Engineering EDUCATOR

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

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INSIGHTS

RF Engineering – Back to the Future

Jerry Murphy, Guest Editor

Picture this: 50 job openings in RF engineering, and only 10 candidates apply. Of those 10, only 5 have RF experience. This couldn't really happen, could it?

In fact, I've seen this scenario in Europe and know it is occurring elsewhere. Few candidates apply for openings and recent graduates typically need extensive training in RF engineering basics.

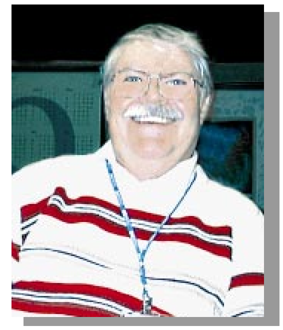
I hear industry leaders complain that universities neglect training RF engineers. Educators tell me they can't keep up with the ever-changing technology.

How did all this happen?

During the computer industry's growth in the '80s, computer science classes knocked RF engineering off the map at many universities. Now, these schools are paying the price, struggling to create new curricula so they can meet the demand for RF engineers. Fortunately, there are promising alliances developing to end this problem.

In the U.K., where RF engineers are scarce, the Department of Trade and Industry (DTI) developed RFEEI, the Radio Frequency Engineers Education Initiative. This initiative, funded by a government/industry partnership, provides grants to universities willing to develop wireless curricula and produce more RF engineering graduates. England's University of Surrey received some of this grant money to expand their RF curriculum.

Surrey is developing labs and experiments for the new RF curriculum. When available, we'll post them to the HP Educator's Corner website for any educator to use. You can read about Surrey's program, and see one of their labs in this newsletter.



Another group I'm hearing more about is the Global Wireless Education Consortium (GWEC). One of their goals is to develop a standard knowledge base for wireless education. It seems like an obvious tactic, but until they came along, no one thought to do it. (See page 3).

To support these efforts, HP now extends the education discount to products from our Microwave Instruments Division — spectrum and network analyzers, signal sources and power meters.

Picture this: More education/industry partnerships developing so that educators and engineers can keep pace with wireless technology changes. Thanks to the forward-thinking of groups like RFEEI and GWEC, RF engineering education can get back to where it once was — and beyond.

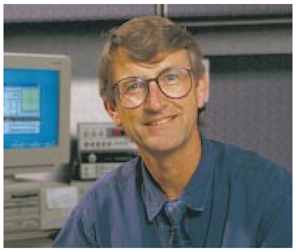
Jerry Murphy
European Product Line Manager for
HP Test and Measurement Education Initiative,
European Marketing Organization
in the Netherlands

IN THIS ISSUE

HEWLETT PACKARD

Share Your Thoughts

Marsh Faber, Editor



This newsletter, as well as the HP Educator's Corner Website (**www.hp.com/info/college_lab101**), 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@hp.com.

Recognition for Brazilian Teachers

In the HP Engineering Educator Fall 1998 edition, I was surprised that your comment about the "Powerful Revolution in Engineering Education in Latin America" made no mention of the work being done by Denise and Seabra, teachers from the University of Sao Paulo. Their labs are a reference for other universities in the country.

Eduardo Bassanello
Brazil

Eduardo,
It's a shame that we don't have the time and space to recognize ALL of the people who are major contributors to excellent engineering education programs. We'll keep trying.

Sharing Calculator Methods

Here is a calculator method that I would like to share with your readers: A systematic method of using a calculator to convert "decimal fractions" to other number system bases.

When converting from one number system base to another, many calculators only convert INTEGER values. The typical bases available [on a calculator] are decimal, binary, octal and hexadecimal.

This method shifts the fractional part to an integer value, uses the automatic conversion feature of the calculator, then shifts the converted value back to the proper radix point position.

The [key] is to use the biggest power value for the multiplier of the final base, without exceeding the limits of the calculator.

EXAMPLE 1: Convert 0.1234 in DECIMAL to BINARY

1) Multiply 0.1234 by the biggest possible power of 2, since it is to be converted to BINARY: $0.1234_{10} \times 2^{10} = 126.3616_{10}$
2) Convert integer part to binary: 126 in base 10 = 1111110 in binary
3) Shift back 10 places: $0.1234_{10} = 0.000111111_2$

EXAMPLE 2: Convert 0.163 in DECIMAL to OCTAL

1) Multiply 0.163 by the biggest power of 8, since it is to be converted to OCTAL: $0.163_{10} \times 8^{10} = 175019917.3_{10}$
2) Convert the integer part: 175019917 in base 10 = 1233513615 in base 8
3) Shift back 10 places: $0.163_{10} = 0.1233513615_8$.

Henry Franz, Associate Professor
University of Houston, Downtown

Tighter Control

To the scores of people who noticed the accidental swap of figures 2 and 3 in our lab for the Winter edition of the HP Engineering Educator (U.S. version): The figures denoted the difference between "loose control" and "tight control." During the final layout phase, we were obviously invoking our own "loose control" editorial algorithm. Next time we'll throw in a little lead compensation.

GWEC Wires Industry to Education

Misty Baker, Executive Director of the Global Wireless Education Consortium

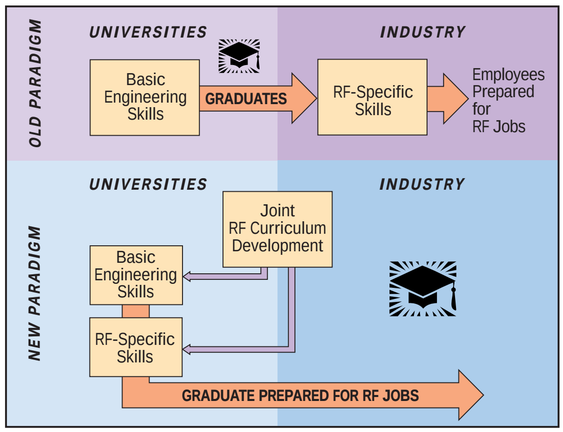
Wireless industry analysts predict that the demand for wireless technicians and engineers will reach 300,000 by the year 2007. The wireless industry won't have enough qualified workers, warns Misty Baker, Executive Director of the Global Wireless Education Consortium (GWEC), unless there are fundamental changes in wireless education. GWEC is taking its first steps to implement this change in the United States.

"Industry had taken over the job of education – teaching RF basics," reports Baker. "Our goal," she says, "is to put basic RF and wireless education back into the experts' hands – the educators and schools."

GWEC members include wireless and related companies who need RF engineers and technicians, plus academic institutions committed to developing wireless programs. "HP became interested in GWEC when we saw that their strategy was similar to our own," says Marsh Faber, program manager for HP's Test and Measurement Education Initiative. "GWEC's breaking down traditional barriers and creating solutions that work for industry and academia."

Educational Strategy

GWEC's mission is to increase the quality and quantity of wireless workers. To accomplish this task, GWEC needed a different model for industry/academic partnerships. "Many one-on-one relationships existed between companies and schools," explains Baker. "Schools duplicated efforts instead of working together."



GWEC members – companies and schools – work together to develop the wireless curriculum. The goal is to create the curriculum once. Then, any school that wants to join GWEC can share the curriculum and start a similar program.

GWEC members realized early on that school accreditation requirements created a problem for standardizing wireless curricula. To allow flexibility while still covering the same information, GWEC created Points of Knowledge (POKs). The POKs outline the information and experience required for 2- and 4-year wireless-focused curricula. GWEC schools agree to cover each of the POKs, but have flexibility in delivery methods.

Benefits for Educators

GWEC education partners have access to RF training sources they simply couldn't gather on their own. "Many of our industry partners already developed extensive wireless curricula," says Baker. "With some course materials already complete, schools can quickly put their wireless programs in place."

GWEC also holds an annual educator's conference which is free for GWEC educational members. Each year, the conference hosts training workshops for educators.

The conference gives educators the opportunity to share resources, course materials, and experiences. Industry partners attend to give feedback and share expertise on how to incorporate new wireless ideas. "Educators and industry partners can really hash it out, discuss what needs to be taught at schools and what's better for on-the-job training," Baker professes. "The atmosphere we've created at GWEC makes these dialogs possible – and productive."

To find out more about GWEC or the August 1999 conference, visit our links page at **www.hp.com/info/educatorlinks** or contact Misty Baker at mbaker@gwec.org.

University of Surrey Responds to the RF Engineer Shortage

Mobile Communications growth in the United Kingdom is both exciting and troubling: the more the industry grows, the more high-paying, challenging careers there are for RF graduates. The trouble is, the U.K. doesn't produce enough RF engineers to fill even the current needs of mobile communications companies.

At the University of Surrey, we expanded our RF engineering program in response to an initiative by the Radio Frequency Engineers Education Initiative (RFEEI), a government/private industry partnership that funds RF engineering programs. RFEEI wanted to change the quantity and quality of RF engineers in the U.K.

RFEEI asked universities to develop programs that would produce an additional fifty RF engineering graduates per year. Surrey submitted a proposal to produce twenty graduates. We were one of just three universities to receive funding in RFEEI's first initiative.

Job 1: Attracting Students

The first task we faced was attracting interested students. Surrey's standing in Electrical Engineering put us in a good position to accomplish this. Even though students view the RF curriculum as being difficult, the popularity of our instructors makes the choice more palatable. Many students are also very excited by our extensive research in Mobile Communications and Satellite Engineering – we've built 14 satellites here at the Surrey Space Centre. Plus, students are aware that many mobile communications companies in our area want and need to recruit RF and DSP graduates. So, we have many advantages when it comes to attracting students to the program.

A technician makes final adjustments to a satellite in the clean room at the Surrey Space Centre.

Providing Hands-On Training

We faced bigger obstacles in the area of providing top-notch training to students in the RF program. In recent years, cutbacks on lab work at U.K. schools has caused a decrease in hands-on ability among undergraduates. Also, our increasing foreign student population had little or no lab experience. To bridge these knowledge gaps, we needed to teach RF basics: spectrum analysis, network analysis and RF measurement techniques. Students would need lab work to reinforce the information they learned in lectures.

We struggled to find a way to add RF lab work to an already full curriculum. Our engineering department ultimately decided to add an RF lab to final year options, in addition to students' existing project work.

Our RF Program

We created a 36-hour module covering phase-lock loops, frequency synthesis, oscillator design, mobile communication systems and RF CAD. We took an existing 36-hour electronics and TV module, which already included material on small system RF design, and replaced the 12-hour TV systems section with RF power amplifier design.

RF concentration requirements include a 36-hour module on telecommunications theory, plus DSP modules or microwaves and antennas modules.

Tony Jeans, Senior Lecturer,
Centre for Communication Systems Research
School of Electrical Engineering,
Information Technology and Mathematics,
University of Surrey

A University of Surrey student measures the noise sidebands of the oscillator he is designing for his final-year undergraduate project.

Students also need to undertake a final-year project relevant to some aspect of mobile or RF systems. Together, the two RF modules include twelve 3-hour lab sessions. Six are devoted to RF CAD basics and design, centered around HP EEsof design software, one copy of which we were intending to purchase with our RFEEI grant money. We were pleased to discover that HP's university support program provided a way for us to license 20 seats at an affordable cost (just the maintenance fee).

We then bought six relatively inexpensive 1-GHz spectrum analyzers and some RF signal generators. With this new equipment, we could run six simultaneous experiments (with students in pairs) for a total of twenty-four students over a 12-week semester. Six pairs worked on RF CAD problems, while the other six pairs performed hands-on lab work for six weeks. Then they switched.

The lab experiments we developed included spectrum analysis with coupled tuned circuits and noise factor measurement: characteristics of FM IF amplifiers, and measurements of capture effect and AM suppression; phase-lock loops and frequency synthesis; RF power amplifier matching; and timing characteristics of sample antennas.

Our Success

So, did we meet our twenty-graduates-per-year goal? To our surprise, we over-enrolled the program in our first semester. We scraped around and produced another set of experiments so more students could participate. Of course, the experiments and exercises required additional staff supervision, which did make the course more expensive to run.

Both students and RFEEI industry partners voted Surrey's first program a success. Our success led RFEEI to fund a second phase with five universities, including the University of Surrey.

Today, eighty students per year work in pairs and perform a 6-week CAD exercise. The lab exercise workload is now three instrument sessions and a three-week oscillator lab in the second semester. With seven sets of equipment, we can handle fifty-six students – amazingly, still less than the number of students who want to take this module.

To find out more about RFEEI's initiative, use the link to the website at **www.hp.com/info/educatorlinks.** There, you'll find links to participating universities (including the University of Surrey), a list of industry partners (including HP), and information on other aspects of their initiative.

Capacitor Measurements

Objective

This experiment will demonstrate some of the limitations of capacitors when used in Radio Frequency circuits.

After completing the experiment, the student should be able to

A. ***Measure the self-resonant frequency of a capacitor***

B. ***Measure the corresponding equivalent series resistance***

C. ***Avoid the problems associated with connecting capacitors in parallel***

D. ***Select suitable capacitors for various decoupling and coupling applications.***

Equipment

- Spectrum analyzer with tracking generator up to 1 GHz
- 50 ohm microstrip test jig (See note on page 8)
- 2 coax cables, 50 ohm BNC to BNC, 0.5 m long
- 10 dB BNC coaxial attenuator (pad)
- Various capacitors

Equipment Set - Up

Connect the equipment as shown in Fig. 1. Remove any capacitors from the test jig and check that the insertion loss is 10 dB over the entire frequency range of the spectrum analyzer. Any small variation can be corrected by normalizing the display. Always have at least 10 dB on the input attenuator of the spectrum analyzer.

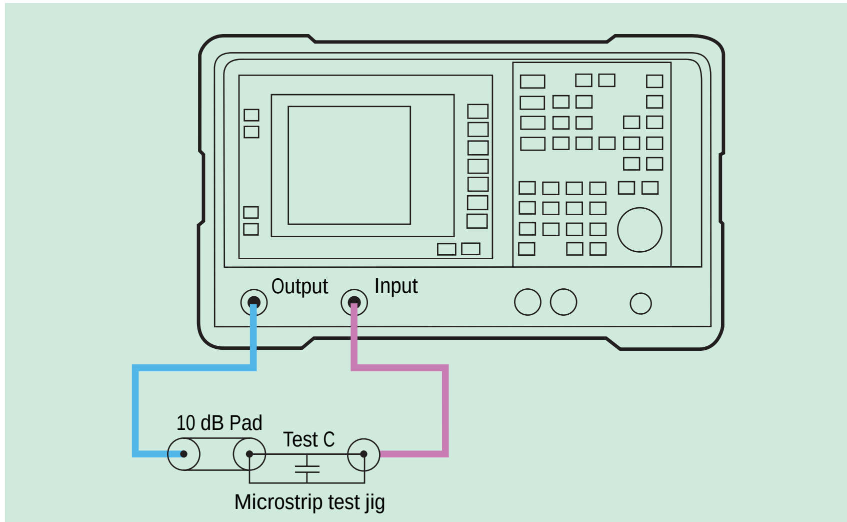


Fig. 1 Equipment set-up

Theory

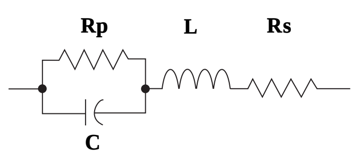


Fig. 2 Capacitor equivalent circuit

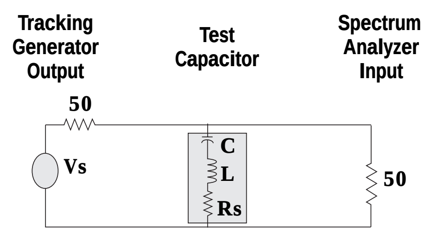


Fig. 3 Equivalent measurement circuit

Figure 2 shows the equivalent circuit of a capacitor. Rp, the parallel leakage resistance is usually many Megohms and can be ignored at RF.

The inductance L is mainly due to the leads of the capacitor. The electrode structure has inductance but is usually only significant in leadless surface mounted types and large capacitors with spiral wound electrodes.

At the self-resonant frequency of the capacitor the impedance (|Z|) will be equal to the series loss resistance Rs.

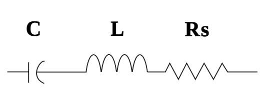


Fig. 2a Equivalent circuit assuming Rp = infinity

From the equivalent circuit at resonance, Fig. 3, we can calculate the attenuation. Here we assume the system impedance is 50 ohms.

With the test capacitor (Z) disconnected, the input voltage to the spectrum analyzer (Va) will be:

$$Va = \frac{Vs}{2}$$

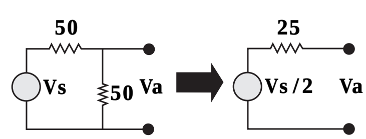
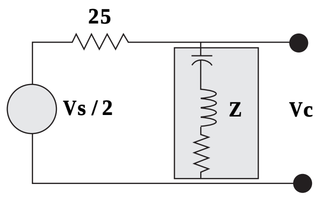


Fig. 3a Thevenin equivalent of source

Mike Blewett
Department of Electronic Engineering
University of Surrey

With the test capacitor (Z) connected, the input voltage to the spectrum analyzer (Vc) will be:

$$Vc = \frac{Vs}{2}\left(\frac{Z}{25 + Z}\right)$$



At resonance the insertion loss (A) will be due to the equivalent series resistance (Rs)

$$A = \frac{Vc}{Va}$$

$$= \frac{Rs}{25 + Rs}$$

$$\text{Therefore, } Rs = \frac{25 \cdot A}{1 - A}$$

Or, if the insertion loss (Ad) is measured in dB then:

$$Rs = \frac{25 \cdot 10^{\left(\frac{Ad}{20}\right)}}{1 - 10^{\left(\frac{Ad}{20}\right)}}$$

Measurements

To make accurate measurements it is essential the output and input impedance of the tracking generator and spectrum analyzer respectively are equal; this is usually 50 ohms. In addition, the characteristic impedances of all the cables, connectors and test jig must match this impedance.

A 10 dB pad reduces any error due to the source mismatch. During the experiment, try making measurements with and without this pad to see if you can detect any change. Also, try putting the pad on the other port of the test jig to see if there is any change due to the input connection to the spectrum analyzer. Note that you should have at least 10 dB selected on the input attenuator of the spectrum analyzer to improve the input match.

Connect a 1 nF ceramic capacitor with 2 mm-long leads (4 mm total) to the center of the test jig. Measure the maximum insertion loss and corresponding self-resonant frequency. Tabulate your results as shown below calculating Rs, L and Q.

Continue measuring a range of different types of capacitors. Experiment with different lengths of lead on the same capacitor. Tabulate your results as before.

Reconnect a 1 nF short-lead capacitor to the center of the test jig. Connect a 10 nF capacitor in parallel with this. Note any changes in the insertion loss over the full 1 GHz sweep range. Are there any frequencies where the insertion loss is less than that with a single capacitor? Replace the 10 nF with a 100 pF short-leaded capacitor. Can you predict, from your previous measurements on single capacitors, where a minimum attenuation peak may occur? Experiment with a range of different capacitors noting their effect on insertion loss.

Does connecting the parallel capacitor at a different point on the microstrip line make any difference to your results?

Finally, connect a short wire link in place of the test capacitor. Is the attenuation now infinite? Can this measurement help you estimate the inductance of the capacitor leads?

Results

Capacitor Type	Dielectric	Value	Lead Length	Resonant Freq. MHz	Loss dB	Rs	L nH	Q
Ceramic Plate	K14000	1 nF	2 mm	94	37	0.36	2.9	4.7
Ceramic 1206 Chip	X7R	1 nF						
Polyester								
Polystyrene								
Various	Vary	10 pF to 1 μF	Vary					

Continued on page 8

Capacitor Measurements

Continued from page 7

Student Questions

- ***Estimate the inductance of the 2 mm-long leads of the 1 nF capacitor you first measured.***
- ***What type and value of capacitor would you choose to decouple the power supply of a 100 MHz small-signal high-gain amplifier?***
- ***It is sometimes an advantage to connect resistors* of, say, 10 to 100 ohms in series with the power supply between different stages of small-signal RF circuitry. Can you think of two reasons why this should be?***

**Often, low-Q ferrite bead inductors are used instead of resistors. These have a lower dc power loss in higher-power circuits.*

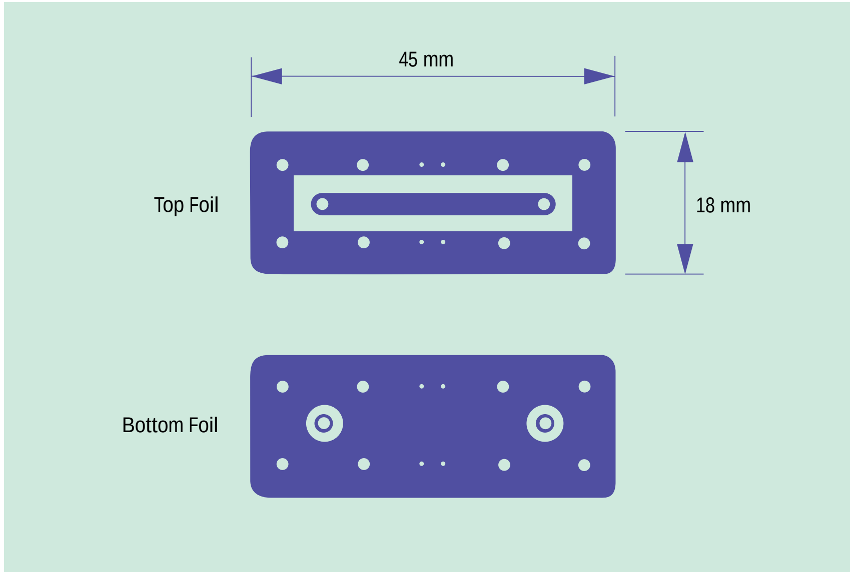


Fig. 4 Foil pattern for test jig

Note to Tutors

The experiment can use any convenient transmission line as a test jig so long as:

1. It has the same characteristic impedance as the rest of the system.
2. Capacitors can easily be connected in parallel with it.

An informal arrangement could use a BNC Tee; however, it is difficult to measure short-leaded components with this arrangement.

A slot cut in semi-rigid cable has been used for small capacitors but is inconvenient for larger types.

For general-purpose use, a double-sided printed circuit board with 50-ohm BNC connectors is used. A 1.6 mm thick epoxy glass substrate (FR4/GF) requires a track width of 3 mm for 50 ohms. The foil pattern of a suitable test jig is shown above.

Note the four small holes near the center of the jig connect the top and bottom ground planes. This makes the ground impedance low at the point where the test capacitor is connected.

RF Curriculum: Ready, Set, Go

HP's Swept Measurements Educator's Package can be ordered with either the HP 4396B (left) or the HP 4395A (right) RF Network/Spectrum /Impedance Analyzer. The package comes complete with a demonstration kit and a collection of valuable teaching aids.

Here's a great way to jump-start your RF curriculum. HP's new Swept Measurements Educator's Package helps teach your students the basics of RF Circuits.

The package includes:

- Spectrum/Network/Impedance Analyzer – either HP 4395A or HP 4396B
- Lecture/Presentation package (over 100 slides)
- Demonstration kit and automation program

The presentation material reviews frequency domain as well as phase and impedance measurements, using a liberal assortment of application examples.

The demo kit for the combination analyzer contains typical devices: an amplifier, a pulse-modulated oscillator and a variable-bandwidth filter. Measure them manually or try the automation program for error-free results.

This package complements your existing curriculum – use only the materials you need. If you're teaching a filters class, simply use the appropriate slides and filters. Then plug a VGA projector into the analyzer and run the demos in the middle of your presentation.

Use this versatile package for engineering lectures or labs on:

- wireless communications
- control systems
- filters and linear networks
- audio/acoustics and power supplies
- analog active or passive circuits
- digital communications

To find out more about the HP's Swept Measurements Educator's Package, visit **www.hp.com/info/educatorlinks**.

Strap Rack

Does your test equipment sometimes walk down the hall all by itself? Well, here's a quick fix.

The HP N2725A Basic Instrument Desktop Racking device will keep your instruments in one place. It's a simple solution to a troublesome problem, and it keeps your workbench uncluttered at the same time.

It works with the HP 33120A Function/Arb Generator, HP 34401A DMM and one of several HP E36xx-series power supplies. You can use it with either two or three instruments, and it's a whole lot cheaper than a half-size rack. For more information, see ***www.hp.com/info/educatorlinks.***

ABET 2000: The University of Denver's Approach

Our last issue featured an overview of ABET 2000 criteria that must be implemented by the year 2001 at any U.S. school seeking ABET accreditation. The article featured an interview with Dr. Albert J. Rosa, Chair of The University of Denver's (DU) Department of Engineering, and an ABET program evaluator. In this issue, we'll look at some of the program changes DU implemented, plus some techniques it's using to measure student performance and program success.

The University of Denver is ahead of the curve in implementing ABET 2000 Criterion 3 Program Outcomes and Assessments. Before the announcement of this criterion, Dr. Rosa and his faculty devised a program specifically for DU.

The DU program, called Vision 2000, maps perfectly into the eleven ABET 2000 objectives — and even exceeds its requirements. DU's program, now in year four of its five-year implementation plan, makes DU about 80 percent ABET 2000 compliant. Dr. Rosa, however, is less concerned about conforming to standards. What drives him is an earnest desire to prepare a new generation of multi-disciplined, team-oriented, and globally competitive engineers. That's precisely what ABET 2000 aims to do as well.

Background

DU's engineering department is small – only 150 students. The department offers four programs: electrical, mechanical, computer, and general engineering. According to DU professor Dr. Paul Predecki, "The idea (for the new program) was to create an integrated sequence of courses and programs that emphasized teams as well as multi-disciplinary knowledge and problem solving in the freshman through junior years. So, at least one project each year brings together a team of students representing each of the four engineering disciplines. Then, when they're seniors, they spend the entire year in teamwork mode."

How did DU develop Vision 2000?

The DU faculty spent more than a year meeting, discussing, arguing, and agreeing. With input from their Industry Advisory Board and Engineering Affiliates throughout the country, the faculty came up with a set of 14 Program Objectives. (See sidebar.) These objectives define the overall skills and abilities a DU engineering graduate should have. The fourteen objectives correspond with 45 Program Outcomes, which DU uses to assess all engineering graduates.

How did the faculty define the 45 Program Outcomes?

The professors wanted each student measured against each of the 45 Program Outcomes using a skills matrix. To accomplish this, they plotted the objectives against existing courses and curricula, rearranged and consolidated courses, then re-plotted. "Our goal," says professor Dr. Ronald DeLyser, "was to be both wise and efficient, so we reorganized classes to best meet the new objectives, moving some to other years or to interdisciplinary classes."

After reorganizing their program to fit the objectives, they assigned individual

DU's 14 Objectives

(To see the corresponding ABET 2000 Criterion 3 outcomes and assessments, see last issue's article or visit **www.hp.com/info/educatorlinks**.)

Students need:

1. a strong grounding in the fundamentals and their applications

2. the ability to analyze and synthesize engineering problems, including designing and conducting experiments

3. good communication skills

4. the ability to independently accomplish engineering tasks

5. the ability to enter industry with the needed skills to solve real-world problems

6. to know and uphold ethical and professional standards of the profession

7. to develop and practice interpersonal skills; know how to work effectively as a member of a team

8. to know how to solve open-ended design problems

9. to be computer literate and Internet capable

10. to develop and practice interdisciplinary skills

11. the ability to pass the Fundamentals in Engineering exam as a first step toward professional registration

12. to be capable of functioning in a global economic environment

13. to be cognizant of some current engineering problems and assess their social and economic implications

14. to be prepared for a life of continual learning, consisting of formal, informal, and self-education.

Program Outcomes to specific courses. Suddenly, they realized that over the course of the degree program, students would be over-assessed – up to 106 times – if they applied all 45 Program Outcomes. The faculty reduced the required outcomes to 30 on a key set of courses. This pared individual student assessments down to 62 conducted over a student's four years in the program.

How are students assessed?

"ABET 2000 puts the burden of measuring success on the school," Dr. Rosa says. "It allows us to continuously measure for improvement." At the end of each quarter, the faculty evaluates and records the results of the assessments using the skills matrix. They keep summary records, both for individual students and for each class year, locked in dedicated file cabinets.

During the summer, an Assessment Committee, consisting of a senior faculty member from each program, plus the Assessment Committee Chairman, reviews the results of the quarterly assessments. The committee prepares a summary report to the faculty on how well each program meets each of the fourteen objectives, noting program weaknesses and making recommendations for improvement. The entire faculty considers each of the report's recommendations. The faculty can accept, deny, modify or defer a decision to the respective curriculum committee. Accepted and modified recommendations are implemented immediately, after which the assessment cycle ends. The next assessment cycle determines the success or failure of any changes made.

	Electrical Engineering Courses vs. Inputs to DU Educational Objectives	ENGR 0611	ENGR 0621	ENGR 0631	ENGR 2035	ENGR 2510	ENGR 2620	ENGR 2900	ENGR 2950	ENGR 3310	ENGR 3320	ENGR 3330	ENGR 3610	ENGR 3950	ENGR 2015	ENGR 2025	ENGR 2301	ENGR 3210
1	Strong Grounding in Fundamentals	■	■	■	■			■					■		■	■	■	■
2	Analyze & Synthesize Problems and Experiments	■	■	■	■	■	■			■	■	■			■	■	■	■
3	Good Communications Skills	■	■	■	■	■	■			■	■	■						■
4	Independently Accomplish Engr. Tasks			■						■	■	■			■	■	■	
5	Enter Industry with Needed Skills	■	■	■	■	■	■			■	■	■						■
6	Know/Uphold Ethical Standards	■						■				■						
7	Interpersonal Skills	■	■	■	■	■	■			■	■	■			■	■	■	■
8	Resolve Open-Ended Problems	■	■	■	■	■	■			■	■	■			■	■		■
9	Computer Literate/Internet Capable	■	■	■			■	■		■	■	■						■
10	Practice Interdisciplinary Skills/Topics				■	■	■			■	■	■						
11	Pass FE Exam							■	■				■	■	■	■		
12	Function in a Global Environment							■										
13	Implications of Current Engr. Problems							■		■	■	■						
14	Prepare for Life of Continual Learning					■	■			■	■	■						

	DU Educational Objectives (Criterion 2)	DU Criteria	(a) an ability to apply knowledge of math, science and engineering	(b) an ability to design and conduct experiments, as well as to analyze and interpret data	(c) an ability to design a system, component or process to meet desired needs	(d) an ability to function on multi-disciplinary teams	(e) an ability to identify, formulate, and solve engineering problems
1	Have a strong grounding in the fundamentals and how to apply them	1.	X				
		2.	X	X	X	X	X
		4.	X	X			X
2	Be able to analyze and synthesize engineering problems including the design and conduct of exp.	6.					X
		7.			X		X
		9.		X			
		11.	X	X			
3	Possess excellent communication skills	15.					

Cross-Comparison of Department of Engineering Educational Objectives and Assessment Criteria versus ABET outcomes.

ABET Outcomes (Criterion 3)

DU faculty plotted their educational objectives against course offerings, assessment criteria and ABET outcomes.

And the effect on DU's Engineering Department? "Our freshman retention is up from 50 percent to more than 66 percent, and motivation is high. Plus," Dr. Rosa adds, "our curriculum is very friendly to women. 40 percent of our engineering students are women. The teamwork concept is less intimidating and helps put them in a more powerful, contributing role."

Dr. Rosa continues, "What's more, industry is getting what it really wants. Our curriculum puts out graduates who are ready to work instead of ready to put in another year or more getting up to speed."

You'll find links to a lot more information about ABET and ABET 2000 at **www.hp.com/info/educatorlinks**.

You can also contact:
Modalities Accreditation Director
Accreditation Board for Engineering and Technology, Inc.
111 Market Place, Suite 1050
Baltimore, Maryland 21202-4012
Fax: (410) 625-2238
E-mail: accreditation@abet.org

Website Update

Introducing a New Website for Your Engineering Students

For several years now, we’ve concentrated on building the HP Educator’s Corner website into a valuable resource center for engineering educators. Now, we’ve begun creating a similar web resource center specifically for your engineering students. With the help of the HP Student Advisory Council (see the last issue of the HP Engineering Educator newsletter for details), we’ve designed a site to help engineering students deal with their biggest concerns and issues.

Content Includes:

School Success: technical help and advice from students who have done well in engineering school

Money Matters: financial information for students and lots of links to outside resources

Career Center: tips and tricks for landing that first job and advice from recent grads who have made the leap to the working world

On My Mind: a place for students to share their thoughts and questions and connect with fellow engineering students around the world

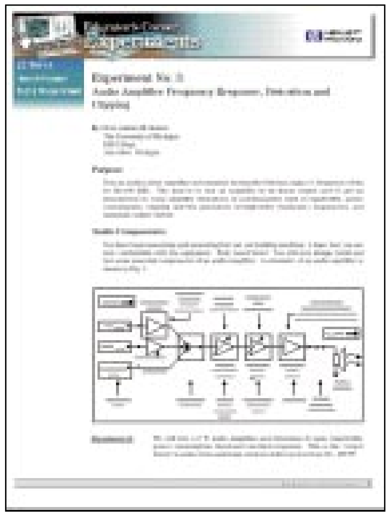
All About Engineering: articles and stories that give students insight into the field of engineering

Brainy Fun: puzzles and brain-teasers for students who enjoy an intellectual challenge.

Check out the new student site at **www.hp.com/info/educatorlinks.** Then pass the word along to your students.

New Content on the Educator’s Corner Website:

The Junior-Year Lab Set:



These lab experiments for the electrical engineering junior-year curriculum come from the University of Michigan. You can use them as is, or adapt them to fit your curriculum.

Puzzled?

Let your students test their knowledge of field components, dc circuits and other engineering lessons with our new set of interactive crossword puzzles. When they’re finished, the system automatically calculates each student’s score.

Just Released!

The latest CD-ROM compilation of the HP Educator’s Corner website is now available. Access all the tools and content without waiting for them to download. To order, visit the Educator’s Corner website at **www.hp.com/info/college_lab101**.

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