AC 2008-812: ON-LINE LEARNING TOOL FOR UNDERGRADUATE ELECTRIC MACHINES AND POWER SYSTEMS COURSE

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Abstract

This paper explores both the modules of the developed Electric Machines and Power Systems (EMPS) software and the assessment results of an investigation of learners' attitude toward this media based teaching tool. The investigation is based on a survey completed by fifteen students enrolled in Electric Machines and Power Systems course at Ohio Northern University. The students are majoring in Electrical Engineering. The teaching tool is designed to optimize students' performance through an instant observation of and among the parameters of transformers, dc machines, ac machines and transmission line models. The information and data collected from survey and questionnaires were analyzed and used for the evaluation of attitudes toward the use of this media based teaching tool. Students have responded favorably to and expressed their satisfaction with the developed software tool.

Introduction

In recent years and due to the evolving technology and its attendant introduction of new material into the curriculum, most colleges face a demand to optimize their curriculum and increase the content of courses. This challenges educators to determine more efficient ways of designing their courses and presenting the material in order to ensure that students are provided with information to help them pass along the essential knowledge of their field and acquire computer skills to be adequately prepared to function as high quality professionals of the future.

Meeting the instructional needs of students to learn the material is the keystone of every effective program. The tools of educational technology and software hold tremendous potential for improving both teaching and learning processes. Cohen et al[1] performed analysis of 74 studies that compared visual-based instruction with traditional instruction. They found that students learned more from visual-based instruction than from traditional teaching. It is evident from the paper by Powell et al[2] that computer based instruction may be the key to improving the grade point average of students. Bartsch and Cobern[3] found that PowerPoint presentation can be beneficial to students' learning. Papers[4-8] reported that those who integrate technology in the learning process believe it will improve learning and better prepare students to effectively participate in the 21st century workplace. Today, educators are concerned with how to use technology to enhance and enrich their learning environments rather than asking whether to use it.

Multimedia which is defined in paper[9] as "the integration of video, audio, graphics and data within a single computer workstation" and according to Willis[10] multimedia enables the instructor to custom design and individualize instruction and learner to "plan, execute, and manage" his or her learning experience at the rate, place, and time of the learner's choice.

Folkestad and De Miranda[11] have used multimedia through screen-capture to teach students how to use CAD software. They reported that students were unsatisfied with this instructional tool due to its fast pace and the need to switch back and forth from the recorded lecture to the CAD software. In paper[12] a new instructional tool was developed and the problems encountered in reference[11] were solved by having a variable pace (slow, medium, fast) which allows the students to proceed at their desired pace. In this paper, a different approach is used. The approach is utilizing this developed software which is one that the students can install it on their personal computers and be able to run it as a standalone program that doesn't need the assistance of any other software. This program was developed using C# and Graphical User Interface (GUI) that provides a user friendly platform for entering all of the data necessary to perform the calculations and receive the outcomes of those calculations. As a helpful learning tool, this program instantly shows the effects that changing one input has on every different aspect of the output and also makes it possible for students to check their homework answers.

This paper is organized through sections. The first section describes the course. The second section includes some screenshots of the software. The data collection and assessment method is described in the third section. This is followed by the results of the assessment and finally the conclusion.

The Course

Electric machines play an important role in industry as well as in our day-to-day life. They are used in power plants to generate electrical power and in industry to provide mechanical work. They are an indispensable part of our daily lives. They start our cars and operate many of our household appliances. An average home in the United States uses a dozen or more electric motors. The electric machines and the power systems areas have been and will continue to be amongst the most important fundamental courses of the electrical engineering curriculum.

Recently, I have attended an NSF-sponsored workshop on the teaching of power engineering courses. The workshop has hosted more than 140 power engineering educators. It was mentioned that 75% of the electrical engineering programs across the United States require a combined course in energy conversion (electric machines) and power systems. As a result of the workshop, it has been recommended that every electrical engineering program should have a combined course in electric machines and power systems to optimize the curriculum. The Electrical & Computer Engineering and Computer Science (ECCS) Department at Ohio Northern University has approved the recommendation and combined two courses the ECCS 335 Energy Conversion and the ECCS 336 Power Systems into one course. The combined course is called ECCS 338 Electric Machines and Power Systems. The course covers the topics of both earlier courses. The topics of this new course include the following:

1. Magnetic circuits
2. Direct current motors
3. Three phase circuits
4. Power transformers
5. Synchronous generators and motors

6. Induction motors
7. Per unit and impedance diagrams
8. Transmission line models
9. Load flow analysis
10. Optimal dispatch of generation.

To optimize the time spent in the classroom and based on the above topics, a viable teaching tool on this subject must be designed to enhance the learning process on every possible front. This will help both students as well as the instructor of the course.

Software Modules

This software is one that the students can install it on their personal computers and be able to run it as a standalone program that doesn't need the assistance of any other software. This program utilizes C# and Graphical User Interface (GUI) that provides a user friendly platform for entering all of the data necessary to perform the calculations and instantly receive the outcomes of those calculations. As a helpful learning tool, this program instantly shows the effects that changing one input has on every different aspect of the output and also makes it possible for students to check their homework answers. There are six modules so far that encapsulate most of the calculations necessary in solving problems in the following topics:

1. Power transformer characteristics and performance measures
2. Direct-current motors characteristics and performance measures
3. Synchronous machines characteristics and performance measures
4. Induction machine characteristics and performance measures
5. Three phase circuits
6. Transmission line models.

Some of the modules are shown in the following figures and they will be displayed to the audience using a laptop during the presentation.

a. Power Transformer Characteristics

Example:
A 100-KVA, 400/2000 V single phase transformer has the following parameters:
$Rp = 0.01\Omega \quad Rs = 0.25\Omega \quad Xp = 0.03\Omega \quad Xs = 0.75\Omega \quad Gc = 2.2mS \quad Bm = 6.7mS$
Note that Gc and Bm are given in terms of primary reference. The transformer supplies a load of 90 KVA at 2000 V and 0.8 power factor lagging. Calculate the primary voltage and current using the exact equivalent circuit referred to primary side.

After students enter the given values in the problem as shown in the figure, the output which is the solution of this problem is shown in Figure 1.

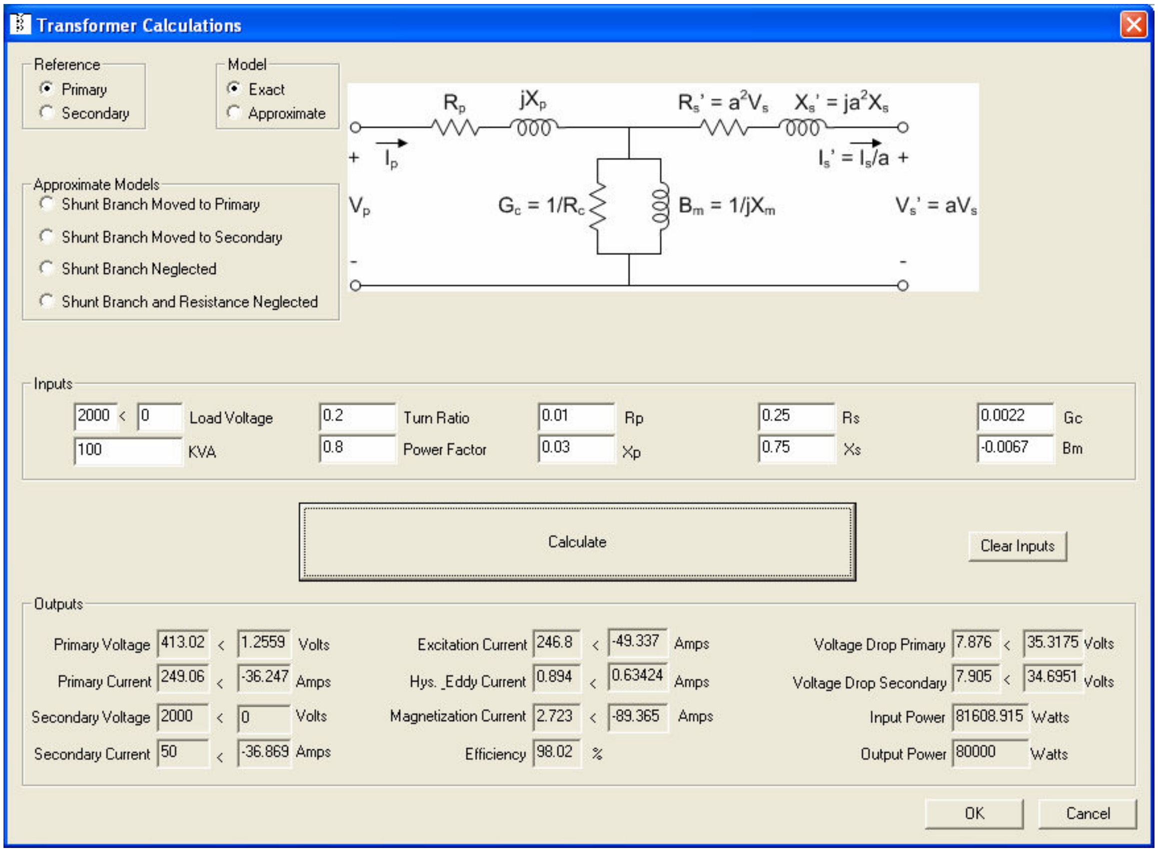

Figure 1_ Output of Transformer Exact Model Referred to Primary

As shown in figure 1, any given transformer can be reflected to the primary side or to the secondary side. Also, the student has the choice of analyzing a given transformer based on the exact model as well as the approximate model. If the approximate model is selected, the student needs to specify one model from the list of the approximate models. The list consists of the following approximate models:

1. Shunt branch moved to primary side.
2. Shunt branch moved to secondary side.
3. Shunt branch neglected
4. Both Shunt branch and resistance neglected.

The parameters of the given transformer in this module must be inserted as an input values. In addition, the load voltage, the turn ratio of the transformer, the rated load in KVA and the load power factor. Problem statements of transformers in most of electric machines textbooks are similar where all the required input values by the above module are stated in the problem statement. This makes the developed modules to work smoothly with most of the available textbooks in the market.

b. Power Transformer Test

Example:
A single phase 2300/230-V 500 KVA transformer is tested and the following data was recorded:

	Open Circuit Test	Short Circuit Test
Voltage (V)	2300	94.5
Current (A)	9.4	217
Power (W)	2250	8220

Find:

1. The equivalent resistance.
2. The equivalent reactance.
3. The magnetization reactance.
4. The core resistance.

After students enter the given values into the specified cells, the output which is the solution of this problem (equivalent parameters) is shown in figure 2.

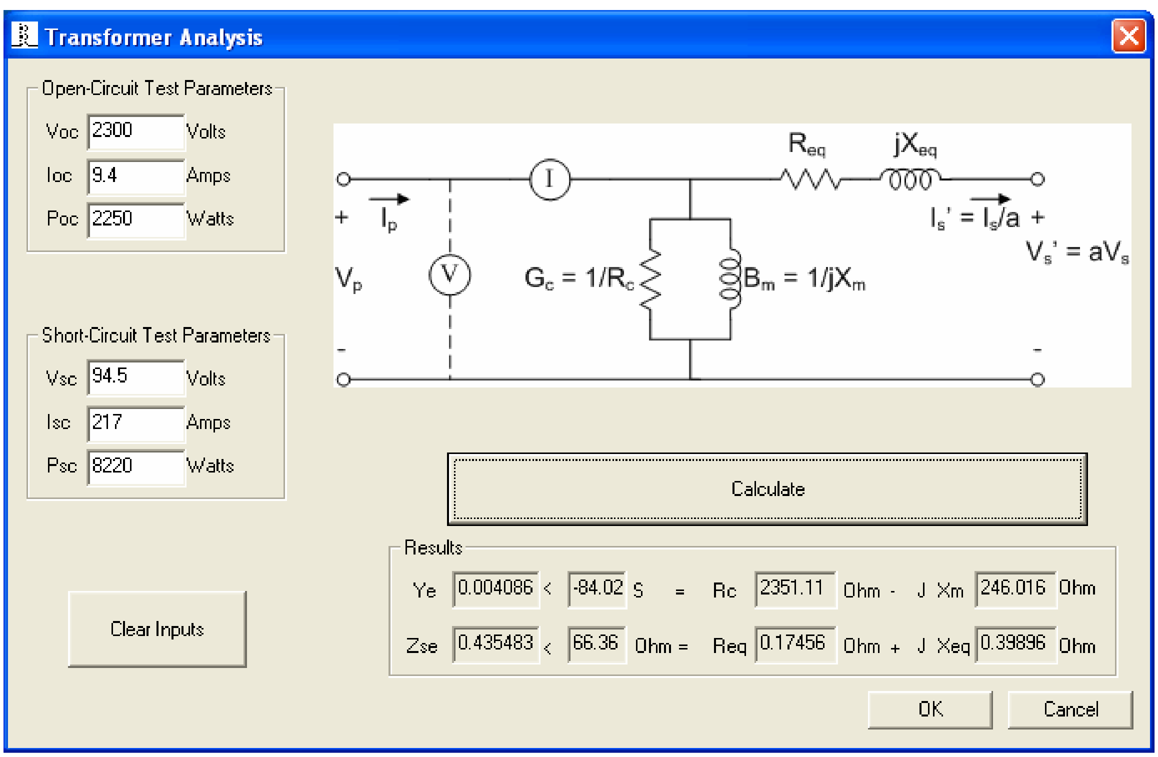

Figure 2_Transformer Equivalent Parameters

c. Direct Current Motors

Example

A 50-hp, 230-V, 1300-rpm dc shunt motor has an armature resistance of 0.05 Ω. At rated speed and output, the armature current is 178.5 A and the field resistance is 115 Ω. Calculate:

1. The shunt field current.
2. The counter emf.
3. The power input to the motor.
4. The efficiency of the motor.
5. The developed torque.
6. The output torque.

After students enter the given values, the program will solve and obtain the solution of this problem as shown in figure 3.

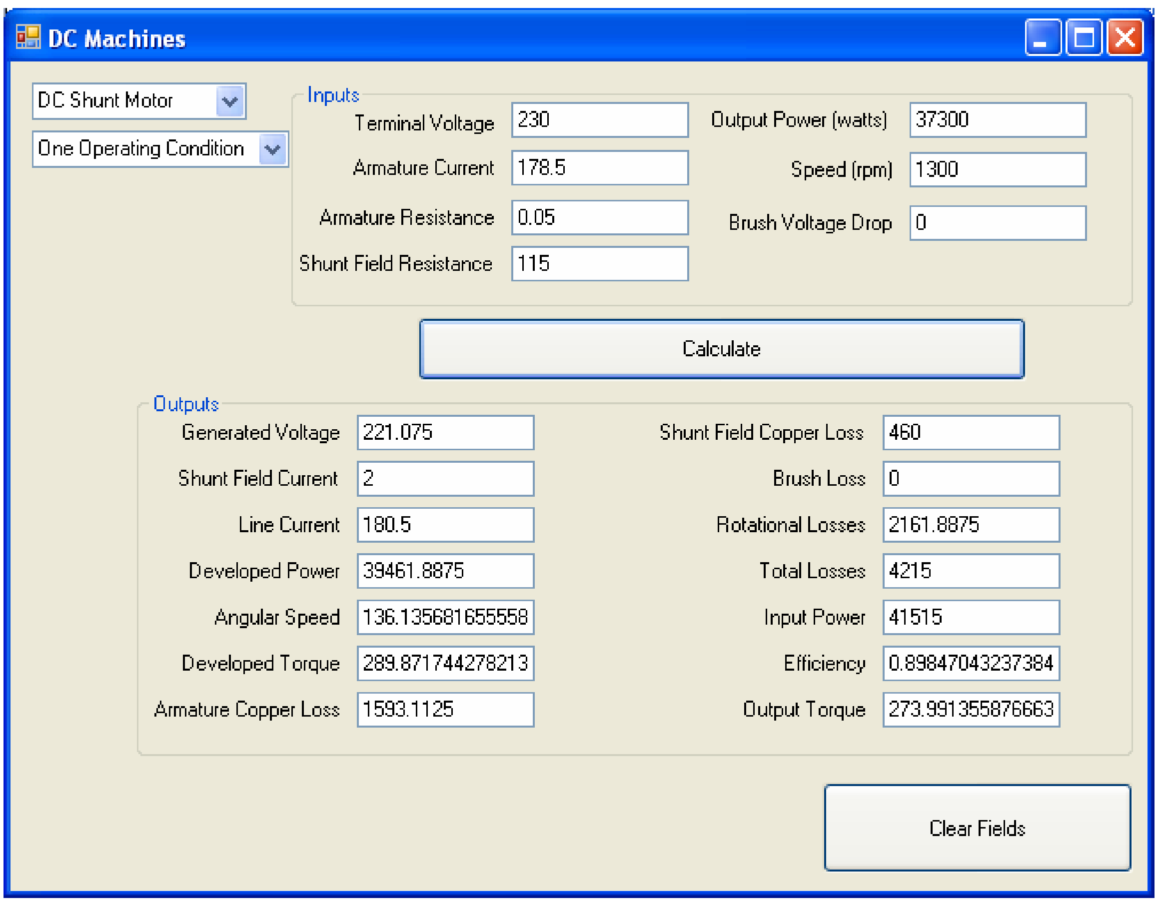

Figure 3_ Output of DC Shunt Motor

d. Synchronous Machines Characteristics

Example:
A 20-MVA, three-phase, Y-connected, 13.8-kV, 4-pole synchronous generator operating at full load condition and 0.8 power factor lagging. The synchronous reactance is $8\,\Omega$ per phase and the armature resistance is $3\,\Omega$. Calculate:

1. The speed of the generator.
2. The generated voltage.
3. The voltage regulation.
4. The efficiency of the generator.

After students enter the given values, the solution will be shown as in figure 4. In this module, I still have to fix the problem which is the stator current value. It is shown to be zero while this is not the correct value.

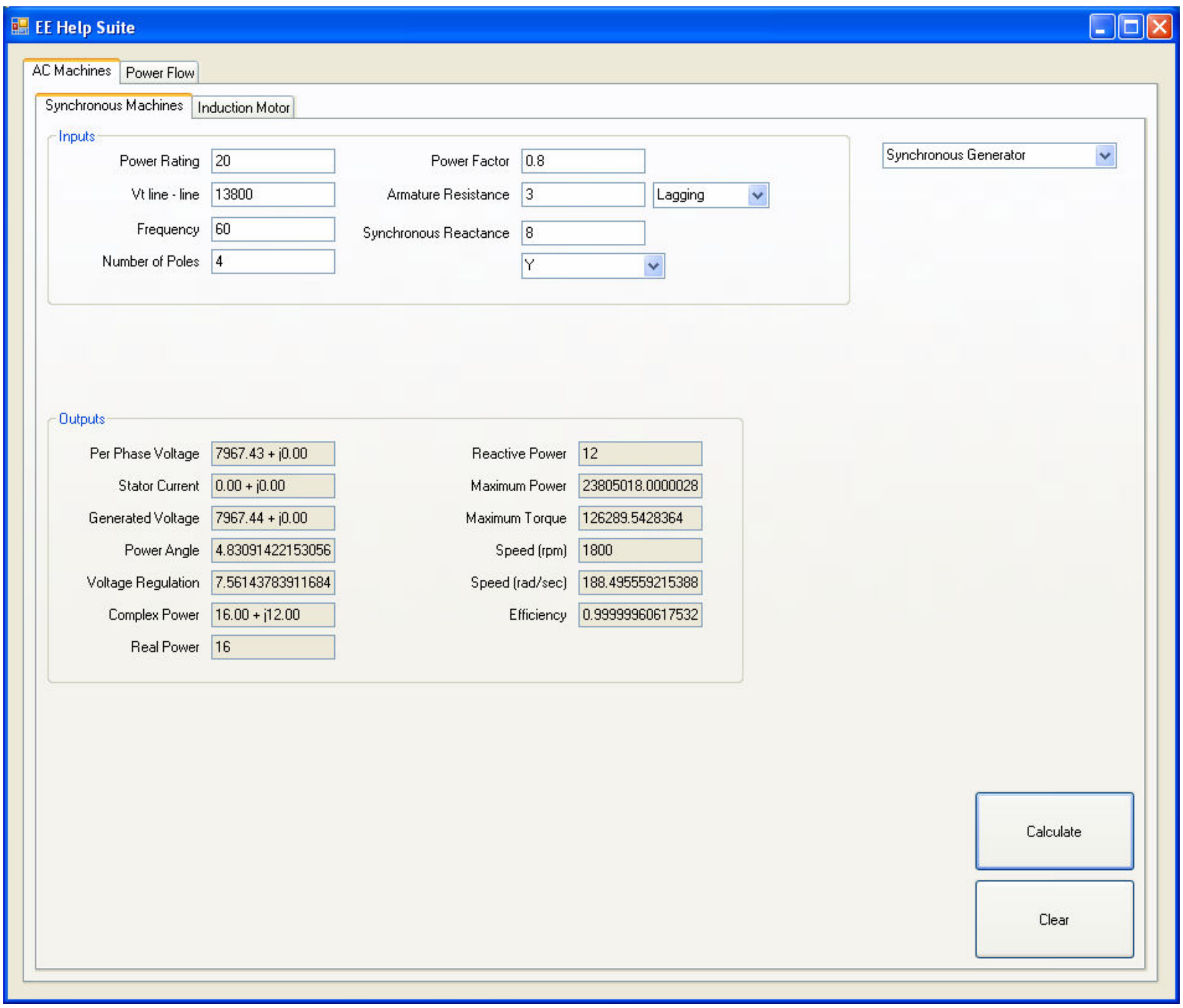

Figure 4_Output of Synchronous Machine

e. Induction Machine Test

Example:
A three-phase. 5-hp, 208-V, four-pole, 60-Hz induction motor is subjected to a no-load test at 60 Hz, a blocked rotor test at 15 Hz, and a DC test. The following data are obtained.

	No-Load	**Blocked Rotor**	**DC**
Voltage (V)	208	35	20
Current (A)	4	12	25
Power (W)	250	450	

Determine the parameters of this induction motor and the involved electric quantities.

After students enter the given values, the output which is the solution of this problem will be shown as shown in figure 5.

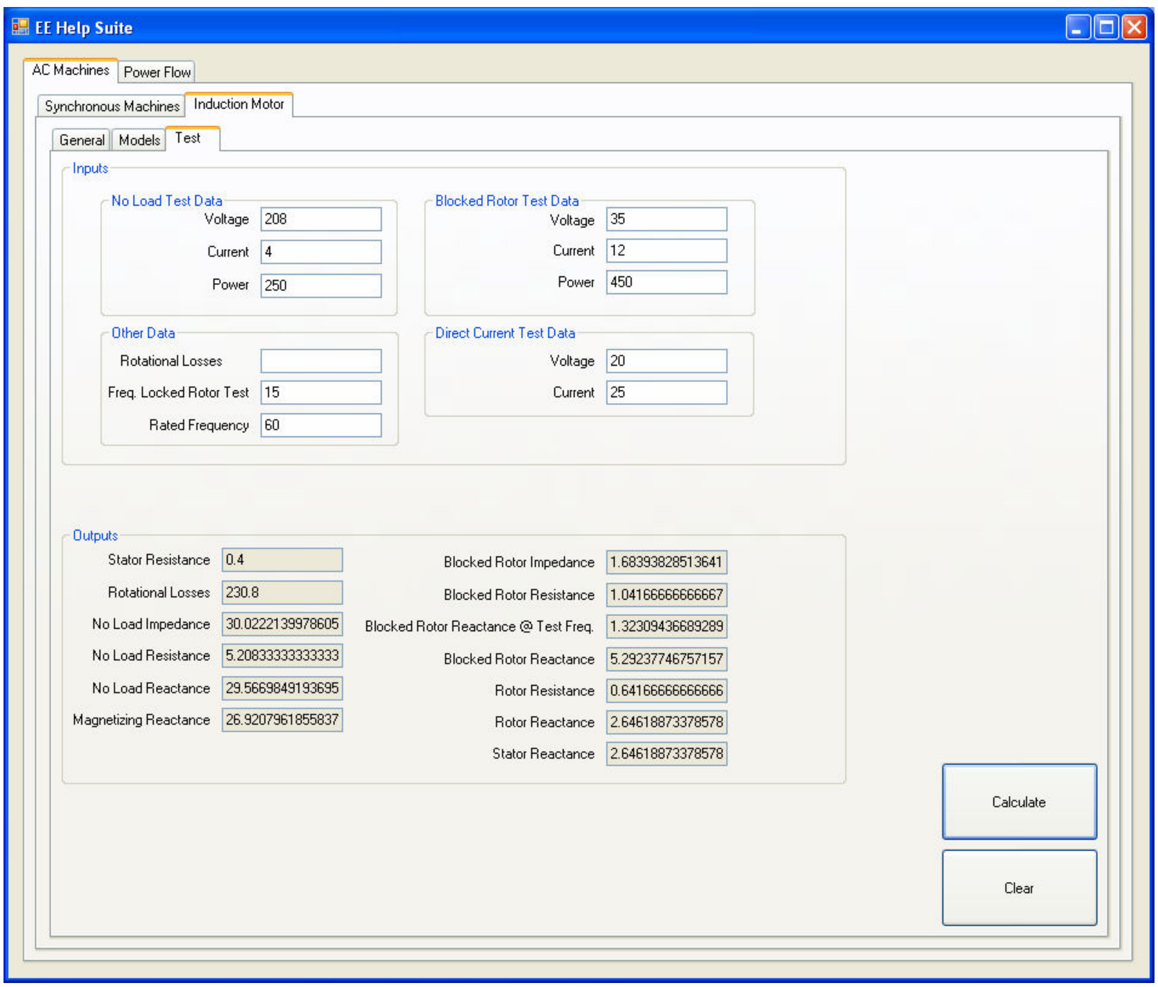

Figure 5_Output of Induction Motor Test

f. Induction Machine Characteristics

Example:
A three-phase, 25-hp, 440-V, 60-Hz, four-pole, induction motor has the following impedances referred to the stator in $\Omega / phase$.

$$R_1 = 0.50 \quad R_2 = 0.35 \quad X_1 = 1.20 \quad X_2 = 1.20 \quad X_m = 25$$

The combined rotational losses amount to 1250 W. For a rotor slip of 2.5% at rated voltage and rated frequency, find all involved electric quantities in this motor.

After students enter the given values, the program will solve and obtain the solution of this problem as shown in figure 6.

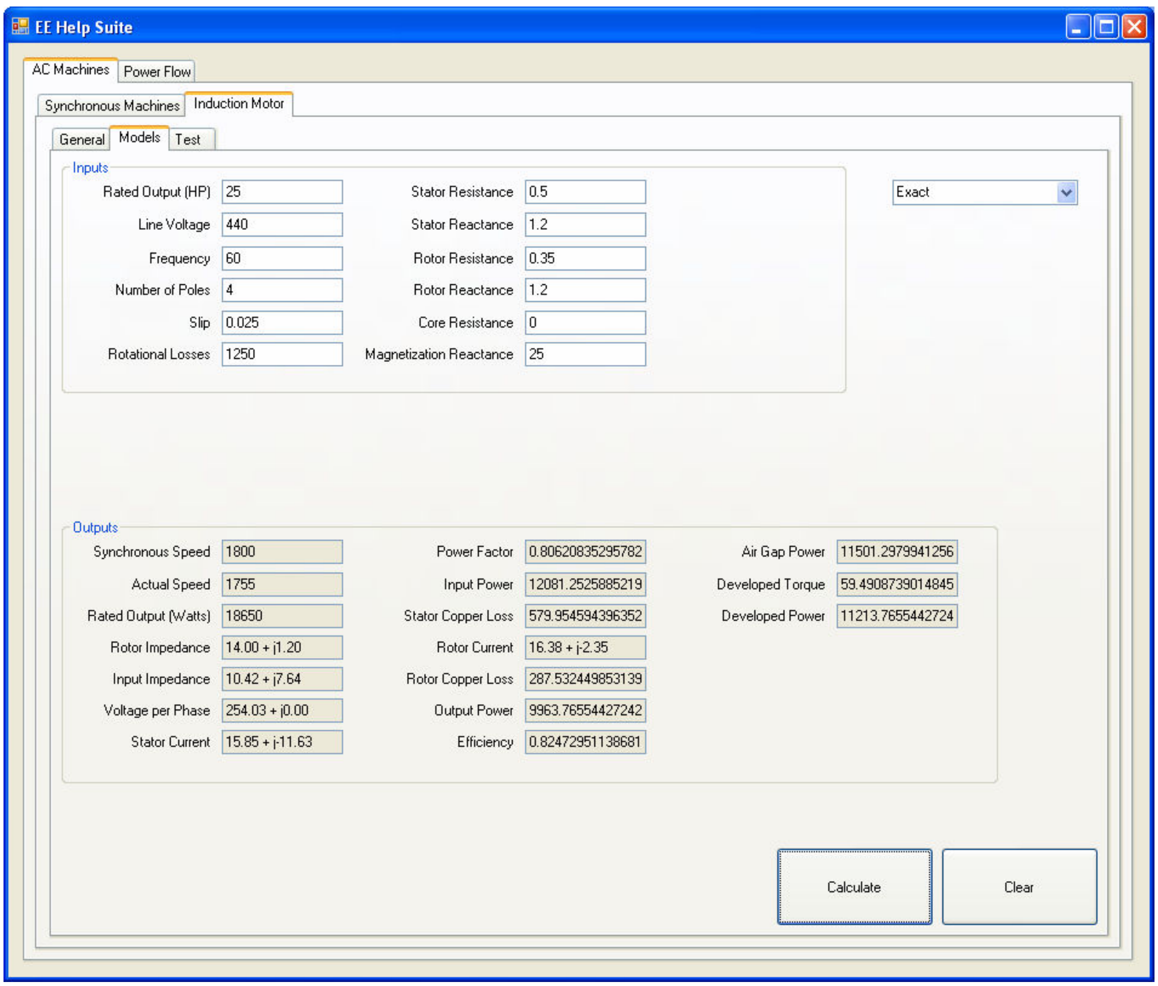

Figure 6_Output of Induction Machine

g. Induction Machine General Case

Example:
A 5-hp, 220-V, 4-poles, 50 Hz, Y-connected induction motor has a full-load slip of 4 percent. Find:

1. The synchronous and the actual speed of the motor.
2. The rotor frequency.
3. The slip speed.
4. The output power of the motor in Watts.

After students enter the given values, the program will solve and obtain the solution of this problem as shown in figure 7.

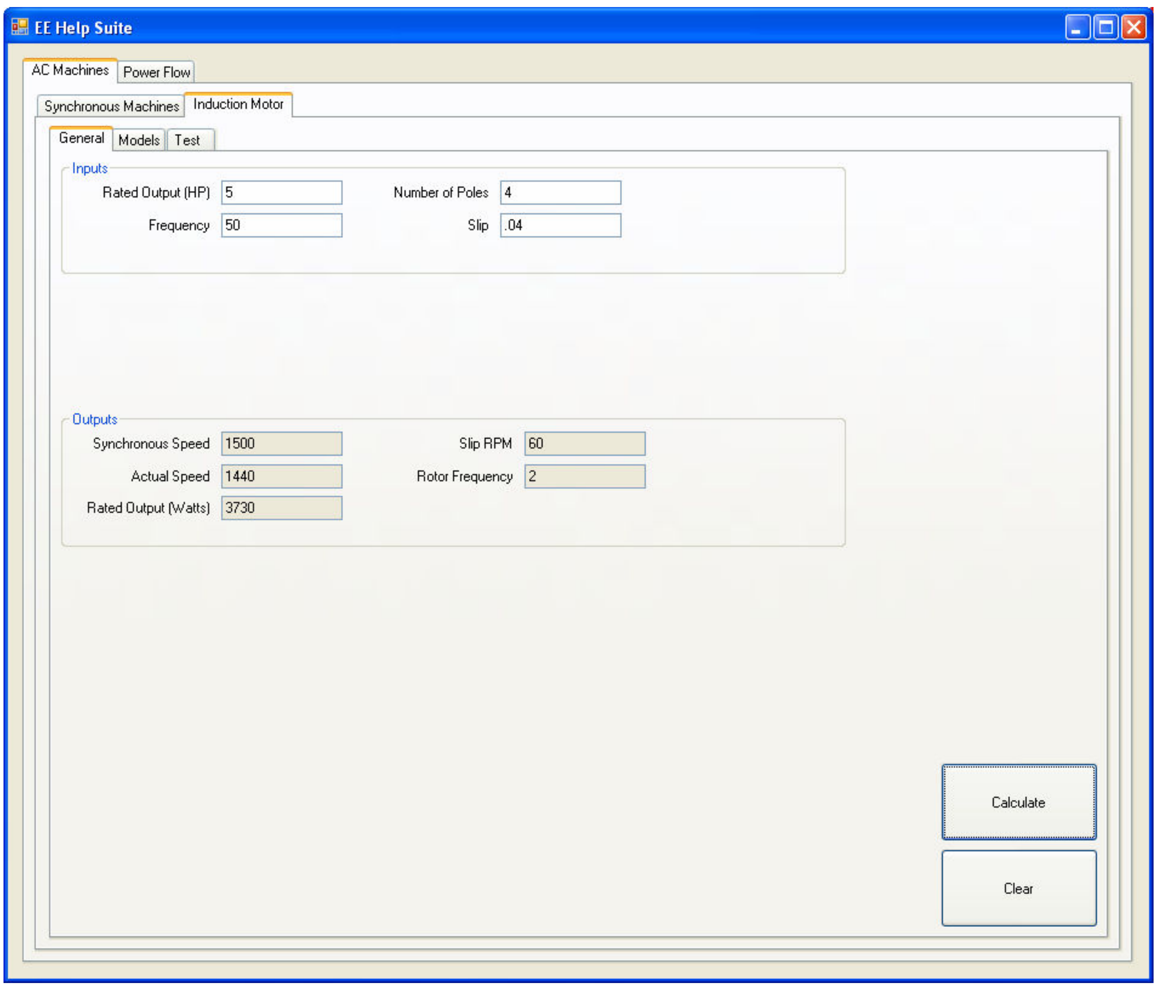

Figure 7_Output of Induction Machine General Case

h. Three Phase Circuits

Example:
A balanced abc-sequence Y-connected source with the phase voltage at the source end of $\tilde{V}_{an} = 120\angle 10^{o}$ V is connected to a- Δ connected balanced load $15\angle 36.87^{o}\,\Omega$ per phase through a transmission line of $0.134\angle 63.4^{o}\,\Omega$. Calculate the electrical quantities involved in this system.

When students enter the given values in the problem into the specified cells and choose the specific connections for the load and for the source as shown and then click “calculate”, the program will output all the required quantities as shown in figure 8.

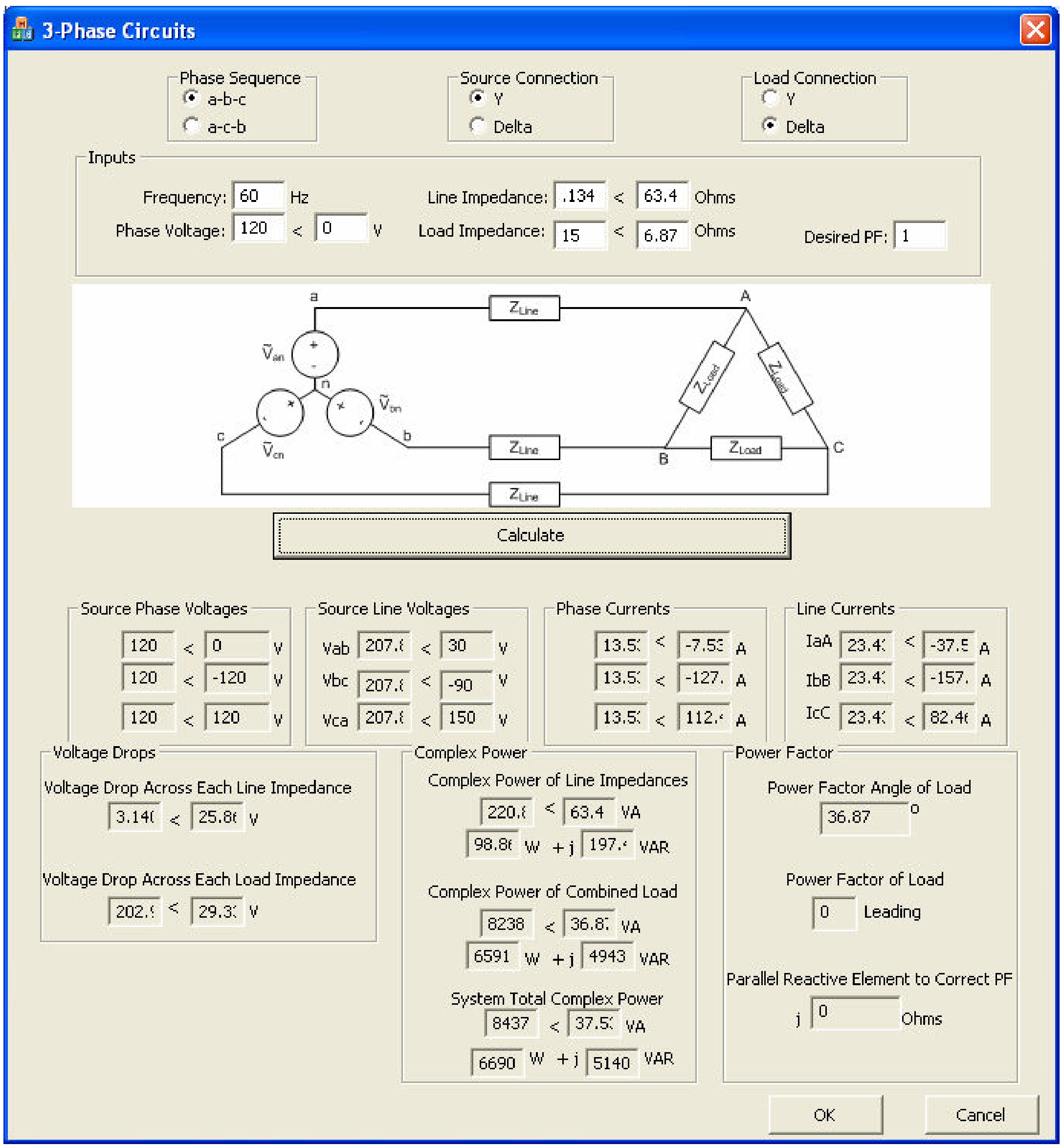

Figure 8_Output of a Three phase Y-Delta connection

i. Transmission Lines

Example:
A 60-Hz, three-phase transmission line is 125 miles long. It has a total series impedance of $35 + j40\ \Omega$ and a shunt admittance of $930 \times 10^{-6} \angle 90^{o}\ S$. It delivers 44.4 MVA at 220 kV and 0.9 power factor lagging. Determine

1. The transmission line parameters.
2. The sending end voltage.
3. The sending end current.
4. The sending end power factor.
5. The voltage regulation.
6. The efficiency of the line.

First, students need to specify the model of this transmission line based on the given length. In this case the transmission line has a medium length and the medium model is selected. Second, student need to specify that the given values in the problem correspond to which end. In this case they are given at the receiving end of the line. Then they need to insert the given values into the specified cells and choose the power factor if it is leading or lagging as shown and then click "calculate", the program will output all the required quantities as shown in figure 9.

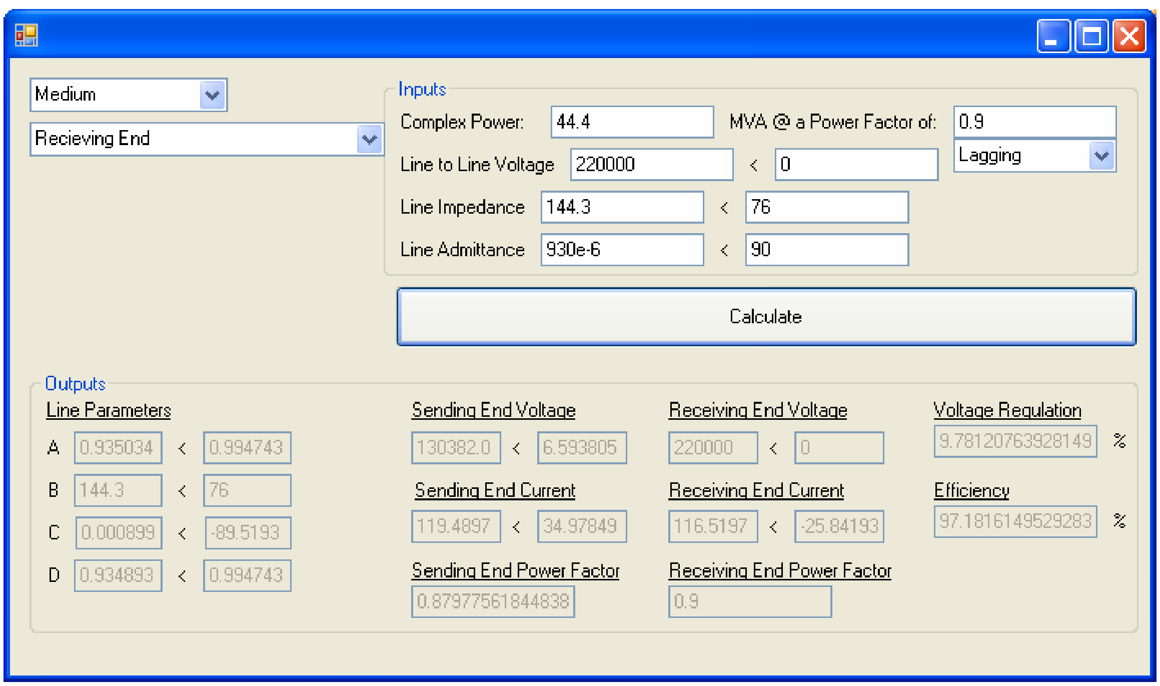

Figure 9_A medium length transmission line

Data Collection and Assessment Method

The participants completed a survey and questionnaires based on their attitude toward the use of the developed software tool.

1. Participants

The pool included fifteen students enrolled in the course at Ohio Northern University. There were 80% male and 20% female. All participants were junior standing. Students have classified themselves regarding computer knowledge based on a score ranges from 1 to 10. There were 40% considered their level of computer knowledge to be 7, 47% higher than 7 and 13% below 7.

2. ***Measures***

The primary assessment goal was to measure the attitude of students toward this teaching tool. In order to perform this assessment, a survey that consists of 11 questions was distributed to students at the end of the quarter. The survey sheet is shown in Table 1.

Students were asked to indicate their level of agreement on each statement of the survey using a five-point Likert scale with higher values indicating greater levels of agreement with the statement. The scale is defined as1 for strongly disagree, 2 for disagree, 3 for neutral, 4 for agree and 5 for strongly agree. This methodology is often used to ensure that participants make at least some commitment toward attitude.

3. Results

1. Statistical Results

The data obtained from the students is shown in Table 2. As shown, the average of student's computer knowledge came out to be 73%.

As a result of the survey, the response average of each question is calculated and is shown in Table 2. The majority of students have indicated that they have enjoyed learning using this instructional tool (80%). (73%) of students supported the idea of media based instructional tool. Majority of students felt comfortable with the instructional tool (67%). Majority of students expressed that they felt relaxed when using this instructional tool (73%). All students believed that it is very important to know how to use variety of software. 40% of the students believed that they have concentrated better using this instructional tool while 60% were neutral. 73% of the students believed the instructional tool has accelerated the learning process and they learned more using this instructional tool compared to textbooks with same content. Majority of students agreed that they have engaged in the learning process (80%). Approximately 93% of students believed that the media based instructional tool has motivated them to work out some more problems related to the material. Statistically, the results show that students are in favor of using such tool to help them in understanding the material of the course. The most important point here is that it motivated them to do more like homework problems and see if they got the answers right.

Table 1_ Survey Sheet

ECCS 338 ELECTRIC MACHINES AND POWER SYSTEMS

Survey of Students' Attitude toward EMPS Software

In a 1 to 10 scale, I consider my computer knowledge at	

Please circle one answer for each of the following questions:	SD	D	N	A	SA
1 I enjoy learning using media-based instruction	1	2	3	4	5
2 I believe that the more teachers use media-based instruction, the more I will enjoy learning	1	2	3	4	5
3 I feel uncomfortable learning material using media-based instruction in my own time	1	2	3	4	5
4 I feel nervous when I know that I need to use technology related instructional material	1	2	3	4	5
5 I believe it is important for me to know how to use variety of software	1	2	3	4	5
6 I concentrate better when a media-based instruction is used	1	2	3	4	5
7 Learning the course content is faster using this software compared to traditional method	1	2	3	4	5
8 I can learn more from this software than from traditional textbook with same content	1	2	3	4	5
9 Using this software improved my engagement in the learning process	1	2	3	4	5
10 Using this software motivated me to solve more problems related to the course	1	2	3	4	5

Table 2 Data of Students Response

Student	Sex	Computer Knowledge	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
1	F	8	5	5	2	1	5	4	4	4	4	5
2	F	9	5	5	1	1	5	4	5	5	5	5
3	F	7	4	4	2	2	5	3	4	4	4	5
4	M	8	4	4	2	2	5	3	4	4	5	5
5	M	8	4	5	1	1	5	4	5	5	5	5
6	M	8	5	4	2	1	5	4	5	5	5	5
7	M	8	5	4	2	2	5	3	4	4	5	5
8	M	8	4	4	3	2	5	3	3	3	3	4
9	M	7	3	3	4	3	5	3	3	3	3	4
10	M	7	4	4	2	1	5	4	5	5	4	5
11	M	7	4	4	2	1	5	3	4	4	5	5
12	M	7	4	4	2	2	5	4	4	4	4	4
13	M	7	3	3	4	3	5	3	3	3	4	4
14	M	6	4	3	3	4	5	3	4	4	5	4
15	M	5	3	1	5	4	5	3	1	1	1	3
Average		7.33	4.1	3.8	2.5	2	5	3.4	3.9	3.9	4.1	4.53

2. *Students Comments*

At the back of the survey sheet, students were asked to write comments regarding the developed software tool. The comments of students included the following:

- In general, it all depends on how the information is presented. I believe a teacher will be able to teach me better while some stuff would be easier to learn through a media representation.
- I like being able to see visually what is being done rather than reading where you don't see the results as quickly as the media allows.
- This software tool helped clarify a few things, such as the relationships among parameters.
- This software helped me to do more problems. It is advantageous to learn by doing.
- This program would not only save time but also allow for a better understanding of the parameters relationship and it really caught me many times with mistakes when I solved my homework problems. I checked my solution and found the mistakes.

Based on the statistical data and the comments obtained from students, the developed software tool is proven to be an effective learning tool that has worked for majority of students. Students were satisfied with the instruction, and the access to the tool.

Conclusion

The software tool was designed to help students in solving problems related to electric machines and power systems. The information and data collected from the surveys were analyzed and used for the assessment and evaluation. Students have responded favorably to and expressed their satisfaction in the developed tool. I believe that the media based instructional tool offers some advantages such as it is a completely learner-paced, it can be followed easily, it does not require a great deal of time or effort and the learner does not have to be at a specific time and place to use it. In the course, Electric Machines and Power Systems, it is no longer necessary to devote additional classroom or laboratory time to provide and solve examples; students can do those on their own time.

Finally, since the role of instruction is not to distribute facts but to grant students with ways to assemble knowledge, educators must find favored strategies that build students' confidence and enhanced course relevance. This can be achieved through the continual investigation of appropriate ways to introduce new technologies into the classroom.

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