JAVA APPLETS FOR AN OPEN AND DISTRIBUTED COURSEWARE IN POWER ELECTRONICS

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***Abstract* – This paper introduces Java applet programs for a WWW (world wide web)-HTML (hypertext markup language)-based multimedia course in Power Electronics. The applet programs presented in this paper were developed with the purpose of providing an interactive simulation platform and steady-state analysis of idealized controlled single-phase, and three-phase rectifiers. In addition, this paper discusses the development and utilization of Java applet programs to solve some design-oriented equations for controlled rectifier applications. The major goal of these proposed Java applets was to provide more facilities for the students increase their pace in Power Electronics course, emphasizing waveforms analysis, and providing conditions for an on-line comparative analysis among different hands-on laboratory experiences, via a normal Internet TCP/IP connection. Therefore, using the proposed Java applets, which were embedded in a WWW-HTML-based course in Power Electronics, was observed an important improvement of the apprenticeship for the content of this course. Therefore, together with others applet programs developed to uncontrolled rectifiers, the course structure becomes fluid, allowing a true on-line course over the WWW, motivating students to learn its content, and apply it in some applications-oriented projects, and their home-works.**

I. INTRODUCTION

One of the most important basic structure of a country for support their social development is the education. In the last decades, researchers have been trying the refinement of concepts, techniques (approaches) and the development of new tools to aid the improvement of the educational process in several levels [1].

The traditional form of teaching presented in the classrooms, it can be complemented with the employment of interactive help systems based on computers, involving so much the teaching as the training [2].

These systems provide an learning environment with high quality, helping to improve the teacher's productivity and, consequently, the quality of the student's learning [3].

The computers evolution, together with the distribution every time larger of Internet, it turned easy the information access, of almost everywhere, the any hour and respecting the user's rhythm. The coming of the hypermedia technologies accompanied by hypertexts, interactive simulations, videos and sounds, originated a new and effective mechanism of information delivery, with power for creating virtual laboratories and virtual classrooms [4].

On the other hand, still (2001), the teaching of circuits in Power Electronics usually uses a methodology based on textbooks, where concepts are presented in a static way. Besides, it should be observed that in spite of the available technologies, unfortunately, the teaching still stays in a primitive state of development and the teachers today they are not better than those of 20 years ago, because they continue teaching in the same way how they were taught. Although some of these traditional methods are effective, the use of computer simulations and graphic tools guided to object, to illustrate the concepts in a more dynamic and interactive way, they can provide to the students a more pleasant, and elegant way of visualization of the most important concepts, usually difficult to reproduce in the molds of the traditional class rooms [1, 2, 4-8].

In this context, one of the most essential factors for productivity in education is the student's desire to learn. Thus, this desire can be enhanced by presenting the course material in an attractive manner that motivates, and encourages students to learn more, and with more quality [9].

On these last years, several researchers are looking for the development of tools that aid the teaching, and that can be executed in a distributed environment, which are reused and provide a high interaction level. In other words, a tool that allows a effective teaching on-line through WWW. In this context, Java is one of the main used platforms, for their intrinsic advantages [10-15].

In this context, this paper introduces several Java applets with regard to controlled rectifiers, increasing the resources available in the WWW-HTML-based course in Power Electronics, which can be accessed free of charge at http://www.dee.feis.unesp.br/gradua/elepot/ajuda/applets.html [16].

II. SYSTEMS OF LEARNING AID

Currently, there are two defined categories of employment of technologies based on computers linked with teaching, the computer aided learning (CAL) and the computer based training (CBT).

The computer-aided learning is based on the use of computers as tools to promote the learning. Operating with an agent, which inserted in a teaching environment, supplies a new mechanism of delivery of information.

On the other hand, the training based on computers focalizes the use of computers as facilitators of specific learning tasks in a certain domain of the knowledge, almost always using computer simulations in their apprenticeships.

The systems of CAL and CBT have been passing for many development apprenticeships since your beginning in the decade of 1950. The evolution apprenticeships were usually unchained by a group of revisions for improvements, usually after failure of a methodology, or for appearance of new hardware technologies and software providing new environment for research. With passing of years, classification work and identification of the previous mistakes, it led to an improvement in sketch of the initial projects. Remainder in all the evolutions of approaches(methodologies) was the main conclusion, that is the verification that the use of computers in the education improves the productivity.

The main approaches have been trying to replace the traditional didactic material or some the teacher's functions, as: drilling, presentation, correcting and even teaching.

One of the first consents was recognition that educating is so much complex task that computers could only provide help in the teaching process, instead of "replacement" the teachers completely in all senses. Therefore, computers became seen as tools, that offered resources of complementary audiovisual structures [11].

The students can learn better and faster when they are stimulated by a high interactive level. So, they could follow a personal way of learning. In a particular way, they can personalize their participation to the didactic software, establishing the amount of spent time in each topic and individually their own learning steps.

Some researchers have concentrate efforts on the development of computer-assisted learning systems, wich are designed to provide an individual learning environment, where the focus of the work concentrates on interactions among the group composed by students and computer. In this context, the programming language Java, in the form of Java applets, provides an open , distributed, and expandable platform for a courseware system [10, 12].

The platform Java was introduced by Sun Microsystems Inc. and provides an information technology (IT) architecture for different platforms integration. Java applets provide platform independence, being executed in any web navigator, as well as allowing the integration with Internet [13].

On the other hand, the main attributes of Java (security model, web access, neutral architecture, fast development, portability, usability and robustness) make it a powerful platform for the industrial control, as well as, for the development of control and courseware systems [14, 15].

The main advantages of the education system (courseware) based on WWW are the independence of time and space, allowing a great number of simultaneous attendances, besides possessing a simple and family interface, due to their methodology to be based on the use of a web browser.

III. Development and Organization of Java Applets

The proposed Java applets were developed to assist Power Electronics education at the undergraduate level in engineering course.

The main goal of the proposed Java applets, used as an instructional tool, is to produce an interactive visualization of idealized steady-state circuit simulations in Power Electronics, which are embedded in a WWW-HTML-based course. Emphasis is on interactive visualization of main waveforms, average and rms values of important circuit variables, allowing hands-on changes in all circuit parameters.

Therefore, simulation processes and results in steady-state may be visually presented to the learner in real time, illustrating important concepts that are difficult to realize at the time in a traditional classes.

It should be noticed that circuit simulation has become an important tool of several engineering courses, and these proposed Java applets are a contribution for an idealized, and introductory analysis of some Power Electronics circuits, allowing by themselves an on-line, and interactive platform for circuit simulation over WWW.

Therefore, other important tools, as Pspice® and Saber®, for example, are strongly recommended for complementary, and advanced analysis. So, for high quality education in Power Electronics, these additional tools must be adopted in spite of introduction of proposed educational Java applets.

In this work, basically two categories of Java applets were developed. The first category is regarding the construction of abaci, responsible for the resolution of mathematical problems for the determination of the angle of extinction of the current in rectifier structures (β), average and rms values of normalized currents for certain structures, abacus of Puschlowski, and determination of the conduction angle and average value of voltage over the load, considering the effects of the commutation inductances. The second category is formed by the simulation applications for rectifier structures to diodes and to thyristors, in single-phase and three-phase configurations.

Currently the available applets for the simulations and abaci include:

A. Uncontrolled Rectifiers (Idealized Circuits)

- Single-Phase : half-wave diode rectifier, half-wave diode rectifier with free-welling diode, full-wave center-tapped diode rectifier, full-wave full-bridge diode rectifier;
- Three-phase : three-pulse diode rectifier, six-pulse full-bridge diode rectifier.

B. Controlled Rectifiers (Idealized Circuits)

- Single-Phase : half-wave thyristor rectifier, full-wave center-tapped thyristor rectifier, full-wave full-bridge thyristor rectifier;
- Three-phase : three-pulse thyristor rectifier, six-pulse full-bridge thyristor rectifier.

It should be noticed that except the applet developed for single-phase half-wave diode rectifier with free-wellind diode, all others interactive simulation applets present the possibility of choice of load type by the user.

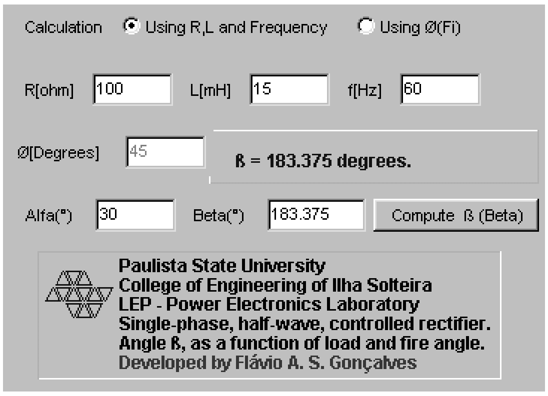


Fig. 1 - Single-phase, half-wave, controlled rectifier, Calculus Abacus of angle β.

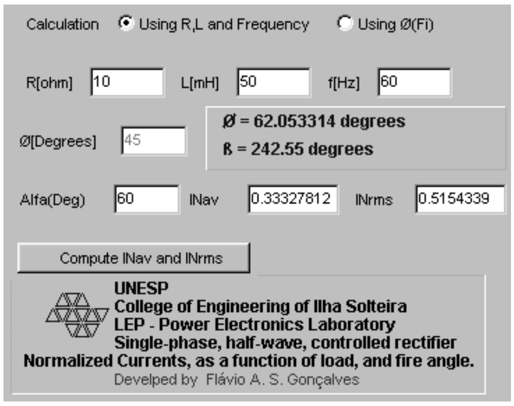


Fig. 2 - Single-phase, half-wave, controlled rectifier, Calculus Abacus of normalized currents across the load.

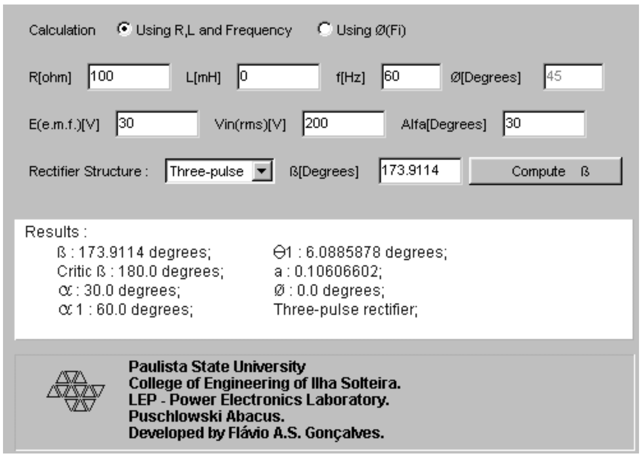


Fig. 3 - Puschlowski abacus: Three-pulse controlled rectifier example.

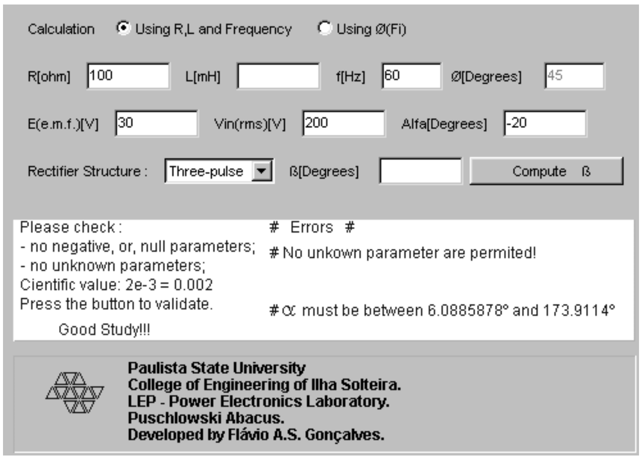


Fig. 4 - Puschlowski abacus: Warning - data errors.

It could be: purely resistive (R) or with resistive-inductive characteristic (R-L).

C. Abaci (Idealized Circuits)

- Compute of the Extinction Angle of the Current (β) for single-phase, half-wave rectifiers, controlled and uncontrolled (Loads: R and R-L);
- Compute of the Normalized Currents across the Load for single-phase, half-wave rectifiers, controlled and uncontrolled (Loads: R and R-L);
- Puschlowski - Compute of the Extinction Angle of the Current (β), for single-phase and three-phase controlled retifiers, loads of the type R-L-E;
- Compute of the average value of voltage over the load, and the commutation angle, considering the effects of the commutation inductances, in single-phase and three-phase rectifiers, in controlled and uncontrolled configurations.

The next step of this work intends to include non-idealized circuit parameters in the interactive simulation applets, as example: analysis of commutation inductances and influence of circuit parameters during the commutations.

IV. Java Applets Developed

It should be informed that the applets group regarding the uncontrolled rectifier structures were presented in [16].

Therefore, in the next figures one can verify the developed Java applets for controlled rectifier structures.

Fig. 1 shows Java applet for calculation of angle β, where the current through the thyristors becomes zero, and Fig. 2 shows the Java applet for calculation of normalized average and rms currents, for single-phase, half-wave, controlled rectifiers. It should be noticed that these applets are very important for some applications-oriented projects.

One can verify in Fig. 3 the proposed Java applet for calculation of angle β, for 1, 2, 3, and 6 pulses uncontrolled, and controlled rectifiers, which is well known as Puschlowski abacus, including R, R-L, and R-L-E loads. This applet is very important for analysis of circuit rectifiers, as well as for some applications-oriented projects, and student's home-works.

Figure 4 shows the Java applet with warnings for errors in input data, applied at the Puschlowski abacus. It should be noticed that in all proposed Java applets, some warnings were introduced to facilitate its use by the students.

The interactive Java applet for simulation of single-phase, half-wave, thyristor (controlled) rectifier is shown in Figs. 5 and 6, where the one can observe the main waveforms for resistive-inductive type load, furthermore several values of the main variables of the circuit.

One can verify that the main circuit variables are calculated on-line, and all circuit parameters can be hands-on specified by the learner.

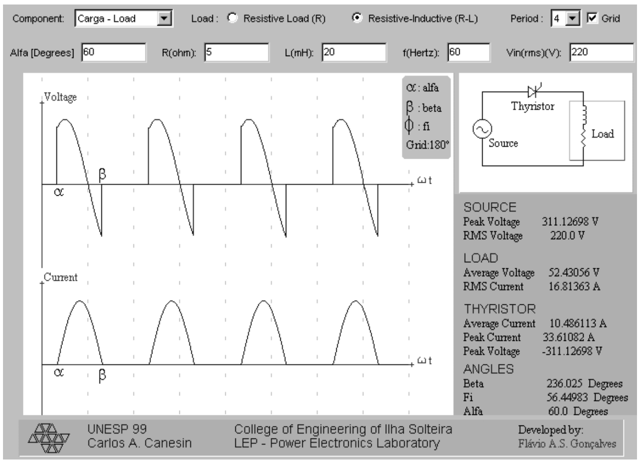


Fig. 5 - Single-phase, half-wave, controlled rectifier, circuit simulation: load – main waveforms.

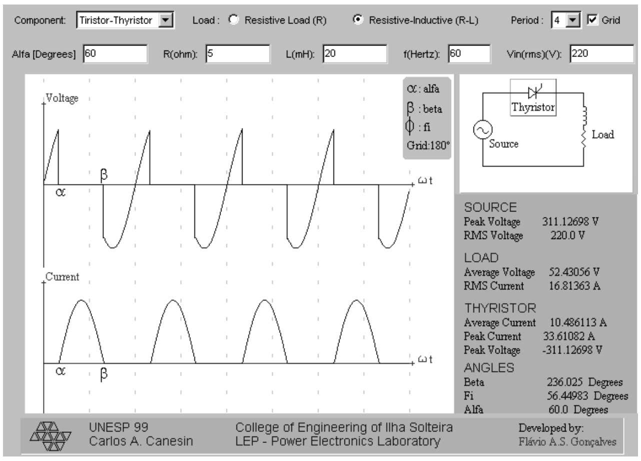
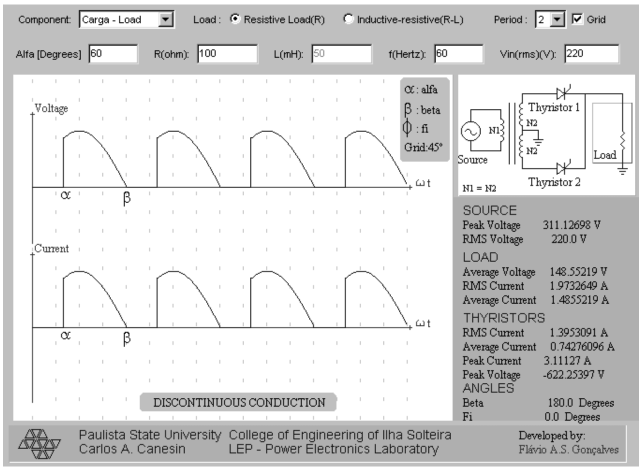


Fig. 6 - Single-phase, half-wave, controlled rectifier, circuit simulation: Thyristor – main waveforms.



(a) Circuit simulation- resistive load : Load – main waveforms.

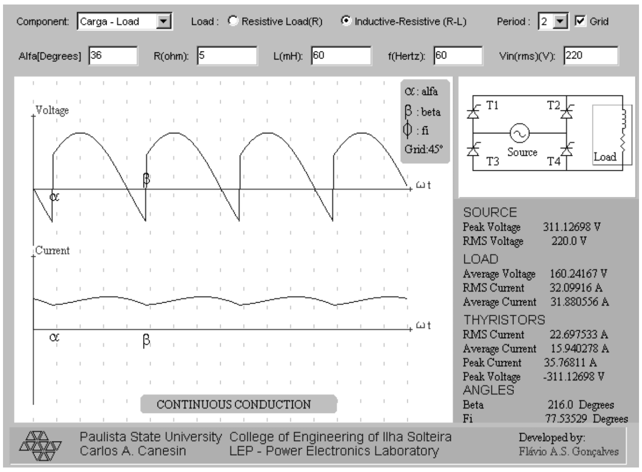
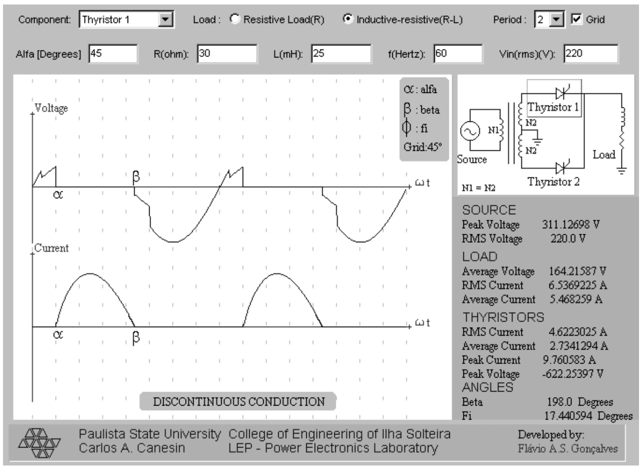


Fig. 8 - Single-phase, full-wave, full-bridge controlled rectifier, circuit simulation: main load waveforms.



(b) Circuit simulation – Resistive-inductive load: Thyristor 1–main waveforms.

Fig. 7 - Single-phase, full-wave, center-tapped controlled rectifier.

In addition, it should be noticed that all developed Java applets presents an specific area containing the mathematical results obtained in the steady-state simulation, in function of the user's chosen parameters.

Using these applets, one can verify the main waveforms, and values of some circuit variables. Therefore, allowing interactive changes in all circuit parameters, these applets become very important for designs, and home-works proposed to the students.

Also, it should be informed that in all developed JAVA applets were included warnings to wrong hands-on parameters specified by the learner, for example: such inconsistent values as negative resistences, etc...

The interactive JAVA applets for simulation of single-phase, full-wave, center-taped and full-bridge thyristor (controlled) rectifiers are shown in Figs. 7 until 9. Furthermore, one can verify in these applets the conduction current mode across the load: continuous or discontinuous.

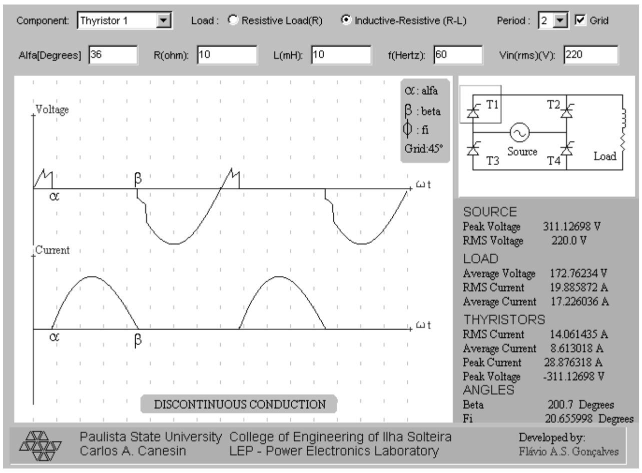


Fig. 9 - Single-phase, full-wave, full-bridge controlled rectifier, circuit simulation: thyristor 1 - main waveforms.

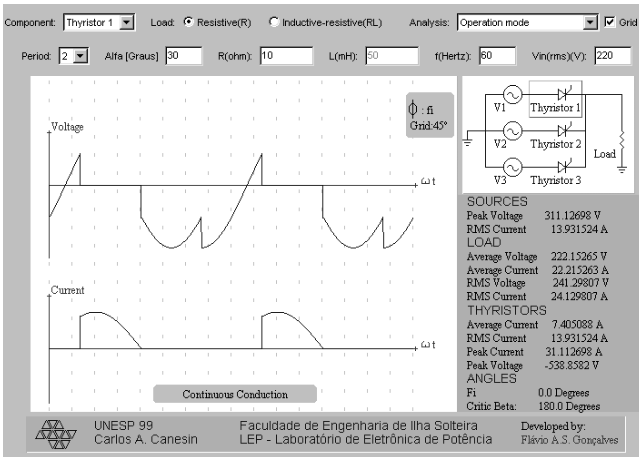


Fig. 10 - Three-phase, three-pulse, controlled rectifier, circuit simulation: thyristor 1 - main waveforms and analysis of load current conduction mode.

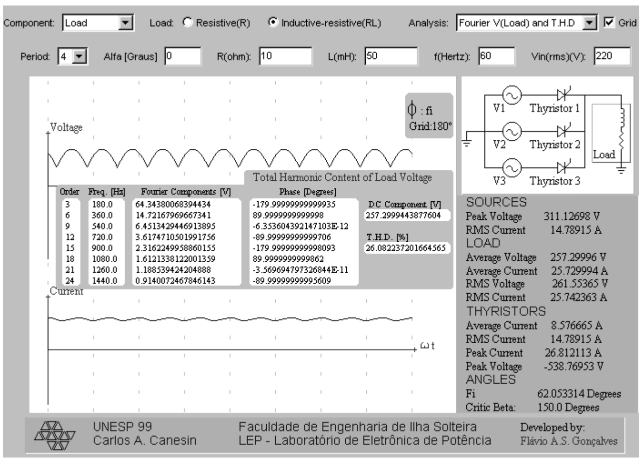


Fig. 11 - Three-phase, three-pulse, controlled rectifier, circuit simulation: main load waveforms and harmonic analysis of load voltage.

Additional examples of interactive JAVA applets developed for simulation of three-phase, three-pulse and six-pulse full-bridge controlled rectifiers are shown in Figs. 10 until 13.

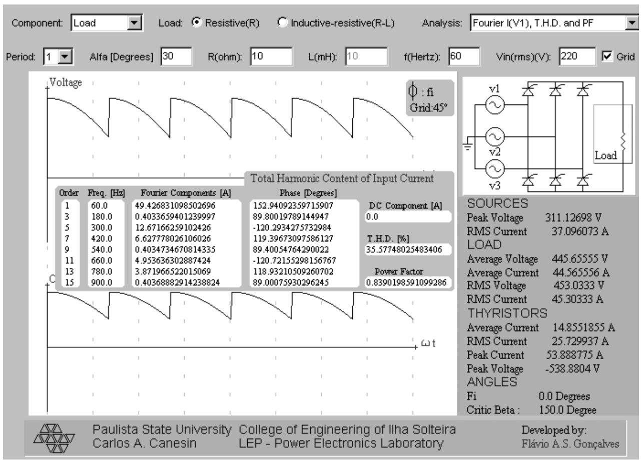
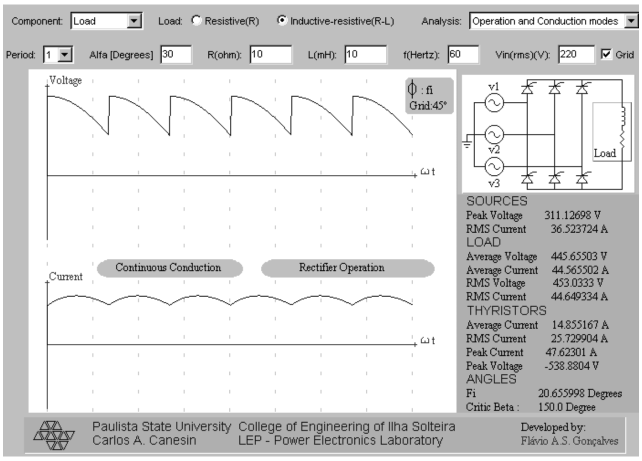
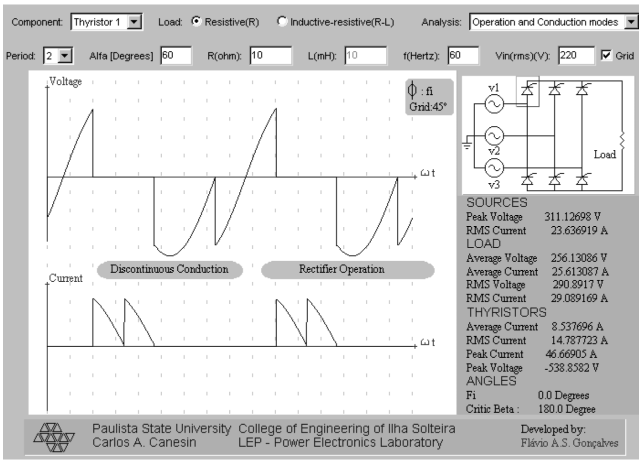


Fig. 12 - Three-phase, six-pulse, full-bridge controlled rectifier: main load waveforms, and harmonic analysis of input current, computing T.H.D. and Power Factor values.



(a) Circuit simulation: Load – main waveforms.



(b) Circuit simulation: Thyristor 1 – main waveforms.

Fig. 13 - Three-phase, six-pulse, full-bridge controlled rectifier, analysis of load current conduction and operation modes.

It should be noticed that all the interactive applets developed for three-phase controlled rectifiers present the option of accomplishment of the Fourier analysis, structure operation mode and current conduction mode across the load, whichever the component chosen by the user.

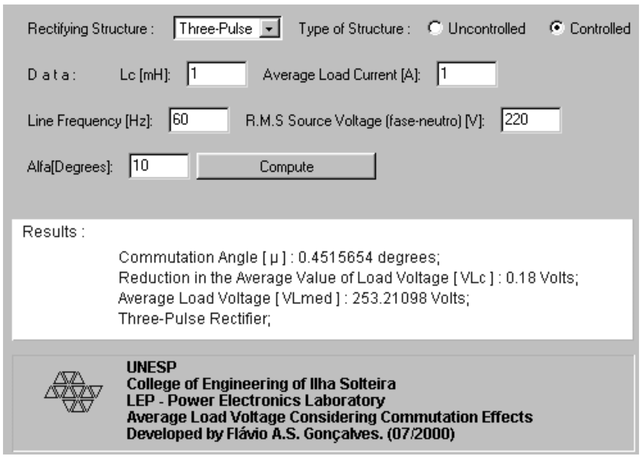


Fig. 14 – Calculus Abacus of average value of load voltage considering the effects in the commutation.

It is observed although, the analysis of available Fourier include the input current in one of the voltage sources, current and voltage across the load. Moreover, the computing of power factor (P.F.) and total harmonic distortion (T.H.D.) at the input current can be performed through these applets.

Figure 11 shows interactive simulation applet regarding the three-phase center-tapped controlled rectifier presenting the referring results to the Fourier Analysis of voltage waveform over the load, in the table format, containing the order of the components, their amplitudes in peak values and their phases. The referring results to the Fourier Analysis of the input current of voltage source, the computing of total harmonic distortion (T.H.D.) and of the power factor, obtained in the applet regarding the three-phase, six-pulse controlled rectifier in full-bridge are presented in the Fig. 12.

As a first stage of future works was implemented an applet, shown in Fig. 14, which computes the decrease of average value of load voltage and commutation angle, considering the effects in the commutation due to series inductances (commutation inductances), and other parameters of the circuit, in controlled and uncontrolled rectifier structures.

V. CONCLUSIONS

This paper has presented JAVA applets for a WWW-HTML-based course in Power Electronics. It should be noticed that these tools were not developed to replace the educator, but to improve the quality of apprenticeship for the learner.

The use of information technologies bring us new perspectives for education, not only on the technologies themselves, but also on the philosophy, and strategies of instruction and learning, allowing significant changes on many aspects of higher education.

In this context, it was observed an important increase in the student's desire to learn the content of the Power Electronics course, when the proposed JAVA tools were included together with the traditional classes, resulting in an important improvement of apprenticeship, due to the increase of student's motivation, and the increase in the student's abilities to comprehend the behavior of several rectifier circuits.

In addition, using these tools during the execution of traditional hands-on laboratory experiences, via a normal Internet connection, were possible an on-line comparative analysis among these lab-experiences, and the theoretical concepts developed in the classes, allowing an interactive, and attractive learning system.

Therefore, due to a significant improvement in the productivity to instruct, and in the efficiency to learn, the course structure becomes more fluid, and effective. In these contexts, we expect that more interactive learning systems will be developed, creating new environments for instruction and learning, to benefit, and to increase the quality of the education in different areas of the engineering.

VI. ACKNOWLEDGMENT

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