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COMPUTERIZED TUTORIAL IN ELECTRIC MACHINES

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ABSTRACT

The aim of the program described here is to provide the students taking the course of electric machines with an on line information and tutorial which help them during the course of their study. The program contains textbook materials in a lively manner. This encourages the student to follow up the explanations in an interesting , easy to follow, self explanatory and step by step manner.

The program consists of four modules: Transformer module , winding module, dc machines module and ac machines module. The first one was written in C-Language , while the other three modules were programmed using Visual Basic.

It was found that the Visual Basic is quite suitable for such a problem. The four modules were integrated under one package using Visual Basic.

The program was developed over a period of more than 3 years by students in their final year study under the two semesters final year project course . The program is still under test before full implementation along with course work.

KEYWORDS: Education, Electric Machines, Projects, Tutorial.

INTRODUCTION

With the wide scale availability of personal computers at low costs and with network accessibility, use of personal computers in education is increasing continuously. Educational software available in specialized fields is spreading in spite of their need of highly specialized and delicate human effort. Educational programs help lecturers in educational institutions in many fields. There has been quite a number of software available in the market in the field of electrical engineering. An investigation of adding more intelligence to such programs is very much necessary. In the field of electrical power engineering quite a number of such programs were reported.(1,2,3,4). Very few are reported in the field of electric machinery (5).

Some locations on the world wide web are specifically interested in educational software in the field of power

engineering areas.(e.g.: uow.edu.au/pwrsysed/elec221 and cran.esstin.u-nancy.fr/EAEIE /PresEAEIE.html)

The software described here was developed over a period of three years by few electrical engineering students in their final year projects. Final year projects (6) at the department of Electrical engineering of Jordan University were utilized to develop the software in a step by step manner.

Final year project is a two semester course with a total credit hours of 6 hours. Students usually carry out the project individually under the supervision of a staff member or seldom in a group of 2 students.

The fundamentals of Electric Machines are taught at University of Jordan and many other universities in three main courses: Two courses for electrical engineering students and one course for non electrical (namely : mechanical and industrial engineering students). The first course covers Magnetic circuits, transformers and dc machinery . The second covers induction and synchronous machines(7). While the third one (for non electrical) covers almost the same materials in less depth(8).

Classical books in electrical machinery seldom give any hint to the use of computers , or any programming in solving machines problems. Most numerical problems are based on linear equivalent circuits which need only to use complex algebra for solving them. In very few topics, nonlinear manipulation is used and in such cases trial and error solution is required. Computer programs then can help a lot in such cases. Use of detailed and more exact equivalent circuit can now be used with the aid of computers.

In order to provide the students with some aid in their study, computer programs may be prepared specifically for such purposes.

Main characteristics of software which should be available for students to aid a specific course teaching are:

It should be based upon a well defined syllabus which contains material covered by the course instructor and need more elaboration as well as extra material which the student can grasp by himself when using the software.

It encourages the student to look for further literature material and follow up references.

It should provide the students with material supplemented with suitable graphical aid to explain phenomena difficult

to comprehend and make it easy to understand. The utilization of these graphical aids is very useful in such explanations. Such figures should be selected in line with experience of the lecturer related to difficult matters. It should provide the student with further numerical and non numerical problems to try to solve in a suitable form.

PROGRAM STRUCTURE & FEATURES:

The program of concern here consists of four modules. The first module of the package which is related to the Transformers, is subdivided into magnetic circuit section, two winding transformer section and three phase transformer section. First the magnetic circuit problems were tackled. As regards two winding transformer, all basic material was considered starting from test, parameters calculations, problems related to equivalent circuit, voltage regulation, efficiency as well as phasor diagram. Graphical tool is provided to enable drawing the phasor diagram. It is available to the user to use it for trying his own diagrams. Exercises included many types of numerical problems as well as quizzes which included multiple choice types of problems. Module 2 which is specifically related to the machine winding. One of the difficult topics in electric machines for students to understand is machine winding. This is why a special attention is given to this topic with extensive use of graphics and animation. It was created both for the purpose of explanation and for drawing of the winding diagram of given specifications.

The module starts with selection of the type of winding diagrams namely developed diagram or polar diagram. A help option is provided for quick user help. Once one of these two options of the nature of diagram is selected, the user has to provide the necessary data for the diagram to be drawn. These include number of slots, number of poles as well as selection of type of machine. For dc machine type of machine (lap/wave), number of plex

It should provide the student with enough solved numerical examples with the possibility that the student may try to solve by himself and to check his solution in a step by step manner.

(simplex,/duplex/triplex), direction of winding progress (progressive/retrogressive) have to be selected.

After all the above data are set, the drawing can be drawn either in a complete form by using the (quick) option or in a slow motion as a step by step while the user can watch the progress of construction of the diagram. See Figure (1).

If the user supplied wrong data, an immediate window is opened showing inside a remark about the mistake and how to correct it.

Description of winding information is given in a text mode with some option for detailed information for terms.

When terms or subjects which are underlined in the text are clicked window is opened to give detailed information. Such information includes insulator information, winding materials, conductors specifications ..etc.

After diagrams (developed or polar) are drawn, they may be saved for further reference in the future. Animation is used all through for extensive explanations.

Module 3 is concerned with DC machines. Main menus include Theory, DC machines Fundamentals, DC generators, and DC motors. The theoretical part contains the sub-titles of induced emf in conductors, force produced on current carrying conductors and magnetic behavior of magnetic materials.

The DC machines fundamentals contains the introduction of linear machine, commutation principles, armature reaction, torque equation, power flow and losses in DC machines. See figures (2 and 3).

DC generator consists of the equivalent circuit, magnetization curve, separately excited DC generator, shunt generator, compound generators and parallel operation of DC generators.

DC motors section contains all necessary materials for the shunt, series and compound motors.

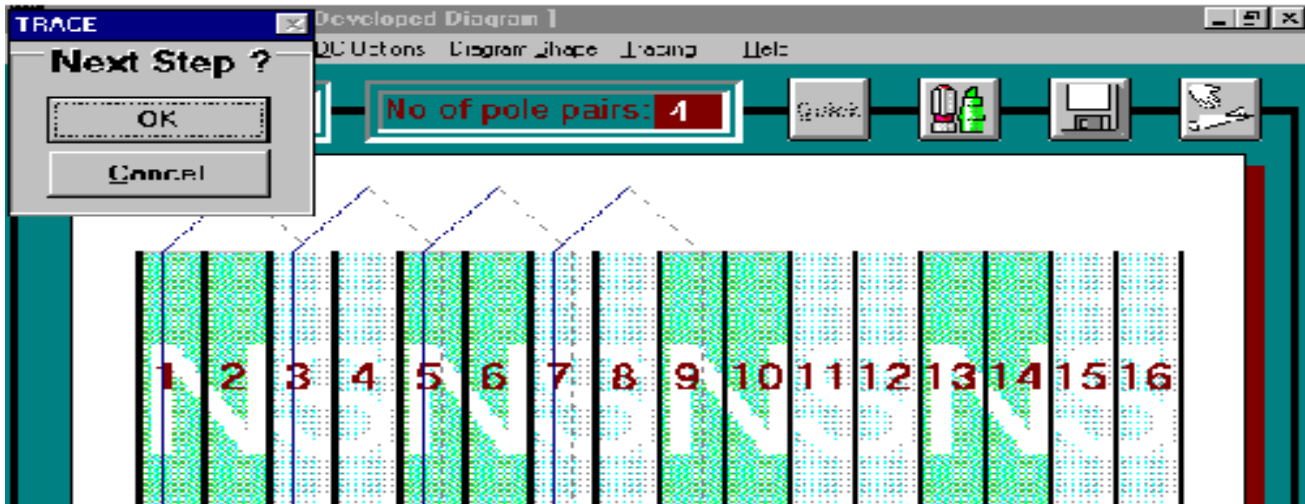


Figure (1) Part of the picture showing how to construct developed winding of dc machine in a step by step manner

Module 4 covers AC machines fundamentals: construction, magneto-motive force, field of the rotor, air-gap magnetic field and rotating m.m.f., induced voltage in ac machines, reduction of harmonics, salient poles and cylindrical rotors, power factor and losses., Synchronous machines includes construction, equivalent circuit, use of generator to provide an isolated load, parallel operation of synchronous generators, connection to infinite bus-bar, and capability diagram. Synchronous motors topics include operation, effects of load changes, power factor corrections and starting of synchronous motors. Induction machines includes construction, equivalent circuit, losses and power flows diagrams, power and torque calculations, torque speed characteristics, starting methods of induction motors, speed control for both squirrel cage and slip ring motors. Induction generator also is given some attention. Sub menus give details to second or third level of branching. Jumping between topics is also possible. Help facilities were made available for various parts of the system.

The program has many interesting features among which are:

1. It operates under windows and is menu driven (pop down menus).
2. It consists of basic information including theoretical background, equations, hints and remarks.
3. It contains diagrams. Animation is available when moving parts exist or when there is a phenomena which is best explained by moving objects. Use of colors gave the program an extra merit.
4. Solved examples and quizzes with multiple choices, and numerical problems are also available for students training.
5. Hot word helps and on line calculators are also available.

6. It utilizes the technique of OLE control using OLE commands in Microsoft System Programming.

7. Multimedia may be added to the system for further benefits.

The student may use the above features in various ways. He may use it as a textbook, page by page flapping (by clicking a button by the mouse). Otherwise he may select a specific topic through the menu selection.

Figures reference in the text is given by colored "Fig #". Hot words are also shown in colored typing. Mouse clicking of such word will open a window showing the referred figure, giving the definition, explanations, remarks, diagram or reference to another topic in the text. The size of the window is directly proportional to the size of the figure.

If the figure is too big and may hide a lot of text space, then adjustment facilities of the windows size becomes available. This solves the usual problem of referring to a figure which is not available on the same page of the text in textbooks.

Figures which contain possibility of moving parts explanations are provided with animation button. These figures are usually stationary. When animation button is clicked motion starts. Speed of such animation may be adjusted by sliding bar.

Forward flapping and backward are available via two buttons.

Possibility of evaluating the students' answers to the problems and quizzes is available so that the student may find out the correct and wrong answers as well as the overall performance in solving the set of exercises. The student can judge his own performance after going through these exercises and quizzes.

All drawing provided were prepared using the PAINT-BRUSH format and then embedding them in the program.

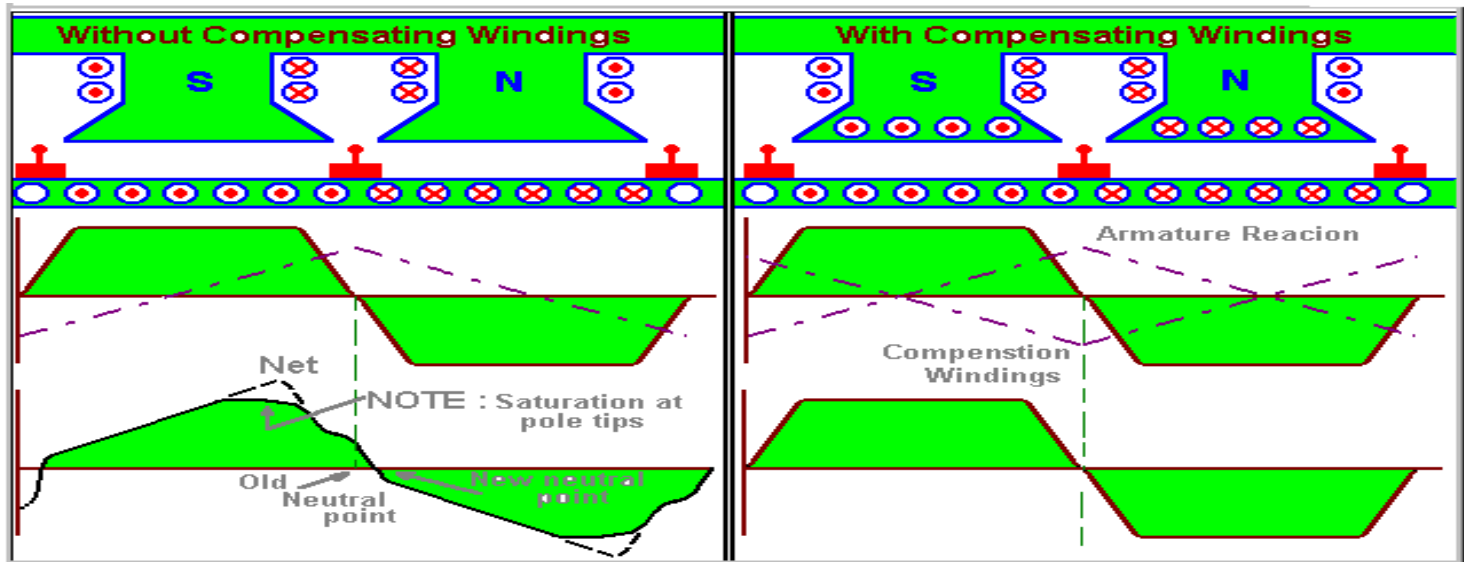
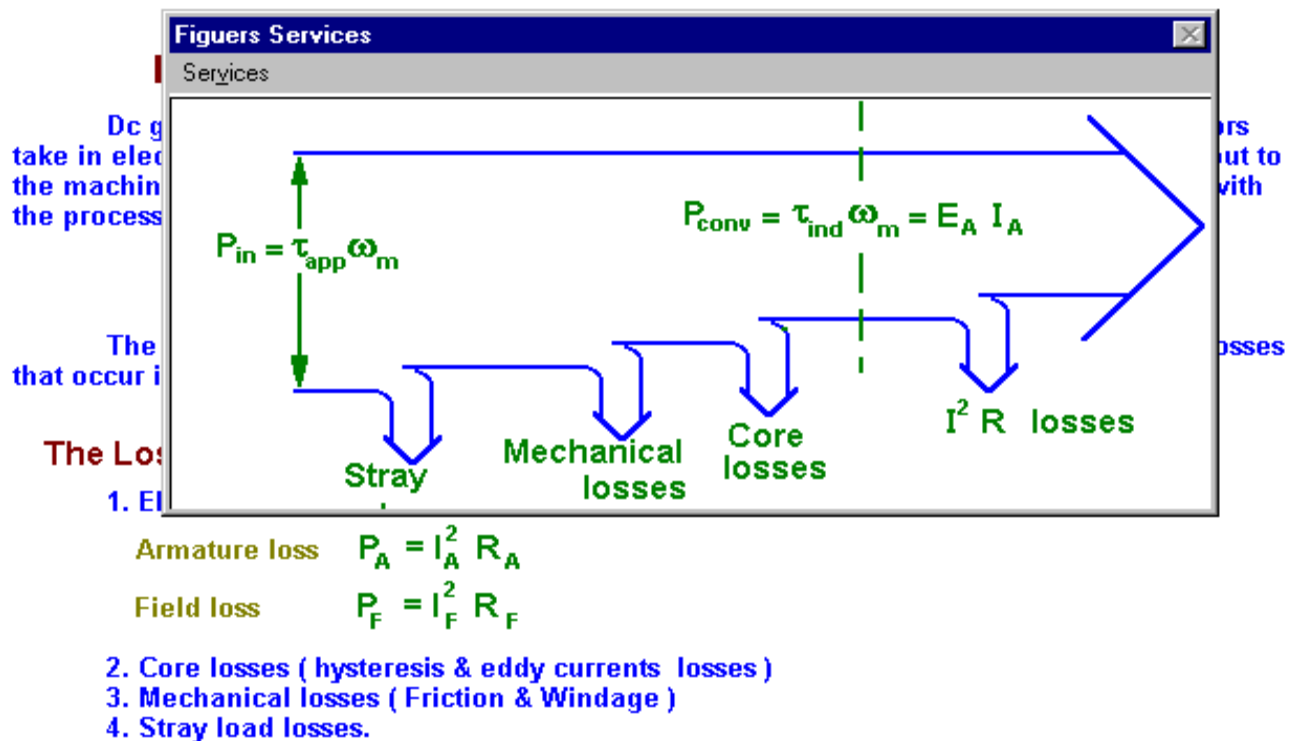


Figure (2) Diagram showing the flux distribution due to armature reaction of DC machine and its remedy by adding compensating winding.



The Power-Flow Diagram

Figure(3) Text with a figure showing power flow diagram in generators in a window over the text

DISCUSSIONS AND CONCLUSIONS:

The aim of the program is to provide the student taking the course (or courses) of Electrical Machines with information and tutorial which help him during the course. The program gives textbook materials in a lively manner. It encourages the student to follow up the explanations in an interesting , easy to follow , self explanatory and in a step by step manner.

The program was built up in a step by step manner utilizing the final year two semester project subject. Hence it is highly recommended to utilize final year projects to produce useful software which can help in the teaching process. Such pieces of software may be a small problem which is difficult to comprehend when such software can help in its understanding. It may be a stand-alone program to explain an inter-related teaching

materials or it may cover a complete subject like the present software. It may be very useful to extend the work over a reasonable period of time or among a group of students who may exchange ideas and experience among themselves to produce an integrated piece of software to serve as a teaching aid to the lecturer. The experience gained by the students who work on such systems is tremendous. It covers both scientific bases as well as mastering of programming techniques and system development.

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