Teaching Required Electronic Courses with the Support of TK Solver

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Only two electronics courses are required in our curriculum. I teach both of them on a rotational basis with two of my colleagues. These courses are:

- EE 3310 Introduction to Electronics
- EE3330 Linear Electronics Design
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I also teach several elective electronics courses:

- EE 4330 Electronic Systems Design
- EE 4560 Power Electronics
- EE 4250 Network Synthesis

The main software packages I use in these courses are: PSpice, TK Solver, and SigmaPlot. I also use (in some degree) Excel and Quattro Pro. I use TK Solver while teaching all electronics courses and also other courses like ES 2210 Electric Circuits Analysis, and EE 3150 Electromagnetics, but here I will write only about the role of TK Solver in EE 3310 Introduction to Electronics.

Based on a number of factors, I concluded that I had to develop a new method of teaching electronics courses which would be based on my work in electronic hardware. I started to use my analytical descriptions of electronic circuits in teaching. Developing a mathematical model of an electronic circuit and its verification with TK Solver is an important part of these descriptions. In this method the mathematical model and values of parameters must be precise, which is not easy to achieve but is very rewarding when working in laboratory. In order to get everything right it is necessary to use data-books and PSpice to obtain the right functions and parameters, which needs to be done primarily by the instructor.

My mathematical models of electronic circuits became part of my courses. My TK Solver files are available to the students. By my request our computer laboratory has been equipped with copies of the student version of TK Solver. This became the core of my teaching method, and provides students the opportunity to analyze and design electronic circuits, in contrast to many electronics textbooks that often contain dozens of electronic circuits with very limited explanation and no information on how to analyze and design them.

A significant improvement in the quality of teaching the EE 3310 course has been made by the teaching assistant, Brian W. Zuelke (see below). He developed a new method of teaching laboratory for the EE 3310 course and implemented it in the Fall of 2008. In the laboratory students learn how practical electronic circuits behave, how to design and test them, and how to document their work in the laboratory. His method is tightly bonded with lectures. In special laboratory sessions students are instructed how to use instruments available in laboratory as well as how to use PSpice and TK Solver.

Now I can freely use TK Solver for demonstrating mathematical models of electronic circuits during my lectures. A simple one transistor amplifier is described by a set of ten or more simultaneous equations, including nonlinear ones. To make full use of these mathematical models, exams of the required electronics courses take place in our Computer Networks Laboratory. During an exam students can use computational tools of their choice, calculators or TK Solver, depending on what is faster to use for a specific task. Students email their TK Solver files to the instructor as a part of the documentation of their work on given problems.

TK Solver Models Power Supply in Introductory Electronics Course

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During the school year of 2008, I came up with the idea of modeling a simple power-supply using TK Solver for the sake of laboratory instruction. This design was comprised of a full-wave rectifier circuit which would perform the bulk of conversion from AC to DC power, as well as a Zener diode shunt voltage-regulator which would source a nearly constant 18V, with the capability of sourcing a maximum of 20mA current.

The primary impetus of designing the power-supply using TK Solver came from a detailed analysis of a full-wave rectifier performed by Dr. Legowski, which I immediately saw could be implemented in the program for the sake of predicting waveforms. My additions to the analysis came in the form of:

(a) Replacing ideal diode models with piece-wise linear models for the sake of more accurate behavior-prediction; and,
(b) Adding a Zener shunt regulator design for the sake of creating a full power-supply.

While continuing my work designing and implementing the TK Solver files that would model the behavior of the power-supply, many advantages of the program made themselves clear to me. For instance, a piece-wise linear diode model requires a designer to choose an approximate operating point of the diode around which it will function. One advantage of TK Solver is that I could have it search for this diode operating point according to the constraints provided in the file. Without this capability, I might have chosen an improper operation point. Another advantage was the ability to switch design constraints around at will. If, for instance, I chose a certain rectifying-capacitor value and calculated the resulting voltage-ripple, I could also reverse this by choosing a certain voltage-ripple and having the sheet calculate a proper rectifying-capacitor value.

Above all, TK Solver gave me the ability to show students how to model an entire electronic system using numerous non-linear relationships, something that they had never seen before and probably otherwise would not have seen during their undergraduate education. Introducing students to mathematical modeling and design through the use of TK Solver should give them a strong advantage in their future studies and careers.