be truly significant. In superordinated learning, it is the student the one who builds new relationships between concepts in an inclusive manner, this is through a greater participation in the learning process, taking into account the characteristics, interests, abilities and different needs of each of the students who are involved; trying to reduce exclusion in education. Inclusion and exclusion are completely opposite concepts and we have to be aware of their level of involvement in the classrooms. In inclusive teaching, the educational systems must be designed taking into account the great diversity of those needs and the great diversity of students with different preconceptions.

Coordinated learning is the most widely used when it is involved in the teaching of physics or any other science. This type of learning coexist to old concepts with new concepts; not being the new subordinates to the former ones. New mental relations appear between them and produce the synthesis and generalization of said concepts, and this creates a new conceptual organization of higher rank than the one previously existing to learning.

In electrical circuits, there are two concepts that correspond to the following physical quantities: the voltage (also known as voltage or potential difference) and the electrical resistance. These two concepts are integrated and related when it introduces the concept of electric current intensity (or simply electric current). This concept is not subordinated to the previous ones; it has the same degree of inclusiveness and gives rise to substantial relations between the three concepts, to state exactly one law: the Ohm, which allows us to link and calculate any of the three physical magnitudes, two of them known [7]. Thus the electrical circuits are perfectly described and controlled by a general law; the Ohm's law, and by the two rules of Kirchhoff, which are a consequence of the conservation of energy and the conservation of electric charge [8].

In the learning generative [9] [10] model the links before the stimulus delivered by the teacher and the information stored in the mind of the learner requires an important effort by the latter, of the student, who should build new conceptual meanings. That effort, which is very necessary for a good learning, sometimes is the missing ingredient so that teaching practice can be properly assimilated.

Obviously, the four forms of learning that have been commented on must merge to the teacher suitability in an alternative way if it is wished to increase the conceptual learning of students. Students in their learning process start from the more general to the particular and sometimes follow the path in the opposite direction. This is a path in one way direction but of two complementary directions. It is necessary for teachers to learn to improve their performance in the classroom and help students achieve learning in a really meaningful way.

3 CONCEPTUAL MAPS

Conceptual maps are a tool that allows us to graphically visualize concepts and the relationships between them [11-15]. These maps enable us to organize knowledge and identify relations and existing implications between the concepts involved using connecting phrases. They have been used in educational research with children, to understand how to acquire knowledge, and graduate students to see how that knowledge had been consolidated and structured in minds with an elaborate and complete training. They have become an instrument widely used in practically all fields of knowledge if we are to achieve meaningful learning, integrating new concepts in our cognitive structure, which is achieved by linking the new knowledge with those concepts that we have previously understood. Because of all the reasons that have been exposed above, the binomial conceptual map and meaningful learning form a good dance partner.

The most general and inclusive concept, should occupy the top of the map, which must have a structure highly hierarchized, and then, as you go down the level, the less general concepts appear. The links between the concepts have a great utility; they allow showing mental relations between them in such a way that may facilitate creative thinking and strengthen new concepts anchored to the previously existing ones. This consolidation is produced by assimilation within an educational process suggested and assisted by the teacher. Assimilation does not permit to explain how people add new concepts to their pre-existing mental schemes, by modifying and improving their individual cognitive structure. Proceeding from the more general concept, the more inclusive, to the more specific concept is achieved to promote the aim that all teacher longs for: meaningful learning in the most efficient manner.

4 ALTERNATING CURRENT CIRCUITS

The conceptual maps are a tool that allows us to graphically visualize concepts and relationships Conceptual maps have been widely used in Physics [16-22] because they greatly facilitate the synthesis of almost any topic. In this work, they will be applied to electrical Alternating current (AC) power circuits usually appearing in Physics, Chemistry and Engineering degrees. Alternating current circuits consist of various elements: sources of variable voltage, which we will assume have a sinusoidal behavior, resistors, capacitors and inductors. Through all of them, the same current passes if they are connected in series or different currents if they are mounted in parallel. There is a difference of potential between its ends that has a different value, in the most general case [23].

In order to correctly describe a circuit of alternating current we must be able to solve a differential equation of second order which provides electrical power, if it is tought of a series circuit, which is the most intuitive way to deal with it, without almost any loss of generality. Being a second-order differential equation, there will be two linearly independent solutions. One of them is given by a transient current, that quickly fades within time. The other solution is sinusoidal but stationary, while we have the closed switch or the connected source. There are two parameters that must be determined, an phase angle (between the electromotive force of the generator and the electric current, and the value of the maximum intensity). This determination is controlled by the values of the elements which are present in the circuit and the angular frequency of the generator.

It is sensed that new concepts appear which must be anchored to the existing ones. Anchor and contextualizing; in other words, establishing relationships with other concepts which have been previously learned. Next, a conceptual map is presented which will provide a new tool to analyze in a logical way the underlying structure in alternating current circuits. What has just been commented on the differential equation and its two solutions is hierarchically outlined on the conceptual map that appears in Fig. 1.

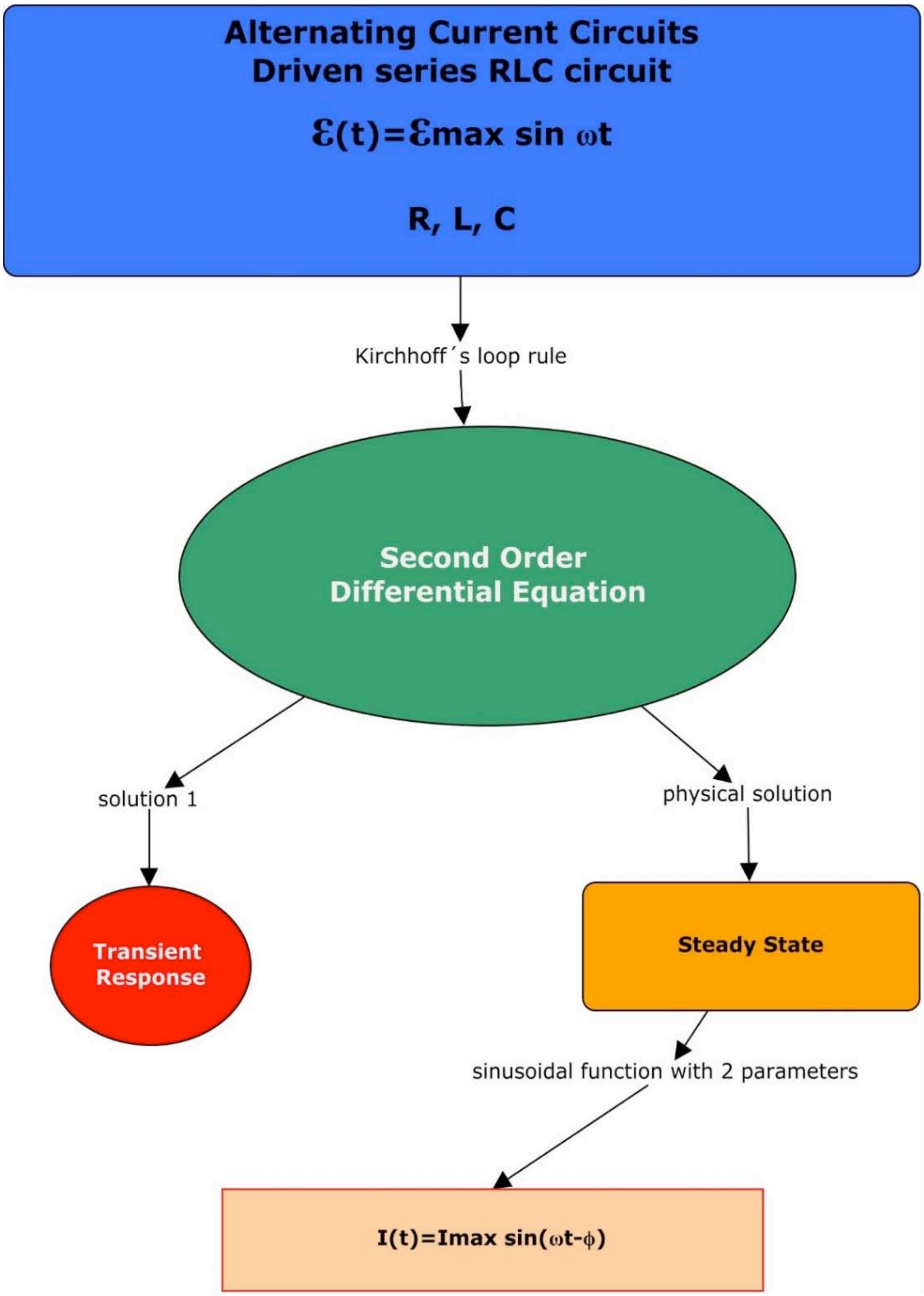

Figure 1. Conceptual map of the differential equation of second order which describes an RCL circuit.

At the end of the 19th century and the beginning of the 20th century, in 1925, Charles Proteus Steinmetz developed the theory of the phasors (all sinusoidal magnitude can be represented by a phasor; i.e., a rotating vector in an anti-clockwise direction; normally, and to simplify, are represented at an initial instant) and the complex numbers, applying both concepts of alternating current circuits. All the concepts that are known for the continuous currect can be applied to the ones of alternating current only if working with complex numbers and then calculating their modules, taking care of having worked with effective (RMS, root mean square) values. This is can be visualized and hierarchized on the conceptual map that appears in Fig. 2.

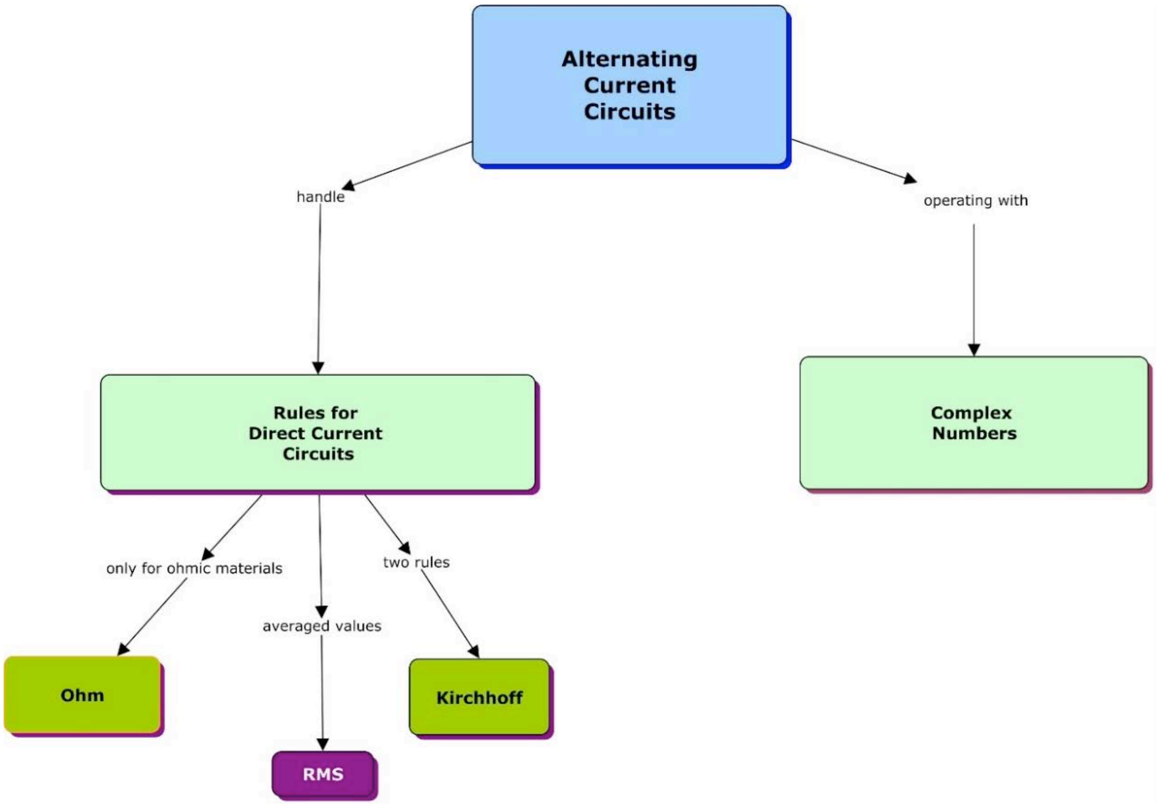

Figure 2. Conceptual map in which it is manifested that the alternate current circuits are equivalent to continuous current, with the condition that it is worked with complex numbers.

It is introduced a new concept: the impedance, which is a generalization of the electrical resistance, is measured in ohms. The impedance depends on the considered circuit; i.e. it is a function of the resistance, the capacity of the capacitor, the inductance of the inductor and the frequency of the alternate generator. Impedance is a complex number that has a module and argument (angle that forms with the axis origin of angles). Despite being a complex number it is not a phasor, it is not a rotating vector, because it is not a sine magnitude. All the concepts of the resolution of the alternating current circuits with complex numbers are described on the conceptual map that appears in Fig. 3.

In this work, it is intended to show the great didactic potency that conceptual maps have to stimulate the underlying ideas in electrical circuits. They allow to develop and communicate ideas and complex concepts in a very flexible and structured manner. They also promote collaborative work amongst students to formalize operating and/or conceptual links between the different magnitudes involved in alternating current circuits. By the use of phasors (at the initial moment) it is established by a biunivocal correspondence between the plane of the complex numbers and the bidimensional plane.

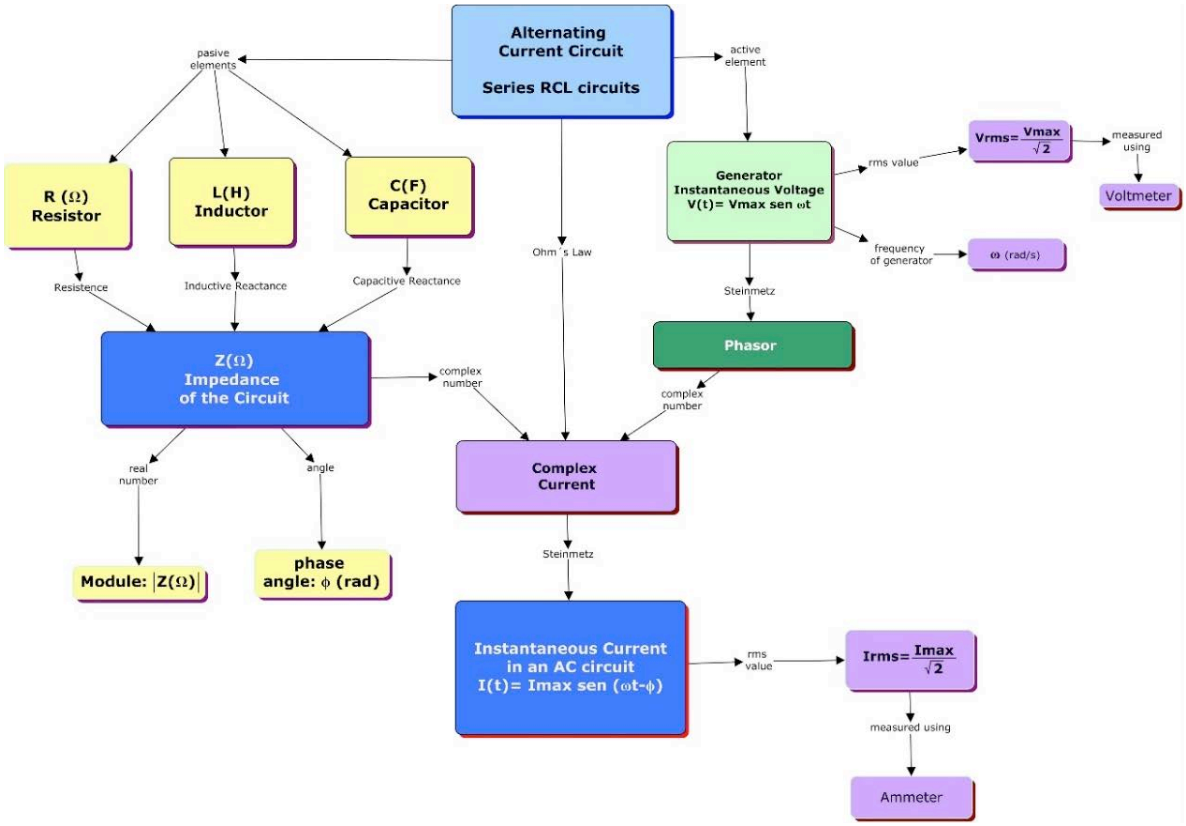

Figure 3. Conceptual map in which we hierarchized the concepts involved in alternate current circuits (RCL series circuits) solved by using complex numbers.

Conceptual maps are tools that allow to visualize, in a very effective way, knowledge about alternating current circuits. They generate a significant learning reinforced by visual memory, which anchors more the ideas in the student’s brains.

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