Computer-oriented course "Power electronics" for distant education

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Abstract

This training course is developed for preparing the specialists in the field of power electronics of different levels (**four**) [1].It is created on the base of computer programs package by method of "**4^3 in one**" . It comprises four levels of educational components: the lecture material itself on the **four** levels mathematical modeling of different devices of power electronics (laboratory works), course designing, control of the acquired knowledge on the **four** levels too. Given course is used for teaching the specialists by method of distant education.

The electronic power converters get all broader spreading, since this provides its best or one possible use. In developed countries already more than 40% worked out electric powers is converted before using. This circumstance requires presence of large number of specialists - energy, electrical, radio engineers — with different level of preparation in the field of power electronics. For the operative decision of problems of preparing the specialists with levels of knowledge, having most demand, there were are conditionally chosen following **four** typical needs for levels of knowledge on power electronics:

- Level of engineer, dealing with usage of devices of power electronics;
- Level of engineer, dealing with designing of their own systems (electric, radio, electronic), where are used ready blocks of devices of power electronics;
- Level of engineer, specialist on power electronics, concerning with designing the devices of power electronics;
- Level of engineer, concerning with scientific study and development of new types of devices of power electronics.

Presently in technical universities of Russia for first two levels of preparation in the field of power electronics the general course "Industrial electronics" is delivered for speciality of power engineering, electromechanical engineering, radio engineering, electronics engineering. For the third and fourth levels of training the special course "Fundamentals of power electronics" is delivered for the speciality of "Power electronics". In NSTU both these courses of lectures are conducted by the department of industrial electronics. It was offered integrated approach for operative provision by instruction literature on these courses. This approach utilizes four differentiated level of teaching material accessibility and got the conditional name "The four in one".

The usage of personal computers and electronic versions of instruction material allows not only simply to structure (the format, color, sound) the above mentioned four levels of depth of interpretation of lecture material, but also covers all the four components of instruction process (again "The four in one") in computer:

- Lecture material;
- Laboratory works;
- Course designing;
- Checking the quality of education.

The usage of the e-mail for consultation with the teacher potentially allows to study the subject at the place of residence or work of student, without wasting the time and money for arrival to the university. The methodical unity of interpretation of material is reached by using the direct methods of calculation of energy factors of power converters [1,2]. This method allows to calculate the rms and average values of nonsinusoidal currents without the decision of the differential equations.
Content of the lecture course is following:

- Methods of analysis and simulations of the power converters.
- Rectifiers and dependent inverters (the one-wave and two-wave schemes);
- Dc-dc converters (buck, boost, buck-boost);
- Dc-ac autonomous inverters (current source inverters, voltage source inverters , resonance inverters);
- Ac-ac voltage controllers.
- Ac-ac cycloconverters.
- Inactive power converters for improvement of electromagnetic compatibility (power factor correctors, active filters, compensators of reactive power).
- Methods and structures of the control circuits of the power converters.
- Using the power converters for the power supplies, electric drives, electrotechnologies, energy systems.

There are the exercises for each part of the lecture course.
The course of laboratory works consists of three parts [3-5] and is founded on computer package programs ParGraph - Parus, intended for computer modeling of electromagnetic processes in devices of power electronics, created in our department. The main advantage of our program of simulation is its small volume (2 floppy disks), that allows the students to study the rules of activity with her on one laboratory occupation. The main window of program with example under investigation scheme controlled three-phase bridge rectifier is brought on Fig. 1. This software package allows to create the principle schemes of devices of power electronics by placing on sheet of elements of power scheme and if necessary, functional blocks of a control system, and joining the outputs of these elements by electric relationships, for reception of necessary structure. Making the scheme passes in suitable graphic interface with use the extensive library of standard elements. After making this the electric parameters of elements are assigned and mathematical modeling of electric processes in scheme is produced. The results of modeling introduce in the manner of set of graphs of instant values of voltages, currents, signals in scheme (Fig. 2). There is possibility of calculation of energy factors of processes in scheme, and building the graphs of dependencies of currents, voltages, when change of some parameters of scheme (Fig. 3).

Another possibility of package ParGraph-Parus is the measurement of set of quality factors of electric energy. In the program the algorithms are used, which control hardware part developed hardware-program complex of measurement of quality factors of electric energy (QFE). Exists 11 quality factors of electric energy, in according to acting Russian standard on quality of electric power (GOST 13109-97). For calculation of quality factors it is necessary to indicate the name of elements of scheme, which are a source of voltage (single-phase or three-phase source) and time of monitoring the processes. Hereon occurs the calculation of instant values of currents and voltages on these elements and displaying calculated QFE (Fig. 4).

The program of laboratory works is oriented to study the base schemes of converters, i.e. performing the tasks of analysis. A student, varying parameters of elements of scheme of converters, gets the dependency from them forms of instant values of currents and voltages in scheme, as well as graphs of dependencies of energy characteristics. Together with that the program of each laboratory work contains a small task on syntheses, when student before beginning of the analysis of scheme is offered to define and assign in model value of one (two) of the parameters of element of scheme, providing reception of required value some energy or dynamic parameter of converters.

The first part of course of laboratory works begins with familiarizations with program ParGraph, mastering the receiving the work with it. Then student necessary to execute following laboratory works:

- Study of the three-phase uncontrolled rectifiers .
- Study controlled rectifiers when functioning in rectifier and inverter modes.

The second part of course of laboratory works is denoted the study of base schemes of autonomous converters. Necessary to execute five laboratory works:
In first laboratory work students get acquainted with parallel and series-parallel current source inverters on single-phase bridge schemes.
In the second work are researched single-phase and three-phase bridge PWM voltage source inverter.
In the third work are researched bridge and half-bridge resonance inverters in modes of continuous and discontinuous currents.
Three types of pulse dc-dc converters are studied in fourth work: buck, boost, buck-boost with inversion of polarities of voltage.
The power converter compensators of inactive parts of instantaneous power are studied in five laboratory work.
The aim of third part of course of laboratory works "Power electronics" is a study of main schemes of frequency converters for electric drives. In first work students get acquainted with the electric drives of induction machine on base of three-phase current course inverter.
The electric drives on the base of three-phase voltage source inverter is researched in the second work
The cycloconverter with induction machine is researched in the third work
For performing the course project is provided preliminary performing the exercises, but then the project, there is a sample of it, with transmitting of results on e-mail in case of distant education.

The four-level testing is reduced to choice of correct answers from ensemble proposed ready answers.
The first level - formal quantitative estimation of number of correct answers to offered questions, characterizing approximately general value knowledge of student about subject.
The second level - qualitative, requiring obligatory correct answers to questions, named base. These questions characterize the deph of understanding by student to essences of subject.
The third level - disqualifying, with results of testing, available only teacher. Here is fixed the presence in response of questions absolutely inadmissible variants of answers, provided in subset of proposed answers. This signals a teacher about need of increased attention to such student or about need of delicate talk with him about correctness of choice of profession.
The Fourth level - super qualifying, characterizing readiness of student to answer the questions of increased difficulty, requiring the presence of creative abilities by testable.

Conclusion

Thus, the designed educational complex on the course "Power electronics" is full, since contains all four mandatory components of educational process (lecture material, laboratory works, practical occupations, quality control of education). The offered technology of training was checked during two years and has received approval for the students. The demo-version of the first part of the electronic tutorial is present on a site: http://edu.nstu.ru/curses/tech/ose/demo/Main.htm.

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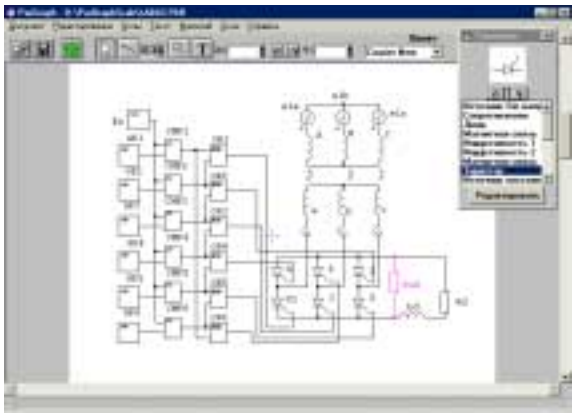

Fig. 1: Program ‘ParGraph’ – circuit modeling.

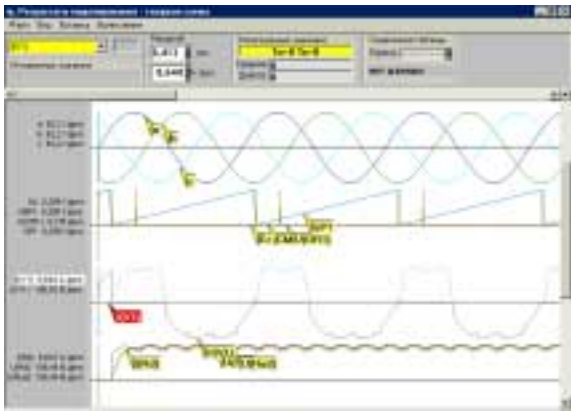

Fig. 2: Results of Modelling.

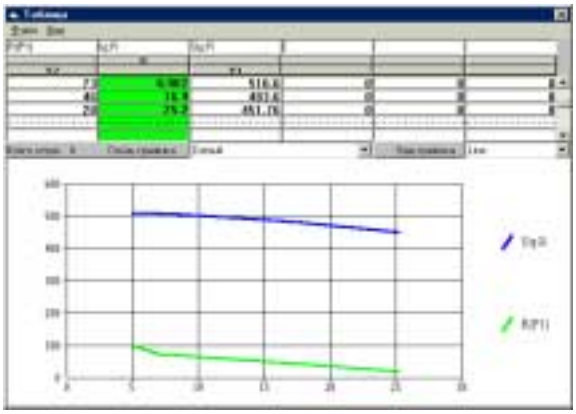

Fig. 3: Graphs of Integral values.

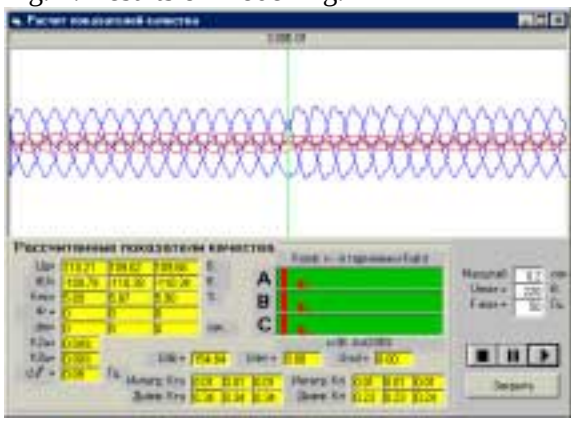

Fig. 4: Quality Factors Measuring.