Engineering Educator

The latest news about teaching tools, measurement technologies and innovations in engineering education

A Miraculous Teacher

Marsh Faber, Editor

Mr. Slocum. Professor Wheeler. Professor Budak. All of us remember that one miraculous teacher who shaped our thinking more than any other. In my career I've been fortunate enough to know several academic icons. One was Prof. Robert Quinn, who had more influence on the Agilent Technologies Education program than anyone else outside the company. I first met Bob Quinn in 1993, when he, Eli Fromm and others were redefining "The Art of Engineering" at Drexel University. At Agilent (then 'HP'), we were creating an education program and we were looking for a visionary. We got lucky.

Watching Bob Quinn in front of a class was like watching Mel Gibson do Hamlet—formal education for normal people. He made engineering relevant to a wide audience. A rocket scientist educated by Capuchin scholars, Bob was equally at home in the research lab and in the classroom. He used to say, "When these kids leave Drexel, they're going to be able to do two things. They're going to be able to SPEAK and they're going to be able to WRITE." (Bob often spoke in capital letters.)

Bob Quinn passed away this past February, and I'm sure his "kids" are still speaking and writing about him. He was my mentor and a dear friend, a leprechaun who was passionate about hands-on learning. The lab was his classroom and his love. In honor of his contributions to the field of engineering education, and his guidance in helping us design a program truly relevant to educators, Agilent Technologies is proud to sponsor the Robert G. Quinn Award, to be presented annually by the American Society for Engineering Education (ASEE). The ASEE Division for Laboratory Oriented Studies will select the recipients.

True to Bob's example, the award will be given to the educator who demonstrates exemplary leadership in the field of engineering education. The person's work will be judged on attributes of hands-on and peer-to-peer learning, reach, innovation and relevance to the real world.

Who knows? Down the road, we might be presenting the award to one of Bob's former "kids."

Thanks, Bob. We all miss "The Mighty Quinn."

Marsh Faber
Education Marketing Manager
Electronic Products and Solutions Group

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Share Your Thoughts

We received several responses to the Women in Engineering articles we ran in the last newsletter. The responses were bipolar:

He said:

Hope the information content of your new look isn't typical of the future. Social "engineering" is not my thing — The issue was saved by the AM lab.

Dr. William Thornton
University of Texas, Medical Branch

Leave the social/political issues to others...There should be no gender issues at all in engineering.

Prof. G.J. Gerard
Gateway Community Technical College

She said:

The issue brings up the topic of helping women become engineers. I have been in the field for many years and that has been my main task! Keep working on this subject. Young women need all the help they can get.

Dr. Estela Llinas
University of Pittsburgh

I liked the focus on women and helping women students to succeed in engineering school. We have an organization on our campus called WEST (Women in Engineering, Science and Technology) and information on mentoring women is important to us.

Prof. Elaine Klett
Brookdale Community College

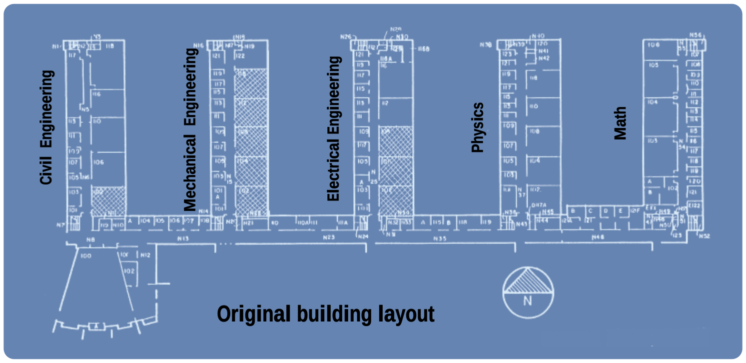
The articles on Women in Engineering were precipitated by, among other things, the difficulties we encounter when trying to recruit women engineers into Agilent Technologies. It is important for us to build a diverse engineering base, and we're not the only company facing this problem. We won't turn the Engineering Educator Newsletter into a vehicle for "Social Engineering," but we do have a genuine need that is not being met by the system.

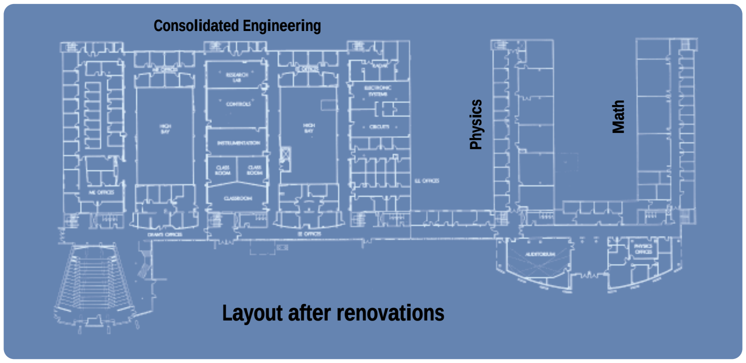
Marsh

In This Issue

This newsletter, as well as the Agilent Educator's Corner web site (***www.EducatorsCorner.com***), is intended to help you, the educators responsible for shaping students into competent engineers. But to do a good job of meeting your needs, we ask for your feedback. Please e-mail your comments, questions and concerns to *marsh_faber@agilent.com*

New Building Breaks Down Walls Between Engineering Disciplines





When Colorado State University's engineering building was erected in 1958, it had no women's restrooms, apparently because its designers believed there would never be women engineering students or faculty to use them. The problem was relatively easy to remedy as women entered the field in increasing numbers.

A bigger problem with the building's design, also indicative of the prevailing mindset of the time, was its isolation of the various engineering disciplines in separate wings. Civil, mechanical and electrical engineering departments each occupied a long, 3- to 4-story, north-south wing. A single east-west corridor connected the three wings.

"It was clear from the design that mechanical engineering didn't want to have anything to do with electrical or civil engineering and vice versa," said Mechanical Engineering Associate Professor Patrick Fitzhorn. "There was virtually no connectivity between the wings and almost no cross talk among the faculty and students."

Industry teams set example

When the time came to expand and renovate the CSU engineering building, faculty members decided it was time to literally and metaphorically break down the walls between the engineering disciplines.

"In today's industry, there is no concept of separation of disciplines," explained Fitzhorn, a former Hewlett-Packard engineer. "Everyone works together."

Recognizing that their students would be working in collaborative environments when they graduated, CSU faculty opted for a flexible, integrated building design that would support and encourage interdisciplinary interaction among students.

"Remove the obstacles and stand back. The results are astounding."

Patrick Fitzhorn, CSU Engineering Professor with Students

New design encourages collaboration

With the renovation complete, students from a variety of disciplines now share facilities. They work side by side in a new design studio, modeled after a Lockheed Martin lab, surrounded by white boards, state-of-the-art computers and the latest test and measurement instruments.

Design studio planners scattered the test instruments into six design areas, rather than concentrating them into one spot, so that electrical engineering students have to be scattered around as well. "Our goal is to make sure that even if the students aren't working in interdisciplinary teams, they'll be working next to each other," said Fitzhorn. "That way, a mechanical engineering student can look over the shoulder of an electrical engineering student and see what he or she is doing. We want the MEs to look over and say 'Holy smoke! That's what we need.'"

Continued on page 10

Competitions Challenge and Motivate Engineering Students

Jonathan Hurst, a third-year student at Carnegie Mellon University, makes a final adjustment to his team's walking machine, Jim2, which placed first overall in this year's decathlon. Jim2 walks using five actuators moving two independent frames so the main mass of the body is in continuous motion. This allows Jim2 to conserve energy and attain high speeds.

During timed trials, the rhythmic pounding of feet fills the air. Between events, students huddle, dissecting their team's performance and analyzing the competition. Snippets of English, Spanish and French waft through the foyer. An international track meet, perhaps?

It is a track meet, of sorts, but a very specialized one where the participants are not human. In the Walking Machine Decathlon 2000, sponsored by the Society of Automotive Engineers (SAE), undergraduate engineering students from several countries bring their walking machines — robots they've designed and built themselves — to vie for prizes in 10 events.

How competitions help

Dr. Fred Smith, PE, mechanical engineering professor at Colorado State University, organizer of this year's decathlon, explained the value of competitions. "Engineering students learn a lot of fundamentals in a wide variety of fields. One of the most essential aspects of their education is learning to synthesize all of that information into something that is useful, practical and applicable to real-world problems.

"Competitions provide an almost perfect simulation of real-world engineering, in the sense that students have to produce a working product, on a schedule, within a budget, and with all of those constraints that are a part of real-world engineering," said Smith. "They also emphasize communication and cooperation in a team setting, and give students a taste of the competitive pressures typical in the marketplace."

Competitions vs. industry problems

If the goal is to provide an experience as much like those found in industry as possible, why not have students participate in solving real industry problems, instead of competing in events that have little or no practical value?

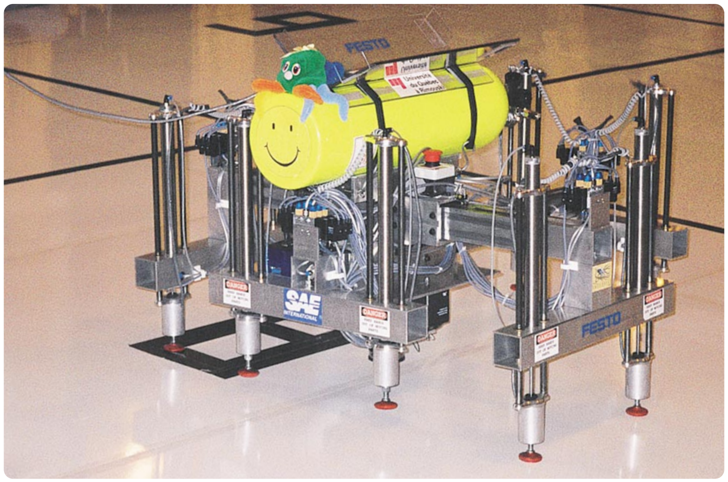
"We've done industry projects in the past," said Smith, "and typically, that doesn't work very well for us. Industry deadlines don't match our schedule of semesters and academic years, and industry deadlines also change. We've had some situations where suddenly our student projects get cancelled in the middle of a semester."

On the other hand, the organizations running student competitions are typically professional societies that are chartered to support engineering education. According to Smith, that means their competitions are more amenable to university environments.

Student perspective

Some of the students participating in the walking machine contest received class credit for their involvement. For many others, however, participation was extra curricular. When you consider the fact that each member of a student team typically spends close to 1000 hours designing, building, programming and troubleshooting his/her entry, you begin to understand the dedication required for this "just for fun" effort.

This robot, designed by a team from the University of Quebec at Rimouski, sports a whimsical grin as it completes the "dash" event. The remote-controlled walking machine features eight independent legs that operate pneumatically.



Ernesto Martinez-Villalpando, a third-year electronics engineering major from the Universidad Bonaterra in Aguascalientes, Mexico, put it this way: "When you love something, you don't care how many hours you work at it. You do it for the personal satisfaction."

The downside of student competitions

If there's a downside to the kind of dedication expressed by Martinez-Villalpando, it's that some students neglect their other courses and activities — even opting to go without sleep — when they are preparing for a competition.

Another downside of competitions mentioned by Larry Carlson, co-director of the Integrated Teaching and Learning Lab at the University of Colorado, is the very fact that they are competitions. "If you have winners, then you have 'losers,'" he said. "We try to emphasize that if you don't win, it doesn't mean you are a loser, but our society certainly interprets it that way. Sometimes, competitions can be divisive and sometimes, they can cause negative feelings."

A negative reaction was not a problem for Simon Dube, a senior engineering student from the University of Quebec at Rimouski, whose team placed third overall in this year's competition. "We didn't come here just to win," he said. "I came here because I love mechanical and electrical engineering. I love to solve problems. I came here because it's fun."

Students are motivated

According to Professor Smith, there's no question that the students are more motivated because they are competing. "I've watched different teams over the years," he said. "As the competition approaches and the deadline gets close, the spirit builds up, the effort level goes up and the commitment to it goes up. There's no question that the competitive nature of these projects has a positive impact."

The *Upside* of Student Competitions

- Simulate real-world engineering challenges
- Motivate students
- Encourage teamwork and communication
- Students learn while having fun

The *Downside* of Student Competitions

- Some students neglect other activities
- Winner vs. loser mentality
- Negative feelings/divisiveness

Lighting a Fire in Education and Business

> **"Education is not the filling of a pail, but the lighting of a fire."**
>
> *William Butler Yeats*

The students we talked to at the Walking Machine Decathlon (see article on page 4) already have it — that inner fire that makes them glow with enthusiasm, curiosity and a love of learning. As educators, one of your biggest challenges is to light that fire in ALL your students. You try to put enough dry tinder in place, then offer them a spark of insight in hopes that it starts a fire that will burn brightly for the rest of their lives. It's not an easy job.

Nor is it easy for a company to do the same for its employees. How do you create an environment that fans the flames so employees have a burning desire to make sure their company succeeds? Where everyone is focused on understanding, anticipating and meeting customers needs? Where employees work with pride and a sense of urgency?

Hewlett-Packard Company took a big stride forward towards creating this "fired up" environment almost a year ago, when it reorganized itself into two separate companies,

One is the $40-billion computing and imaging company, which retains the HP name. The other, Agilent Technologies, is an $8-billion company serving the communications, electronics, life sciences and healthcare markets.

The reorganization has allowed each company to focus on what it does best. At Agilent, this heightened focus, combined with the recent initial public offering on the New York Stock Exchange, has infused employees with the sense of becoming a fast-moving start-up company. With $8 billion in revenue, Agilent hardly qualifies as a small company. But without the enormous computer and imaging business involved, employees get the sense that the company is small enough that a single person or group can actually impact what happens.

According to Agilent Education Program Manager Marsh Faber, that sense of being able to make a difference, combined with a revamped internal organizational structure that mixes new people together, has created a stimulating environment conducive to new ways of thinking — and where people greet change with enthusiasm.

"Agilent employees seem more willing to try new, radical ideas," said Faber. "Having open debate and feeding off of new ideas is turning up new ways for us to help customers. We're moving towards providing 'total solutions' based on sound technology and a real commitment to meeting our customers' needs."

That's what "lighting a fire" looks like in the world of business.

Pulse Width Modulation (PWM) Measurements

Salomón Oldak, Ph.D.
Associate Professor,
Electronics Engineering Technology
DeVry Institute of Technology

Objectives

1. To understand the basics of binary-code-generated PWM signals.
2. To become aware of the time scale measurement tradeoffs that occur in digitally driven control systems.
3. To show a technique for measuring signals operating at significantly different speeds.

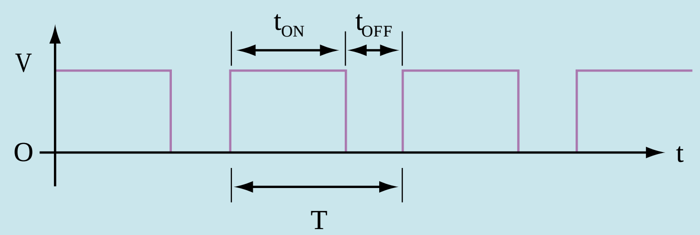


Fig. 1 Pulse width modulated signal

Discussion

Current control systems technology relies increasingly on the use of digital signals to control power devices such as motors, heaters and illumination systems. This is a departure from the past, when controllers were mainly analog. The trend toward digital technology is driven by the ever-increasing computing power in today's microprocessor chips, and the fact that they are rapidly becoming faster and cheaper. The software-based nature of digital controllers is another important reason why engineers choose digital over analog technology.

Although a full discussion on Pulse Width Modulation (PWM) is outside the scope of this article, we will briefly explain the basic principles. PWM is one of the discrete techniques that can be used in a microprocessor to "simulate" a dc signal going into the load to be controlled.

Fig. 1 shows a PWM signal that can be regarded as a square wave with variable duty cycle. Note that the PWM signal has fixed period ($T=t_{ON}+t_{OFF}$) and amplitude (V). The PWM driver varies the proportion of time in which it is in an ON (t_{ON}) and OFF (t_{OFF}) state. The PWM signal period is typically much faster than the dominant time constant of the load, so its net effect is equivalent to applying a dc signal with its average or dc value. The average of the PWM signal will increase when the ON portion of the cycle is increased and vice versa.

PWM technology is commonly used in control systems for some types of loads because of its power efficiency. There are several integrated circuits available to drive and generate PWM signals. Some of them, such as the 123 PWM Demo Module used in this lab, use a binary code to specify the percentage of time the PWM will spend in the ON (or OFF) state. A 4-bit binary code will be used here, so that our PWM has $2^4=16$ different output levels.

The challenge in troubleshooting a digitally driven PWM system is that the generated digital signals may be much faster than the load signals. Thus, as we will illustrate in this lab, when you acquire signals with most oscilloscopes, it can be difficult to observe simultaneously the slow and the fast signals. Fortunately the huge storage capacity (2 MB/channel) and fast sampling rate (200 M samples/sec) of the Agilent 54622D mixed analog and digital oscilloscope will allow us to make these simultaneous observations.

Continued on page 8

Pulse Width Modulation (PWM) Measurements

Continued from page 7

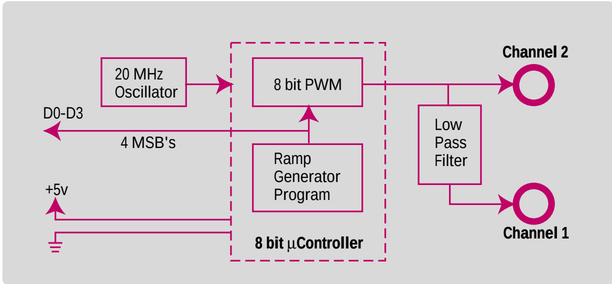


Fig. 2 Block diagram for 123 PWM Demo Module

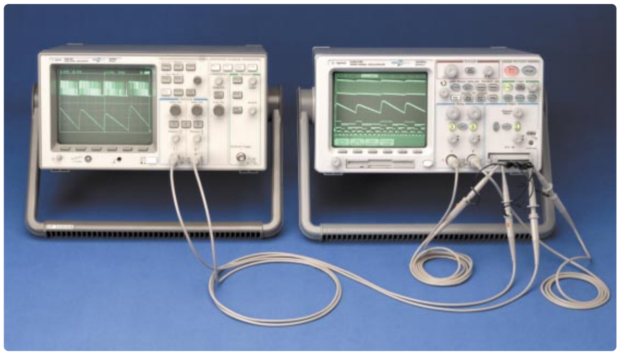


Fig. 3 An Agilent 54622D mixed analog and digital oscilloscope (right), with the 123 PWM Demo Module in the digital port, and an Agilent 54600B digital oscilloscope (left).

Equipment

123 PWM Demo Module[1]

Agilent 54622D Mixed Analog and Digital Oscilloscope

Agilent 54600B Digital Oscilloscope or other 100-MHz analog or digital oscilloscope

2 each 10:1 oscilloscope probes

Setup

Plug the 123 PWM Demo Module into the digital connector of the 54622D scope, as shown in Fig. 2 and Fig. 3. Connect the scope leads, with the ground scope lead wires to the center terminals of the 123 PWM Demo Module. Attach the channel 1 scope lead probe to the terminal marked as 1 in the 123 PWM Demo Module and the channel 2 scope lead to terminal 2. Turn on the oscilloscope. Press the Save/Recall button and then select Default/ Setup from the menu on the screen to make sure that the scope is at its default settings. Now press the Auto-Scale button. Adjust the Level knob on the Trigger controls to obtain a steady display.

Optional: Attach another analog or digital scope, such as the Agilent 54600B digital oscilloscope, and connect both channels in parallel with the 54622D. Adjust the settings of the second scope to match those of the 54622D.

Exercises

At the bottom of the screen (Fig. 4), signals D0-D3 show the states of the binary signals that control the output of the PWM. On the top, channel 1 shows the actual PWM signal. Channel 2 displays a filtered version of the signal on Channel 1; this voltage simulates the average effect of the control signal applied on a load, since most loads have a low pass nature.

One

Observe the digital code on the digital oscilloscope. Can you relate the binary codes to the actual PWM load voltage? We expect the PWM to produce a maximum output at channel 2 when the binary code is 1111 and a minimum when the binary code is 0000. There is, however, some delay involved. For example, if the horizontal scale of the oscilloscope is set to 100 msec/div you will be able to see that the maximum in any given cycle is attained some time after the code following the 0000 is applied. Can you measure this delay time? For any given cycle can you make a table relating the binary code with the voltage generated at the load?

1. This module is available by special order from Agilent Technologies. To inquire, send email to Mel_Downs@agilent.com.

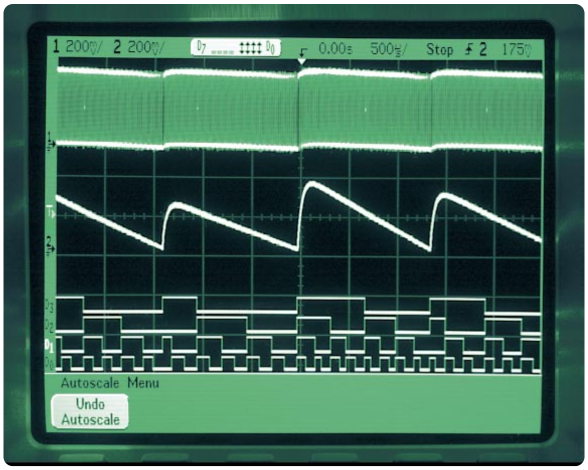


Fig. 4 54622D mixed analog and digital screen showing PWM signal (Channel 1), average dc output (Channel 2) and digital controller signals (D_0-D_3).

Two

Now set the horizontal scale of the scope to 2 msec/div. You will observe that our PWM does not work exactly as expected. Each one of the cycles in channel 2 is slightly different. We would expect all of them to be identical. Can you find the problem in the binary code?

Three

We will focus now on the output of the PWM (channel 1). Can you measure the fundamental period (T in Fig. 1) of the PWM signal? Set the scope to a horizontal scale of 20 msec/div and move the signal left and right by turning the horizontal position knob. You should be able to see how the pulse width changes with respect to the binary code.

You will also be able to observe some glitches in the PWM where it fails to generate some of the pulses. Are you able to pinpoint where this happens?

Four

Try to perform the measurements in questions two and three using either an analog scope (use a 100-MHz scope for a fair comparison) or a digital scope such as the 54600B, as shown in Fig.2. Can you do the same measurements? What problems do you encounter?

Using the analog scope, try to zoom in on the channel 1 signal. For this, set the horizontal scale to 2 msec/div, and try to measure at any given cycle the PWM signal fundamental period and also t_{ON} and t_{OFF} (see Fig. 1). Then repeat using the 54600B scope.

What can you conclude about the resolution of the signals displayed on the different scopes?

Five

To illustrate the advantages of having large memory depth (2 Mbytes in the 54622D), press the Single button in the Run Control section of the 54622D. Now change the horizontal scale over all its possible ranges. You will be able to zoom in and out at any of the available scope horizontal settings and be able to observe the signals with as much detail as desired. Try to repeat this with either of the two other scopes. Can you do it? Why?

Conclusions

One of the most pressing challenges in instrumentation today is making simultaneous measurements of signals that vary at significantly different time rates. You need to make these measurements to troubleshoot digitally controlled systems, since the controller and the piece of equipment being controlled typically operate at significantly different speeds. Most digital scopes have a single sampling rate, so you must oversample slow signals at rates that satisfy the sampling requirements of the faster signals. Thus, to observe both signals simultaneously, you need large memory capacity to store all the necessary sampled points. A deep-memory, mixed analog and digital oscilloscope is a good tool for these types of measurements.

Deep Memory Important for Mixed Analog and Digital Design

Agilent's new 54620 Series scopes offer 2-MB MegaZoom deep memory on each channel. The unique 2+16 channel models and the traditional 2- and 4-channel models are well-suited for analog labs, digital labs and senior projects.

Since most of today's new circuit designs contain a mixture of analog and digital signals, it's important to add memory depth to the list of "banner specs" you evaluate when you are comparing oscilloscopes. Why? Because deep memory lets you keep the sample rate high even when you are capturing long time periods. When your students are testing a new design, for example, deep memory lets them see a long record of signals during power up and power down.

Agilent's new 54620 Series oscilloscopes all feature 2-MB MegaZoom deep memory on each channel so your students can capture long, non-repeating signals, maintain high sample rate and quickly zoom in on areas of interest. And unlike the alternatives, MegaZoom deep memory is not a special mode; it operates with the same familiar controls you use for regular scope measurements. That means it's always available to help your students see more of what's going on in their designs.

For a direct link to more information about 54620 Series scopes, go to **www.EducatorsCorner.com/links**

New Building Breaks Down Walls Between Engineering Disciplines

Continued from page 3

Fitzhorn's wish came true with CSU mechanical engineering students who participate in the International Walking Machine Decathlon (see article on page 4). In past years, participants felt like they had to design and build their machines, including the electronics and controls, themselves.

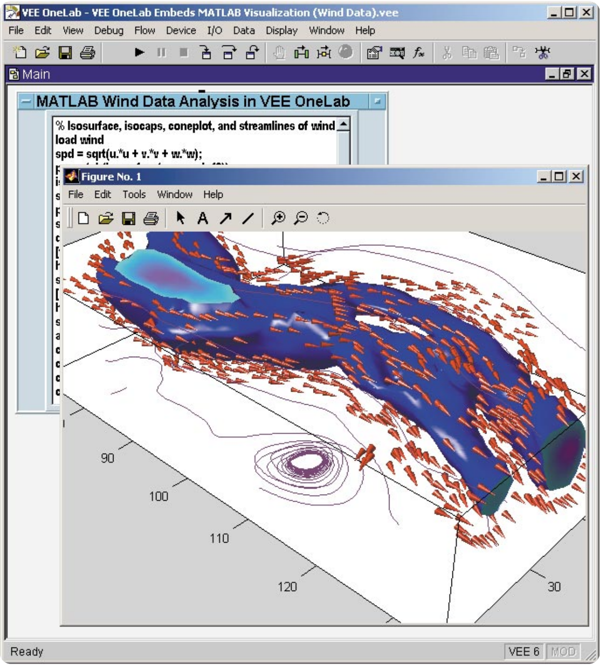
Now, teams of electrical and mechanical engineering students work together, in the school's design studio and joint ME/EE instrumentation and controls lab.

Results

The emphasis on interdisciplinary collaboration has affected both students and faculty. According to Fitzhorn, faculty members were forced to expand their horizons to deal with questions outside their customary fields of expertise. Also, faculty members from different departments have learned to cooperate and share responsibility better.

For students, the new collaborative approach has given them the ability to work on more complex and more relevant projects, which has sent enthusiasm soaring. "It's all I can do to keep up with the first-year students," said Fitzhorn. "We have juniors doing sophisticated analysis that previously only graduate students did. Just remove the obstacles and stand back. The results are astounding."

Inexperienced Students Get Up to Speed Faster with Agilent VEE OneLab



Managing a computer-based lab can be a frustrating challenge, especially when you are trying to teach students about Nyquist criteria, and they haven't even been able to get the data into the computer. It would be nice if you had a high-level programming language that was simple enough for sophomores to grasp in a hurry.

You can mitigate this problem by equipping your students with Agilent VEE OneLab 6.0, an updated version of HP VEE with robust analysis capability. With this PC-based visual programming environment, students can quickly become adept at creating programs for simulation, modeling, measurement and analysis. Instead of getting bogged down, students simply click and drag icons into place, and enter parameters in dialog boxes.

Because the program is so easy for students to learn, your teaching assistants can spend less time helping them with programming problems, and more time focusing on the course material.

MATLAB Script included at no extra charge

By incorporating MATLAB Script, VEE OneLab makes it easier than ever before for your students — inexperienced or expert — to analyze their measurement data. MATLAB Script gives your students direct access to the core set of MATLAB functionality, such as linear algebra and matrix computation, Fourier analysis, statistical analysis, and 2-D and 3-D scientific and engineering graphics. Signal processing functionality from The MathWorks is also included in VEE OneLab via the MATLAB Signal Processing Toolbox.

And there's more good news: there's no extra charge for the integrated MATLAB Script functionality.

Faster measurement analysis results

Even your least experienced students can get answers more quickly with VEE OneLab. When your students run into snags, they can turn to VEE OneLab's seven built-in tutorials for assistance. And if you want your students to come to class better prepared, you can assign the tutorials as homework. MATLAB Script demos are also available, as well as context-sensitive help.

Special Pricing for Universities

VEE OneLab is regularly priced at 50 percent less than competitive programming packages, but we've created an even more affordable version available only to qualified universities. Order the VEE OneLab Faculty Version (H2328G) to get a 40-seat license for all of the functionality at a fraction of the cost.

For a direct link to more information, visit the links page at **www.EducatorsCorner.com/links**

What's New on the Web?

Engineering Students Contribute Content to FutureEngineers.com

A couple of years ago, engineering students helped design the "Resources for Future Engineers" site at **www.FutureEngineers.com.** Now we've got a whole new crop of students adding content at a prodigious rate. In the next issue of Engineering Educator, we'll tell you more about the students involved. In the meantime, send your students to the web to check out these newly added topics:

Money Matters

- How much do engineers make?
- Benefits and other compensation
- Scholarships: Links to financial-aid web sites

Career Center

- Most-admired companies
- Proven techniques for a successful job search
- The "dos" and "don'ts" of business correspondence
- Free resume-writing tool

Brainy Fun

- Best bumper stickers
- 12 things not to say to a cop

Stay Up to Date by Attending Free Web Seminars

You are invited to attend Agilent Technologies monthly R&D engineering seminars, broadcast live over the Internet. You'll see and hear a 60- to 90-minute slide presentation on a timely engineering topic, with live audio and an optional small video image of the presenter, all while sitting at your desk. You'll have the opportunity to ask questions during the session by phoning them in, or by using a pop-up chat window on your PC monitor. All monthly programs will be available for viewing at your convenience for six months following the live broadcast.

Recent topics include:

- Linking Design Software with Test Instrumentation
- Bluetooth Design and Development with EDA, Test Equipment and Application I/P
- Cross-Bus Analysis in Communications Applications
- Web-Facilitated PCB Design and Design Transfer
- Real-time Debug and Analysis of Embedded Designs that Include Core Processors

You will need a JAVA-enabled browser and RealPlayer 5.0 in order to participate. To register for an upcoming live broadcast or to view the archived topics, go to **www.EducatorsCorner.com/links**

New Lab Experiments Added to Online Collection

One of the most popular features of the Educator's Corner web site **(www.EducatorsCorner.com)** continues to be the Online Encyclopedia of Lab Experiments. If you haven't visited recently, you may be surprised at all the new additions to the collection of pre-written labs, interactive experiments and spectral animations. Recent additions include a complete wireless systems lab course and other complete undergraduate lab courses. And we're continuing to improve the site's navigation to help you find the labs you're looking for quickly and easily. Check it out today!

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