ELECTRICAL ENGINEERING

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ELEKTROS INŽINERIJA

Elaboration of Program Package Virtuallab for Power Electronics Laboratories

I. Rankis, A. Lebedev, I. Bunina

Riga Technical University, Faculty of Power and electrical Engineering , Institute of Industrial Electronics and Electrical Engineering, e-mail: rankis@eef.rtu.lv, vagran@inbox.lv

Introduction

Power Electronics is one of the main study subjects for students in field of Industrial Automation and Electrical Transport [1,2]. The subject must be learned in classes and also in laboratories. But last measure is connected with application of special equipment which is sometime expensive and very complex especially in part of control systems. Therefore for full time students often computer modelling on base of special simulation tools as PSpice, PSIM [3], MatLab and other is applied. But application of such tools is expensive measure and therefore can't be used widely especially for extramural students. Taking into account listed above in Riga Technical University a computer program package for typical schemes of power electronics converters is developed and introduced at Internet site www.Virtuallab.sk6.ru/ for free of charge application. Students can download package and use it for realization of laboratory works using their computers at home application.

Up to now there are two parts introduced in the package: Virtuallab v1.0 and Virtuallab 2.0. The former comprises also two parts:

1. The single-phase AC and DC converters;
2. The three-phase converters.

The Virtuallab 2.0 comprises mainly three-phase advanced converters part. It must be accounted that all works are continuously improved and therefore it's possible that some changes should be introduced. In this paper are represented a content of the both parts and also examples of program for certain types of converters.

Index of program package

In the first part of program package Virtuallab v1.0 an AC single-phase and DC most applied 14 converter schemes are implemented:

- Laboratory work N1 Investigation of an AC single-phase voltage regulator;
- Laboratory work N2. Investigation of the DC step-up (Boost) converter;
- Laboratory work N3. Investigation of the DC step-down (Buck) converter;
- Laboratory work N4. Investigation of the DC bridge pulse-width modulator;
- Laboratory work N5. Investigation of the single-phase voltage source inverter with sine modulation;
- Laboratory work N6. Current source inverter;
- Laboratory work N7. Investigation of the AC controlled rectifier;
- Laboratory work N8. Investigation of the DC transmission;
- Laboratory work N9. Investigation of the cycloconverter;
- Laboratory work N10. Investigation of resonant converter;
- Laboratory work N11. Investigation of the centre tap controlled rectifier;
- Laboratory work N12. Investigation of the single-phase centre tap inverter;
- Laboratory work N13. Investigation of the current corrector;
- Laboratory work N14. Investigation of the active rectifier.

In the second part of the Virtuallab v1.0 a three-phase converters are presented corresponding to the following listing:

- Laboratory work N1. Investigation of the centre tap three-phase controlled rectifier;
- Laboratory work N2. Investigation of the three-phase AC voltage regulator;
- Laboratory work N3. Investigation of the three-phase square inverter with star-load;
- Laboratory work N4. Investigation of the three-phase controlled bridge rectifier;
- Laboratory work N5. Investigation of the current source inverter.

In way of continuous work on modifying of the package it should be possible to implement also some new laboratory works connected with the both parts.

Package Virtuallab 2.0 comprises a 7 advanced three-phase converters:

- N1. Cycloconverter;
- N2. Voltage source inverter (sine modulated);
- N3. DC transmission;
- N4.Matrix converter;
- N5. Active rectifier;
- N6. Active DC transmission;
- N7. Active filter.

Principles of presentation of laboratory work

As example in next will be discussed an implementation of laboratory work for investigation of the single-phase controlled rectifier (Laboratory work N2 of the first part). Each laboratory work in the package contains of the three separated parts: workspace presented on the screen of computer; explanation of operation principles of converter; example of possible laboratory tasks on presented converter.

The workspace for discussed laboratory work is presented on Fig.1. In the left upper part of screen an input data are presented: RMS value of the network voltage; frequency of the voltage; inductance L1 of the network lines; resistance R_{ld} of load ; inductance of the load L_{ld}; EMF of the load E_{ld}; delay angle for thyristors α, grad; number of presented voltage cycles km. Here also is presented an optional input field for displaying of several last voltage cycles.

In the right upper side of the screen is presented calculated by program diagrams of loads instantaneous voltage u_d , loads instantaneous current i_d and also for network current i_1. An electrical scheme of the investigated converter is presented in lower-left part of the screen. But in the lower-right part are presented measured parameters for the end position of the process: mean (averaged) values of the load's voltage U_{da} and current I_{da}; RMS value for network current I_{1rms} and its fundamental I_{1h}; amplitude value of load's current pulsation I_{dpm} and its relative value I_{dpm}/I_d; realized an active power P; commutation angle G, grad; THD indicator for network current,%.

Curves and parameters calculation is performed by the program in very fast (some parts of the second) time which allow very fast examination of the converter at different changes of input data.
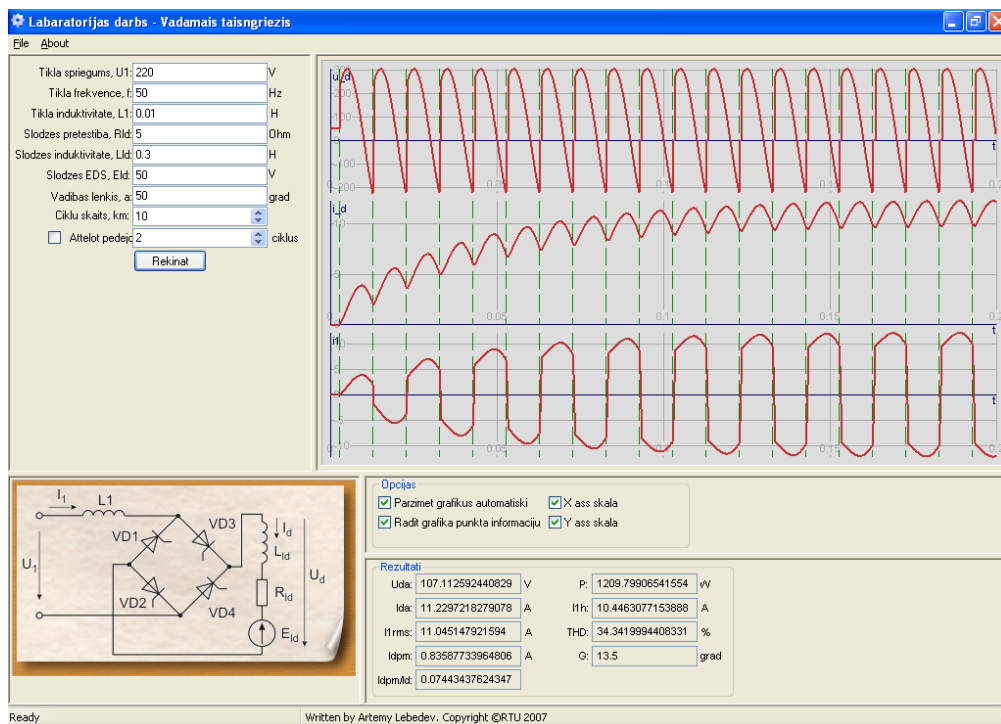

Fig. 1. Screenshot of the workspace for laboratory work N2 "Investigation of the single-phase controlled rectifier"

The second part of the laboratory work is intended for description of the investigated converter. This part can be activated applying option Help on the Main Menu bar. Fragment of this description is presented on Fig.2.

The third part of the laboratory work is example of possible tasks at investigation process for examined converter.

Laboratory task №7

Investigation of the single-phase controlled bridge rectifier

Input data:

1 – Resistance of load R, Ω;

2 – Inductance of load L,H (greater than zero);

3 – EMF of load, E, V in the range from –500 V to +300 V;

4 – Inductance of the AC network L1,H (from zero to some mH);

5 – Delay angle for thyristors switching α from 0 to 180 grad.

6 – RMS value of network voltage U1 and its frequency.

Parameters 1,2,4,6 are denoted by teacher.

Fig.2. Fragment of description of the laboratory work

Output calculated parameters:

Ud – load's DC voltage;

Id – load's DC current;

I1 – RMS value of network current;

I1h – fundamental of network current;

THD – total harmonics distortion factor for network current;

G – commutation angle, grad;

P – active power realized, W.

Task:

1. Take-up in the stationary action case a characteristics Ud=f(Id) at different values of α in its all range if values of L and R are constant ones but current is changed with variation of E.

2. Obtaining mentioned characteristics search a values of currents for

−starting a discontinuous load current regimes;

−thyristors break-down points at inverter regime.

3. Take-up a characteristics G=f(Id) at different values of α!

4. Take-up a characteristics THD=f(Id) at different α!

5. Take-up a characteristics P=f(Id) at different α!
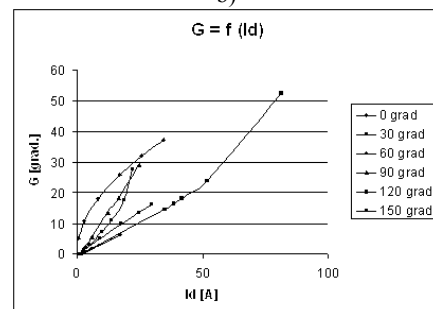
On Fig.3 are represented curves obtained using the program and given above tasks at denoted parameters U1=220 V, f=50 Hz, R=5 Ω, L1=0.003 H, L=0.3 H. All data for construction of the given curves was obtained approximately in 0.5 hour.

a)

b)

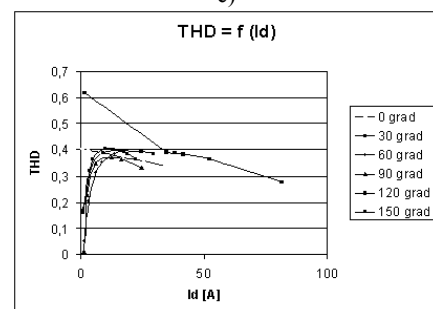

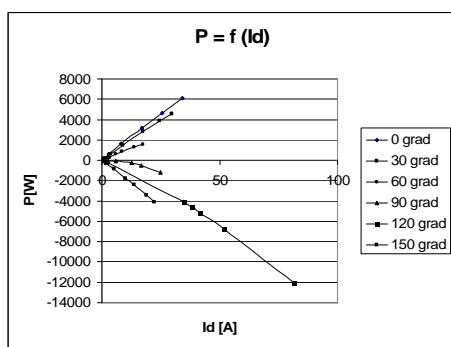c)

d)
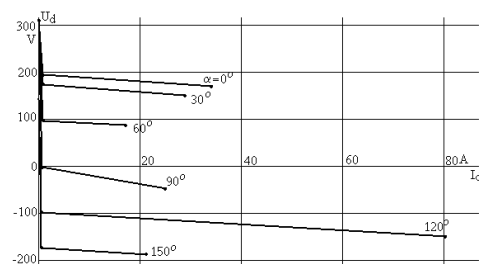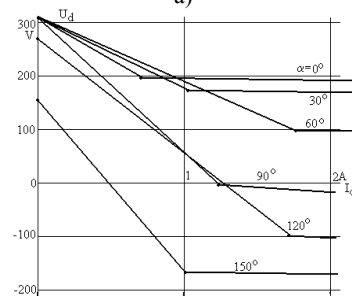
P = f (Id)

e)

Fig. 3. Curves obtained using elaborated program for single-phase controlled rectifier at given input data and conditions: a, b – Ud=f(Id); c – G=f(Id); d – THD=f(Id); e – P=f(Id)

field of Fundamentals of Power Electronics examining in laboratory the basic schemes in the field. Program package can be extended introducing some new investigation schemes for students.

References
1. **Mohan N., Undeland T., Robbins W.** Power Electronics: Converters, Applications and Design. – NY, 1989. – P. 667.
2. **Rankis I.** Teaching of Power Electronics subject in EPE faculty of Riga TU, „Doctoral school of energy- and geo-technology", 2007. Kuressaare, Estonia.
3. **Rankis I., Rodionova I.** Application of Simulation Packages in Classes of Switching Converters // Electronics and Electrical Engineering. – Kaunas: Technologija, 2006. – No. 4(68). – P. 23–28.

Conclusions

Developed program package with laboratory works is useful tool for improvement of knowledge of students in

I. Rankis, A. Lebedev, I. Bunina. Elaboration of Program Package Virtuallab for Power Electronics Laboratories // Electronics and Electrical Engineering. – Kaunas: Technologija, 2009. – No. 6(94). – P. 61–64.

This article shows the description and content of program package for virtual investigation of the typical schemes of power converters learned in study subject of Power Electronics. The program package is intended mostly for application in extramural education but can be also efficiently used for different form students. Programs are elaborated as executable files in C++ language. Elaborated program package is introduced in Internet site www.virtuallab.sk6.ru/ and can be downloaded free of charge. Ill. 3, bibl. 3 (in English; abstracts in English, Russian and Lithuanian).

И. Ранькис, А. Лебедев, И. Бунина. Разработка пакета программ для лабораторных работ по силовой электронике // Электроника и электротехника. – Каунас: Технология, 2009. – № 6(94). – С. 61–64.

В статье описан разработанный пакет программ и его содержание. Пакет предусмотрен для студентов, изучающих предметы силовая электроника или преобразовательная техника. В основном пакет предусмотрен для студентов заочного обучения, но может быть использован во всех видах обучения. Пакет содержит ряд лабораторных работ как по типовым схемам однофазного переменного тока, так и трехфазного и постоянного тока. Разработанный пакет выставлен в Интернете на сайте www.virtuallab.sk6.ru/ и может быть сплавлен бесплатно. Ил. 3, библ. 3 (на английском языке; рефераты на английском, русском и литовском яз.).

I. Rankis, A. Lebedev, I. Bunina. Galios elektronikos laboratoriniams darbams atlikti skirto programų paketo tyrimas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2009. – Nr. 6(94). – P. 61–64.

Ištirta programinė įranga skirta atlikti Galios elektronikos ir Keitiklių modulių laboratoriniams darbams. Iš esmės paketas yra sukurtas nuotolinio mokymo tikslams, bet gali būti taikomas įvairių formų studijoms. Į programų paketą jau yra įtraukti keli laboratoriniai darbai. Tai nemokamas paketas, kurį galima atsisiųsti internetu www.virtuallab.sk6.ru/. Il. 3, bibl. 3 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).