A Knowledge Capturing Integrated Design Environment
for a Course in Electrical Circuits

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Abstract

Software tools have become a major and necessary part of the world of the working engineer. In fact, courses in electrical circuits involve the use of an ever increasing array of software tools. Word, Excel, Power Point, PSpice, and MATLAB represent some of the most commonly used programs. It is extremely important to integrate these together into what is called an integrated design environment. In addition to organizing them into an easy-to-use environment, the information generation by their use must also be captured and captured in an intelligent manner. This knowledge capturing integrated design environment, or KCIDE, becomes a working platform that students can readily use. Besides, the software follows a six-step procedure in solving circuit problems, which gives students a reference framework for problem solving.

The development and utilization of the KCIDE software platform are explained. The design and implementation of the KCIDE software are also discussed. In addition, all the basic concepts can be expanded into the more complex world of the working engineer where laboratory results can also be integrated. Future extensions and advanced features of KCIDE that are being developed are also introduced. An additional benefit to using such a platform is that it makes assessment a much easier task.

It is intended that the KCIDE software will be made available to all conference attendees who wish to have it.

1. Introduction

The objectives of the Knowledge Capturing Integrated Design Environment (KCIDE) for a course in electric circuits are:

1. To provide a software platform that facilitates the learning of electric circuit concepts
2. To help instructors and students gain insights into the learning process.

The following requirements are proposed for KCIDE:

1. It should integrate all tools necessary for a course in electrical circuits. Students must be able to solve homework problems without leaving KCIDE.
2. It should enforce a 6-step problem solving process.

3. It should capture the problem solving techniques and reasons for selecting such techniques.

We identified PSPICE, Excel, MATLAB, Word, and PowerPoint as the essential software tools for a fundamental course in electric circuits. PSPICE is used for drawing and simulating circuits, while Excel and MATLAB for solving mathematical equations. Word and PowerPoint are for documenting the steps in problem solving as well as presenting results.

The 6-step process to solve electric circuit problems is thoroughly discussed and extensively demonstrated in Alexander and Sadiku. Developing a facility with this process is one of the main goals of the textbook. By strictly following the same process, KCIDE reinforces the core concepts. Details of the 6-step process are briefly discussed in Section 3.

As mentioned, KCIDE lets students document their work in Word or PowerPoint. The whole 6-step process, the techniques used and reasons for using them, are put into a Word document or into PowerPoint slides or both.

2. Background

Many studies have been conducted to develop an integrated environment for design, learning, and teaching. Various tools have been integrated into these environments.

Fricks et al. proposed an integrated design environment for the assessment of computer systems and communication networks. In its core, it integrates four software tools, SHARPE, SPNP, D-SPNP, and FSPN.

Djordjevic et al. presented an integrated education environment for teaching courses in computer architecture and organization. It includes: Integrated Educational Computer System (IECS), Software Package of the Integrated Educational Computer System (SPIECS), and Computer Architecture Learning and Knowledge Assessment System (CALKAS).

An integrated program development tool, FLINT, was developed by Ziegler and Crews. FLINT supports the entire process of design, implementation, testing, and debugging. Students receive feedback on their work from FLINT for improving their programming skills. A unique feature of FLINT is that it helps both teachers and students by recording the activities of students.

Mohd et al. developed a tool called Sigma Solution Digital Designer and Simulator which helps students gain practical knowledge in designing digital circuits without the need of costly lab instruments. The tool supports the digital design process, from truth table generation to circuit building and simulation.

Ma and Babelon developed a tool called MECHAMOS, which integrated a multi-body system analysis tool and a CAD system. I-DEAS is the tool used for solid modeling and animation. C++ routines are provided as the interface between MECHAMOS AND I-DEAS.

3. Design of KCIDE

The architecture of KCIDE is shown in Figure 1. The system contains a main module, and six components, one for each step of the 6-step process: DEFINE, PRESENT, ALTERNATE SOLUTIONS, ATTEMPT, EVALUATE, and REWORK/EXPORT.
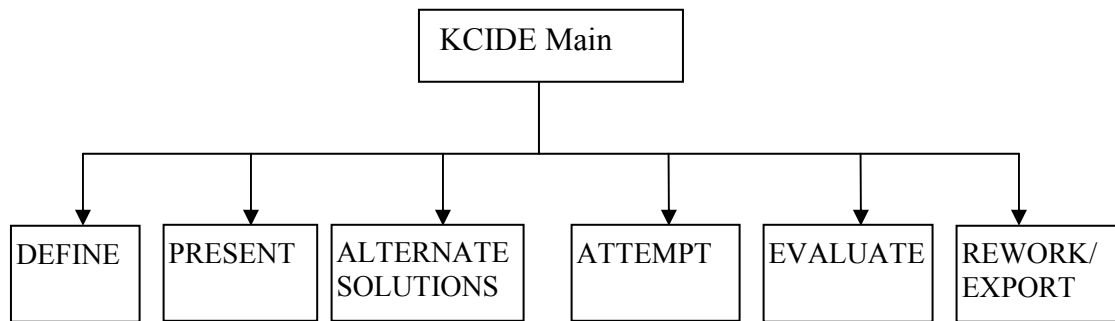

Figure 1. Architecture of KCIDE.

In DEFINE, students use PSpice software to draw the circuit diagram. After drawing the circuit diagram, they give initial findings of the problem in PRESENT, which includes the number of nodes and the number of loops. The circuit diagram will be saved for future simulation to verify their answers.

In the next step, ALTERNATE SOLUTIONS, students will select a particular method of problem solving and give reasons for that particular selection. A broad range of approaches to aid in solving circuit problems may be selected from Ohms Law to Series Impedance. After the selection, students must provide a reason or reasons for the selection. A set of possible reasons are given in KCIDE. Students can give their own reasons too.

In ATTEMPT, students will present important steps and equations used in solving the problem. Once they arrive at the final set of equations, they can solve the equations by hand or employ additional software such as Excel. Currently, Excel is the only such software package integrated into KCIDE. MATLAB will be integrated in the next version.

After obtaining the final answers, the next step, EVALUATE, checks the final answers with simulation results from PSPICE. The circuit diagram drawn in the Define step is simulated and simulation results are obtained by placing viewpoints and current probes throughout the circuit.

In the last step, REWORK/EXPORT, KCIDE asks whether the results obtained are satisfactory, i.e., if they match simulation results and the expectations of the individual assigning the problem. If the answer is no, students will be prompted to rework the problem, where they will be taken back to the Alternate Solutions step and continue from there. Otherwise, KCIDE lets students export their entire activity into a Microsoft Word and/or PowerPoint document.

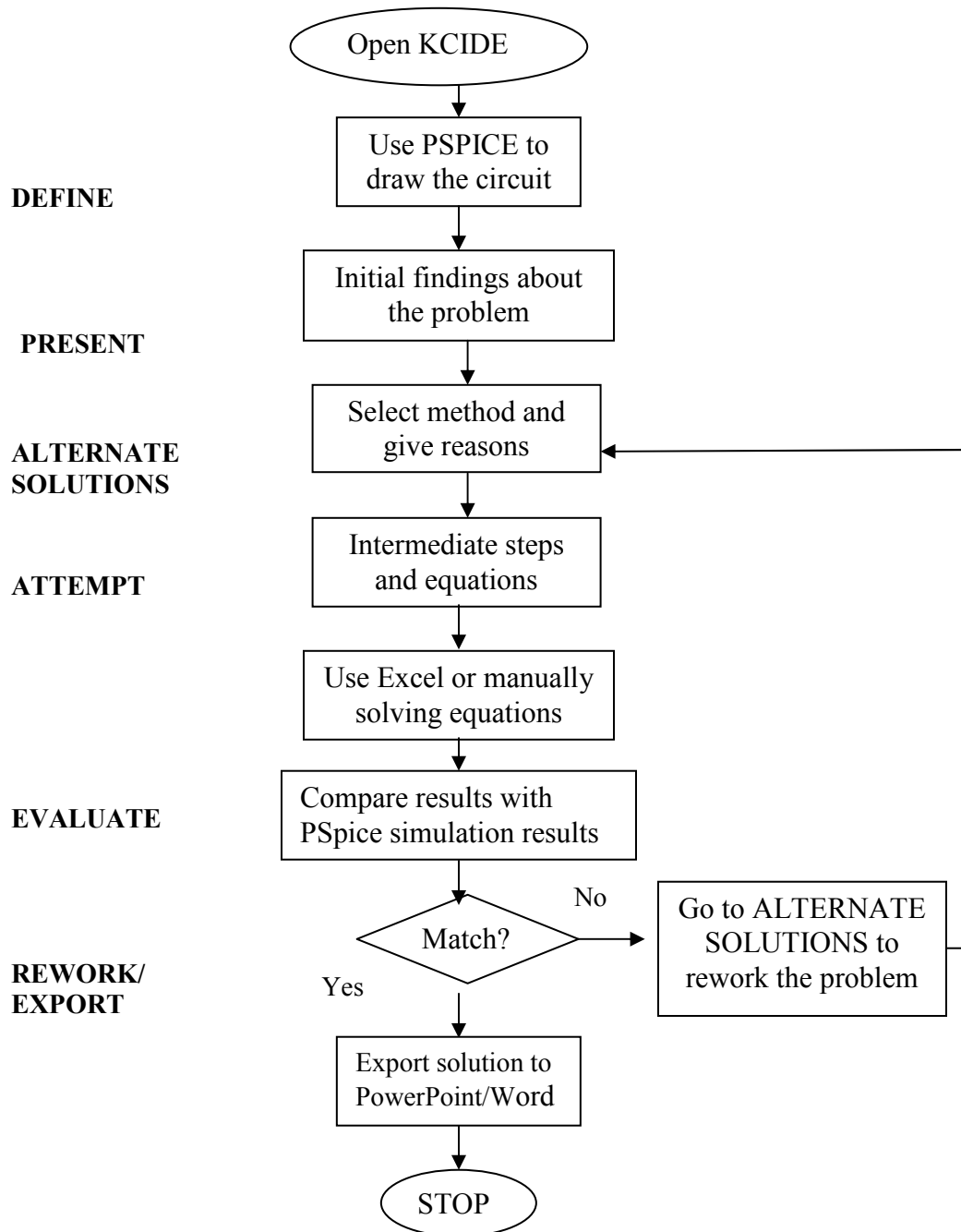The control flow of KCIDE is shown in Figure 2.

Open KCIDE

DEFINE

Use PSPICE to draw the circuit

Initial findings about the problem

PRESENT

Select method and give reasons

ALTERNATE SOLUTIONS

Intermediate steps and equations

ATTEMPT

Use Excel or manually solving equations

Compare results with PSpice simulation results

EVALUATE

Match?

No → Go to ALTERNATE SOLUTIONS to rework the problem

REWORK/ EXPORT

Yes

Export solution to PowerPoint/Word

STOP

Figure 2. Control flow of KCIDE.

4. Implementation

The first prototype of KCIDE has been implemented using Visual Basic.Net. It works with PSPICE version 9.1 and Excel, Word, and PowerPoint in the Microsoft Office XP version.

Figure 3 shows a screen shot of the DEFINE step. As shown in the figure, KCIDE integrates PSPICE for drawing circuits.
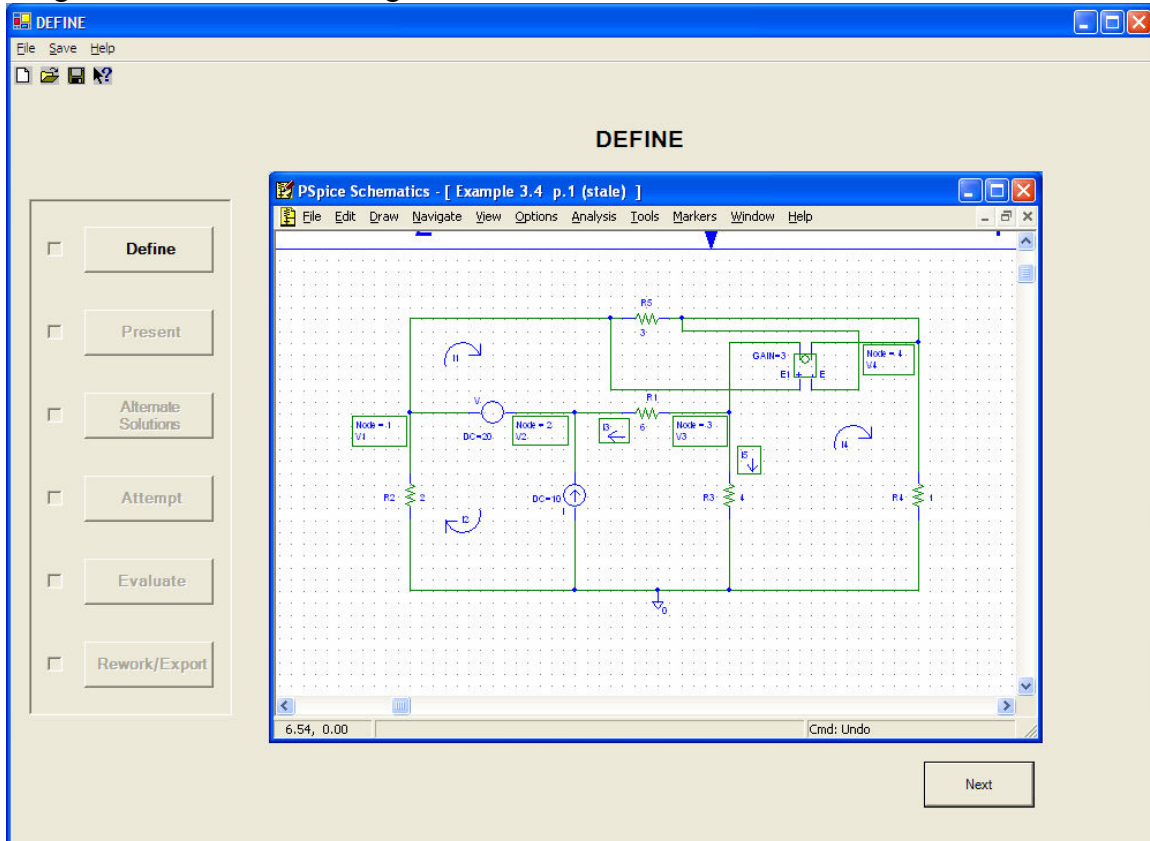

Figure 3. Screen shot of DEFINE step.

Figure 4 shows a screen shot of KCIDE at the EVALUATE step. The final results obtained from either Excel or by hand, are compared with simulation results from PSPICE.
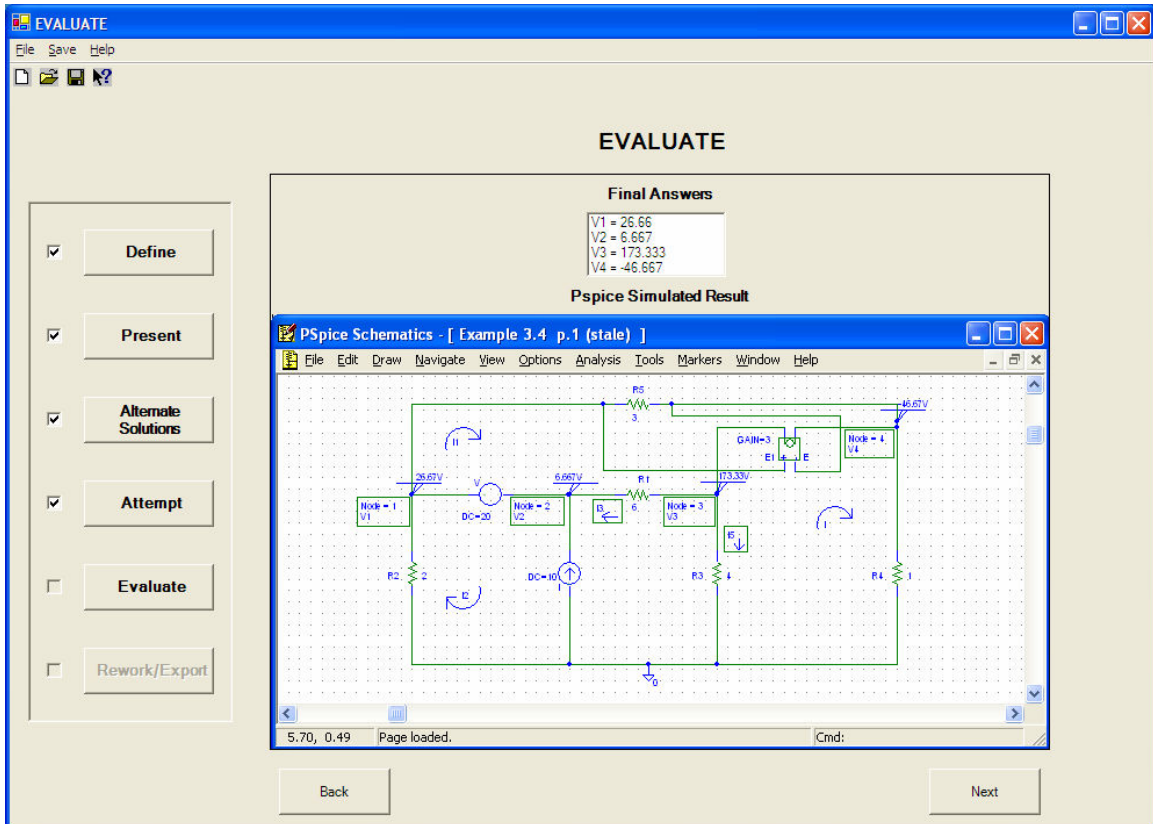
Figure 4. Screen shot of EVALUATE step.

5. Conclusions and future work

A knowledge capturing integrated design environment (KCIDE) for a course in electric circuits has been developed. KCIDE integrates software tools necessary for circuit problems, including PSPICE, Excel, Word, and PowerPoint.

The first prototype was given to students in a first semester sophomore circuits course in December 2004. Feedback is currently being compiled and will be made available by May, 2005. Some students expressed interested in using KCIDE for their homework.

The next version of KCIDE will integrate MATLAB. In addition, the version of the KCIDE platform for circuits, will be available in June, 2005. The new version will work with PSPICE version 10.0 and version 9.2.

Another extension of KCIDE is to make it a client server application as well as a desktop application. Such an architecture will allow us to capture and analyze problem solving process with more details.

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