

Skeptic, Dreamer or Both

Marsh Faber, Editor

Who would you rather have on your design team, Galileo or Robin Williams? Personally, I'll take both.

From our early days, we engineers are taught to question everyone and everything, thinking logically and eliminating emotion. Skepticism serves us well in school, where most of the questions call for analysis, but then it follows us through graduation.

When we get a job, we have to invent something before we can analyze it. Schools don't teach us to be inventors. Engineers analyze. *Dreamers* invent.

I have watched a number of brainstorming sessions that were destroyed by a well-meaning engineer. Someone who has spent a lifetime dwelling on linear, analytical questions will immediately stomp on any impractical idea. They don't realize that the object of brainstorming is NOT to come up with an immediate answer.

Brainstorming is like walking across a lake by stepping on rocks that are hidden beneath the surface. People who are good at brainstorming are not afraid of getting wet. Skepticism is forbidden in brainstorming. The "complete" engineer understands that.

For example, let's brainstorm a new super-insulating fabric:

"What makes a good insulator?"

"Dead air space. Loft."

"Yeah, one of the problems is that you lose loft easily."

"Maybe we should use butterflies. They could keep the loft up."

"Maybe something like a butterfly. A force that keeps the fibers apart."

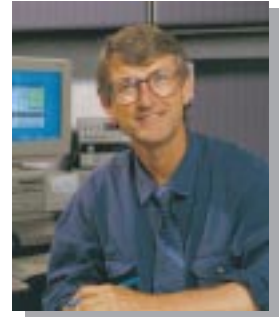
"What about ionizing the fibers?"

Thus was born the Ionized Fiber Parka Company.

It's fictitious, but I think you get

the idea. If a skeptic had halted the process at the "butterfly" comment, the brainstorming would have stopped and the result would have been NO product. We engineers need to know when to turn off the skeptic inside ourselves.

We have a new face in Europe. Jerry Murphy is the new Education Program Manager for HP Test & Measurement in Europe. Jerry was part of the original team that created HP 54600-series scopes, digitizing scopes that work like analog scopes. He's a master of the product development process, a scope GURU. I think you'll like Jerry. He's a skeptic. And a dreamer. He's a *complete* engineer.



Marsh Faber
Education Program Manager
Electronic Measurements Division

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Share Your Thoughts

This newsletter and the HP Educator's Corner Website (www.hp.com/info/college_lab101) are intended to help you, the educators responsible for shaping students into competent engineers. But to do a good job of meeting your needs, we need your feedback. Please e-mail your comments, questions and concerns to: MARSH_FABER@hp.com.

Dear Sirs,

There is a "bug" in *FFT Laboratory Experiments (3): Frequency Analysis of Periodic Signals (EXP54d.pdf)* at [www.../edcorner/English/Exp45d.html](http://www.edcorner/English/Exp45d.html), and in *HP Product Note 54600-3: FFT Lab Experiments Notebook, 50917206E, page 23*. In Table 4.1, the Harmonic magnitudes (dB) of triangle wave are not correct. The right numbers are the followings (normalizing to first harmonic: 0dB):

Harmonic	1	3	5	7	9	11	13
Magnitude (db)	0	*-19.1	*-28	-33.8	-38.2	-41.7	-44.6
		* -19.1 (instead of -22.082),	-28 (instead of -30.946)	...and so on			

The numbers can be verified by measurement, too.

Best Regards,

Dr. Zsolt Papay, Associate Professor,
Tech University of Budapest, Department of Telecommunication
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Dr. Papay,

Thanks for finding this serious error in the table. The remarkable thing is not so much that we made the error, but that the publication has been around for several years and you are the first one to catch it. Congratulations.

It appears to me that most of the error stems from the initial harmonic magnitude. In the case of the triangle wave, it's closer to being a typographical error. The initial magnitude of -4.842 dB should be -7.84 dB [equal to $20 \cdot \log(4/\pi^2)$].

The square wave is worse. Its first harmonic should be +2.10 dB instead of -9.943 dB. Apparently the "4" was left out of the first coefficient, which should be $4/\pi$. This mistake should have been caught when we did the original editing, since the first harmonic must obviously be larger in magnitude than the peak of the square wave. We missed it.

The correct table is as follows (you may want to check me on this):

For the square wave, coefficients are $4/\pi$, $4/3\pi$, $4/5\pi$, etc. For the triangle wave, they are $4/(\pi^2)$, $4/(3\pi)^2$, etc.

	Square Wave							Triangle Wave						
Harmonic	1	3	5	7	9	11	13	1	3	5	7	9	11	13
Magnitude	+2.10	-7.44	-11.88	-14.80	-16.99	-18.73	-20.18	-7.84	-26.92	-35.80	-41.65	-46.01	-49.50	-52.40

Maybe a better way to state the whole table would be to do it as you have suggested, normalizing the harmonics to the first one:

	Square Wave							Triangle Wave						
Harmonic	1	3	5	7	9	11	13	1	3	5	7	9	11	13
Magnitude	+0	-9.54	-13.98	-16.90	-19.09	-20.83	-22.28	0	-19.08	-27.96	-33.80	-38.17	-41.66	-44.56

Again, thanks for your vigilance.

Setting Up an Instructional RF Analog Lab

Lawrence P. Dunleavy,
Associate Professor,
University of South Florida (USF)

There are at least two very good reasons for today's university to update their instructional RF labs: frequency ranges used in consumer products and other wireless manufacturing have shifted, and instrumentation has evolved dramatically over the last ten years.

At USF, we recently installed a new Wireless And Microwave Instructional (WAMI) Laboratory to teach our students about RF/microwave and wireless design and measurements.

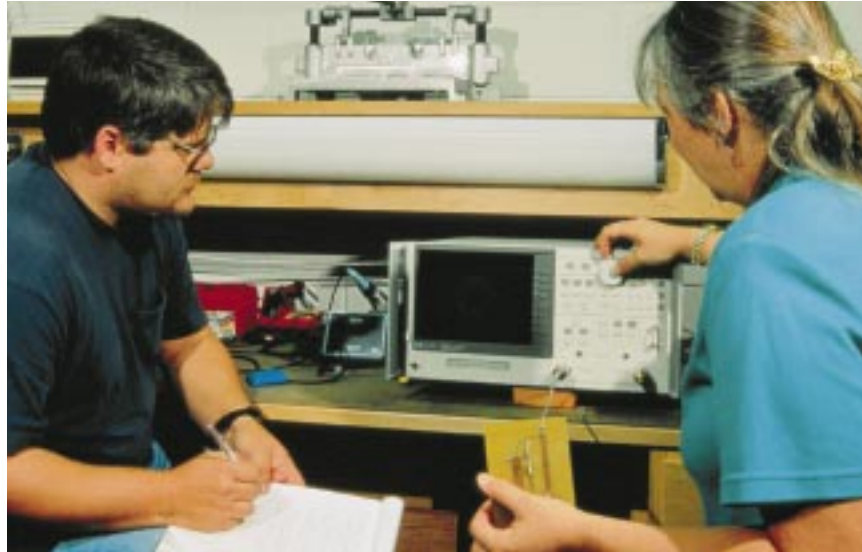
We selected our lab bench instruments based on economy balanced against frequency range and other performance capabilities, including ease of use, reliability and robustness in an instructional environment.

Basic Considerations

To set up a modern RF lab for instruction, consider three things:

1. What do you want to measure?

The type of equipment you need depends on the kinds of components and systems you want to test, as well as the types of measurements to be made. At USF we wanted to measure both passive and active components, as well as subsystems of multiple components. Stimulus-response measurements which characterize a device's parameters as a function of input power are important when testing components. A network analyzer or spectrum analyzer with tracking generator are used for this type of test.



Measuring the time and frequency domain signals of both passive and active devices, as well as systems and subsystems, requires a spectrum analyzer and sometimes a signal generator. Characterizing sensitivity and selectivity on receiver systems requires a signal generator with appropriate modulation capabilities.

2. Frequency range - ISM (industrial, scientific and medical) bands are set aside by the FCC for fairly free use. Consumer electronics manufacturers frequently introduce products in these ISM bands because they can do it without a special license. There's an ISM band in the mid-900 MHz range, another around 2.4 GHz, and one at about 5.8 GHz. For instructional purposes, you can do a lot at lower cost with 1 GHz instrumentation. At USF, we chose to go up to 3 GHz, to cover a wider range of applications through the 2.4 GHz ISM band. Also, experiments involving distributed components are more realistic at higher frequencies, as distributed circuits become large at lower RF frequencies.

3. Budget - In the thin-wallet world of educational institutions, the biggest constraint for lab development is frequently how much money is available. Equipping a 1 GHz bench with a spectrum analyzer, signal source and vector network analyzer costs about 25% less than the same equipment for a 3 GHz bench. We were able to equip six benches to 3 GHz using HP's RF Basic Instrument series. There are alternative equipment configurations that can help reduce costs, discussed below.

Instrument Options

You can make many useful measurements in an instructional setting with surprisingly few pieces of equipment. Below are the main instruments, followed by some supplemental equipment that enhanced our range of experience.

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Setting Up an Instructional RF Analog Lab

Continued from page 3

Network analyzer

A network analyzer (NA) is fundamental for analyzing and measuring one-port, two-port and multi-port components such as voltage-controlled oscillators, filters, amplifiers, and mixers. Both scalar network analyzers (SNAs) and vector network analyzers (VNAs) are used in industry. If all you want to know about a component is the amplification or attenuation factor, or what frequency range it filters, you can save a lot of money with a scalar network analyzer (e.g., HP 8711), which measures reflection/transmission magnitudes.

The vector network analyzer (VNA) goes further, measuring magnitude and phase of transmission and reflection coefficients, and provides more accurate measurement results. Both types of network analyzers include a power sweep to characterize active component saturation and a broad-band detector mode used to measure power levels at input/output of a component or subsystem. The broad-band detector mode also measures the conversion loss in mixers, where input and output frequencies are not necessarily the same. We selected the 3 GHz HP 8714C VNA.

Spectrum Analyzer

To measure the output characteristics of signal sources or devices, a spectrum analyzer (SA) is very versatile. A spectrum analyzer looks much closer

at the input/output signals in the frequency domain – both frequency content and amplitude levels are easy to measure. The SA provides additional ways to measure mixers. In addition to mixer conversion loss, the SA can also look at all the other frequencies that might be present on the mixer's output, including leakage of RF or the local oscillator signals. We selected the HP 8594E, 2.9 GHz Spectrum Analyzer.

Signal Source

In many situations, you will need an additional signal source. This can be as simple as a coaxial voltage control oscillator (only a few hundred dollars from an RF component supplier). In other applications, like RF receiver test, a modulated signal source is required. For a more versatile bench, a synthesized signal generator with convenient control of frequency, amplitude and modulation is best. We chose the HP 8648C, 3.2 GHz Synthesized Signal Source.

Oscilloscope

The oscilloscope displays signals vs. time. Oscilloscopes come into play if you're interested in the lower frequency output of a communications system, or various modulations used in lower frequency communications.

DC Power Supplies and Hand-Held Digital Multimeter

Active components often require DC power supplies. We chose relatively inexpensive HP E3610A digital DC supplies. A digital multimeter is another indispensable tool to ensure proper DC voltages, and troubleshoot bad wires and cables.

Cables, Calibration Kits, and Other Items

Each of our lab benches includes a small tackle box with a collection of coaxial components and cables. To calibrate the network analyzer, we made our own student bench calibration kits (for only a couple hundred dollars). Our purchased calibration kit is used at the instructor's bench to characterize the hand-built calibration kits. Other items that complete the USF WAMI lab include solder stations, a PC board milling machine and simulation and layout software.

With careful analysis of measurement needs, frequency ranges and budget sources, you too can develop a modern, versatile, relatively low-cost RF laboratory.

(For further information, please see www.eng.usf/WAMI).

Don't miss the comprehensive RF Basics Tutorial on the Educator's Corner website at: www.hp.com/info/college_lab101. Download the material and use it in your lectures or have your students study the tutorial online.

Mathcad and HP BenchLink Generate Multisine Test Functions

Zsolt Papay,

Tech University of Budapest,
Department of Telecommunications,
Budapest, Hungary

Purpose:

1. To study numerical signal synthesis and analysis in practice.
2. To show the difference between real and simulated measurements.
3. To show how Mathcad¹ files can be combined with HP BenchLink.

Description:

Linking software files between HP's BenchLink and Mathcad¹ can result in a very powerful analysis/synthesis technique. This experiment will examine the use of Mathcad¹ to create a parabolic-phase signal, which is then loaded into the arbitrary waveform generator via HP BenchLink software.

Note: This experiment from Dr. Papay, along with a second experiment on generating band-limited noise, is available on the HP Educator's Corner website: www.hp.com/info/college_lab101.

Equipment:

- HP 33120A Function/ARB generator
- HP 54600-series oscilloscope with FFT (and HPIB) option
- Personal computer with HPIB card & cables
- HP 34820A BenchLink/Suite Software (Consists of HP 34810B BenchLink/Scope + HP 34811A BenchLink/Arb + HP 34812A BenchLink/Meter)
- Mathcad[®] (MathSoft, Inc.) Software

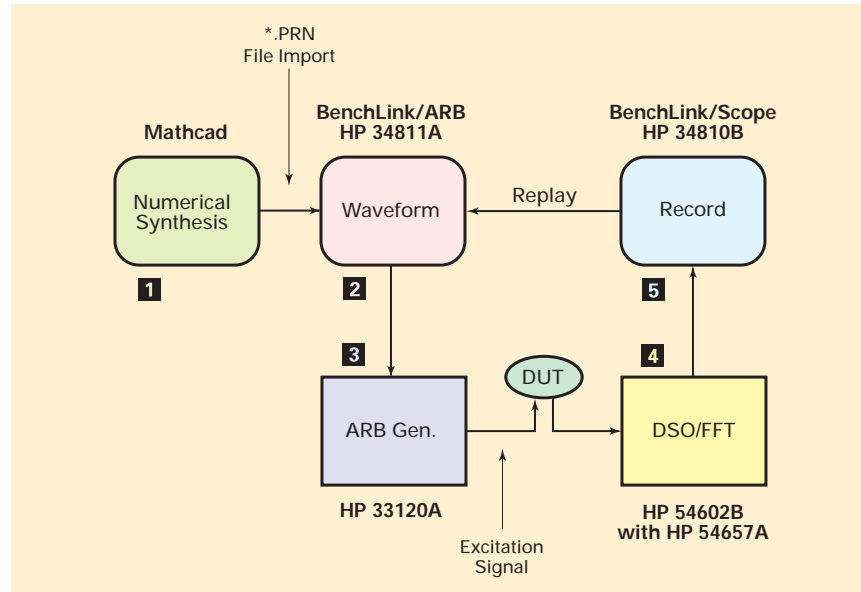


Fig. 1: Setup of experiment

Procedure:

It is possible to analyze the performance of a DUT (Device Under Test) by examining its response to well-designed test signals. In this case, we will generate a comb of frequencies in order to see the DUT's response over its entire bandwidth. This is a convenient way to test the DUT using only one signal. Digital synthesis and analysis techniques are the powerful tools that make it possible (Fig. 1):

1. Create a waveform numerically by using Mathcad¹ software.
2. Transfer that waveform in a file to the HP 34811A BenchLink/Arb Software.
3. Download the waveform to the HP 33120A Function/ARbitrary Waveform Generator and generate the signal.

4. Measure the system response using the HP 54602B Digitizing Storage Oscilloscope with a plug-on HP 54657A (FFT/HPIB) Measurement/Storage Module.

5. Capture the screen data with HP 34810B BenchLink/Scope software.

1. Note: Mathcad is a trademark of Mathsoft Corporation.

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Mathcad and HP Benchlink Generate Multisine Test Functions

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Experiment: Part I

Synthesize the test signal with Mathcad:

Generate a comb of tones over the desired bandwidth, making possible system characterization with one measurement. To use the system's dynamic range efficiently and to improve quantizing error, use parabolic phase to minimize the crest-factor of the multisine waveform. (Reference: S. Boyd, "Multitone Signals with Low Crest Factor" IEEE Trans on Circuits and Systems, Vol. CAS-33, No. 10, Oct. 1986, 1018-1022).

See Fig. 2 for the Mathcad¹ parameters:

Create waveform (R, "*.PRN" file) with Mathcad¹:

num = 10 tone comb with m = 8000 sample points, and simulate DSO/FFT (with hanning window): b = 7.5 effective bits and N = 1024 sample points

Note: Amplitude must be normalized to take advantage of full ARB resolution.

Exercise: Compare multisine signal with and without crest-factor

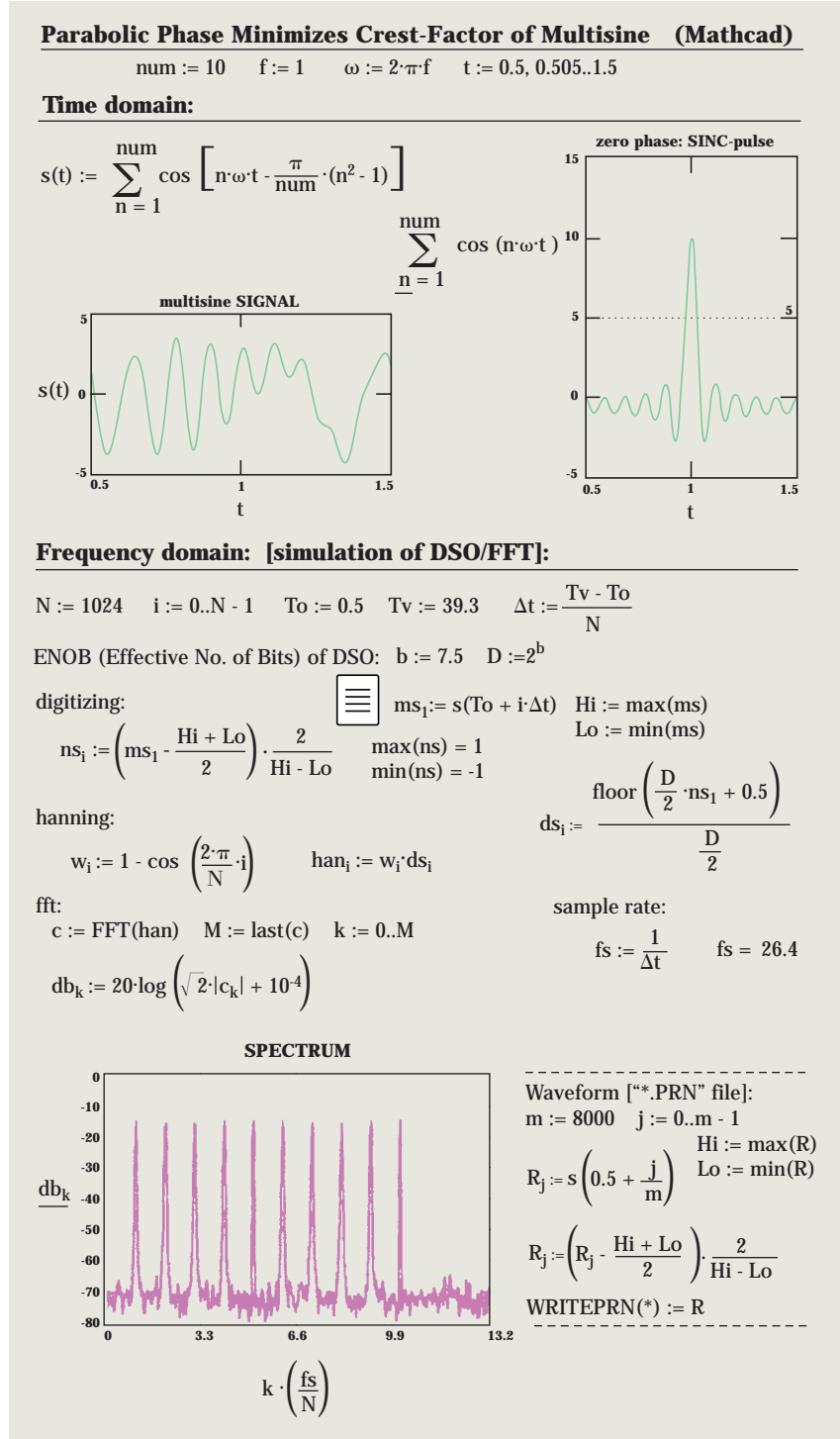


Fig. 2: Mathcad creates waveform and computes spectrum

minimization.

Experiment: Part II

The real measurement:

Import the Mathcad *.PRN" file with BenchLink/ARB, download it into the HP 33120A Function/Arb Gen. and generate the waveform at 1 kHz base frequency. Remember, the downloaded arbitrary waveform is treated as a single cycle by the HP 33120A arb, so a base frequency of 1 kHz means that everything inside the Mathcad window is being repeated 1000 times per second. Then measure the signal vs.

time and show its frequency spectrum with the HP 54602B DSO.

(See examples in Figs. 3a and 3b.)

Exercise: Compare the simulated and directly measured spectra.

Questions or comments about this lab can be sent to Professor Papay at

Comprehensive RF Basics Tutorial now on Educator's Corner

Originally offered as a class for HP customers, the RF "Back-to-Basics" Symposium included in-depth information on a wide variety of RF-related topics. Now this comprehensive course material is available on the HP Engineering Educator's Corner website at www.hp.com/info/college_lab101. You can download the slides to use for lectures or send your students to the web to study the tutorial online.

You'll find a wealth of information on network analysis, spectrum analysis, RF sources and more. The network analysis module, for example, contains more than 100 slides covering topics like S parameters, Smith charts, mixers, samplers, directional couplers, scalar vs. vector analyzers, error correction, reflection and much, much more. Each slide is accompanied by a textual description of the concepts presented.

The addition of this material to the Educator's Corner website (and version 1.1 of the HP Educator's

CD-ROM) is part of our continu-

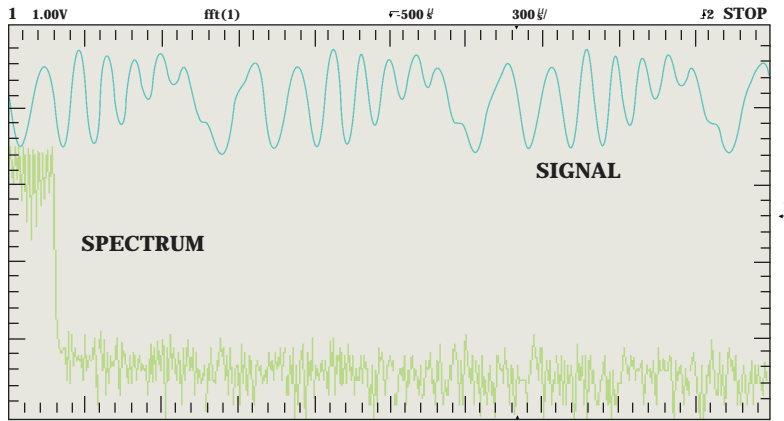


Fig. 3a: Measuring multisine signal and spectrum

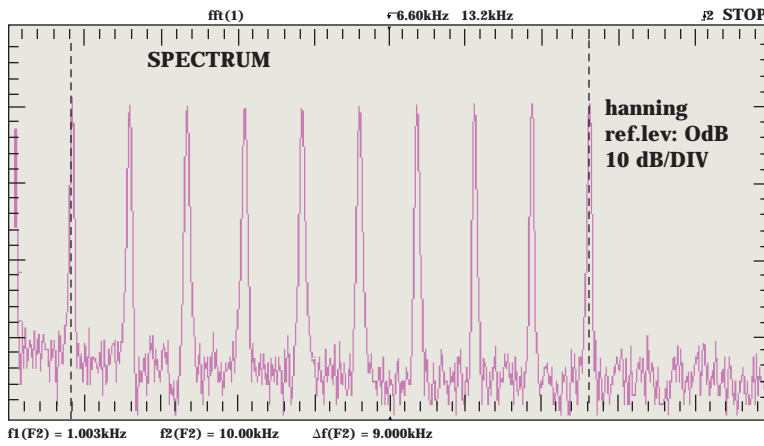


Fig. 3b: Comb of tones ("zoom" spectrum of Fig. 3a)

Dynamic East German Professor Links Education with Industry

When Motorola's Semiconductor Group conducted a road show in East Germany, Professor Matthias Sturm paid them a visit. He pointedly refused the proffered literature and samples and declared instead, "I wish to have what you cannot give me." Surprised and more than a little intrigued, the Motorola representative asked what it was Sturm wanted. "I need more young people who are interested in microcontroller technique and studies," he replied. The staffer nodded in complete agreement.

Sturm continued, "As a leader in the microcontroller market, you can make that happen by becoming a sponsor for our student training program." Professor Sturm had just forged his first mutually beneficial partnership between the electronics industry and Leipzig University of Applied Sciences (HTWK Leipzig).

Following German reunification in 1989, committed professors and students in the former GDR began to change the way engineering was taught, shifting from a highly theoretical approach to more industry-oriented, hands-on methods. Their goal was to close the information gap with their western counterparts and to find their new place in the world. One university that has been successful in meeting this goal, HTWK Leipzig, owes its recent advances to visionary professors like Matthias Sturm, a specialist in microcontrollers and related topics.



Professor Sturm teaches students the intricacies of microcontroller structure.

Creating Industrial Partnerships

Professor Sturm has a grand vision for teaching engineering students: he is determined to give them the most effective learning environment he can provide, thereby leading them to the best job opportunities with industry leaders upon graduation. And, most importantly, Sturm's inspiring vision is dependent on partnerships with those same international industry leaders during the course of instruction.

In a recent interview, Sturm said, "I see it as my calling not only to educate my students in the best possible way on state-of-the-art products, using state-of-the-art methods and multimedia technology, but I also want to take things further: to their application in industry. That is the approach underlying all my activities." To fulfill his vision, Sturm has created several partnerships since his first discussions with Motorola, with industry leaders like Texas Instruments, National Semiconductors, and Microchip.

Practical learning

Sturm believes that students must have access in the lab to the technology that they will later be using in industry. His brand of practical and focused study requires up-to-date equipment and systems from leading suppliers. "I simply cannot use an old single-channel oscilloscope to develop a project in which numerous things are happening in parallel," he explains. "Increasingly, we are involved in signal processing. That means a mix of analog and digital technologies. We need test and measurement equipment that can handle this – equipment like the HP 54645D mixed-signal oscilloscope. Because this scope lets students view analog and digital signals simultaneously, they can see what happens on the analog side when they change the bit positions on the digital side."

Practical, hands-on experience is invaluable for his students because, as

Sturm points out, “Only repeated experimentation can give the budding engineer a feeling for the difference between one milliamper and one ampere.” Just as importantly, Sturm encourages his students to experiment as much as possible and to accept that some experiments will fail. “Only in this way are students later positioned to stay with a problem in industry, sticking with it through difficult patches.”

To gain the experience they need, Sturm’s students experiment with MC68HC11 microcontrollers, high-performance 8-bit microcontrollers used widely in automotive and communications applications. Sturm and his colleagues created their own development boards as well as a new curriculum that tightly integrates lectures with lab exercises and experiments. “I chose the MC68HC11 as a teaching tool because it has clear structure, is easy to understand and has a lot of peripherals,” explained Sturm.

Sturm assigns a series of small tasks to students until they understand how microcontrollers work. Then they move on to small-scale projects. When they are ready, Sturm looks for opportunities for his students to work on projects in conjunction with the school’s industry partners around the world. Students offer to undertake appropriate tasks for their partner companies, usually focusing on developing software and small hardware parts. Using student interns helps companies reduce their work load, and the students quite often come up with surprisingly sophisticated solutions. According to Sturm, because the companies reap significant benefits from their student interns, they are willing to continue the partnerships with the university on a long-term basis.

Even though cultivating industry partnerships is a time-consuming activity, Sturm remains committed to the task. His mission takes him on a constant search for “more brightness:” both the brilliant students who want to learn and the enlightened leaders who want to support that learning.

The Leipzig University of Applied Sciences, founded in 1992, combines scientific education with practical experience. Currently, some 4,000 students are attending the 20 courses offered in engineering, economics, social studies and cultural studies. Students of Information Technology, Electrical Engineering or Automation can graduate with two degrees – an HTWK Leipzig engineering diploma and a British university degree.

For more information, visit www.et.htwk-leipzig.de/fg_nach/profs/sturm.html.

At this site you will find software tools, developed primarily by stu-



HP 54645D Mixed Signal Oscilloscope

Of the electrical engineering students who graduate from your school, the odds are that 60% will work on mixed-signal (mixed analog and digital) design problems. The HP 54645D Mixed Signal Oscilloscope, mentioned by Professor Sturm, integrates two 100-MHz, 200-Msa/s analog channels with 16 digital channels. It gives your students a fast, efficient way to test 8- and 16-bit microcontroller-based designs that incorporate a mixture of analog and digital signals.

For more information on the innovative HP 54645D oscilloscope, use the reply card to request the current issue of ‘Made to Measure’ newsletter and/or an HP 54645D data sheet. If you’d like to learn more about debugging microcontroller-based designs, request a free copy of ‘8 Hints for Debugging Microcontroller-based Designs.’

Use Java to Add Jazz to Your Labs and Lectures

*Glenn Alsup, President, Viewmark
Viewmark is a new media production company,
located in Englewood, Colorado*

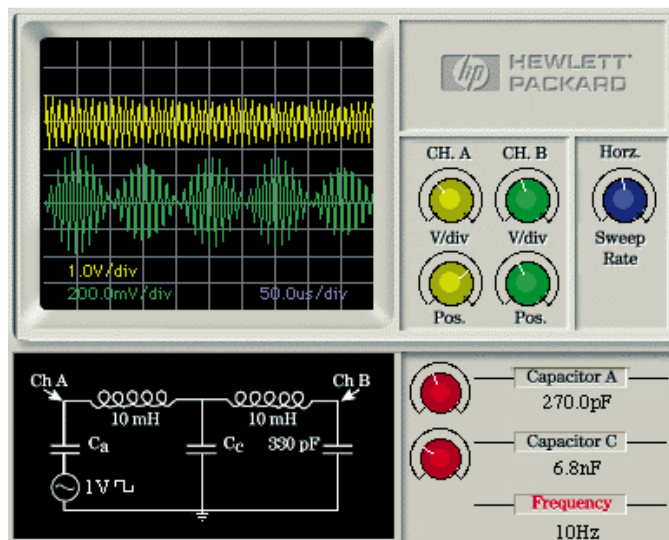
If you haven't explored Java as a teaching tool yet, now is the time. When you sprinkle your engineering lectures with interactive Java demonstrations, you'll capture your students' attention and help them visualize complex concepts. You can also use Java to design interactive lab experiments and teaching modules to post on the Internet or your university's intranet. Then your students can download them to their PCs and learn at their own pace.

If you've never used Java before, the idea of learning a new programming language may sound daunting at first. But there are tools available to make it easy for people – even those without prior programming experience – to use Java.

HP asked us at Viewmark to create some sample interactive college lab experiments for its Educator's Corner website. The first one demonstrates AC circuits, based on an experiment written by Stanley Dodds of Rice University, in Houston, Texas. To see what we're talking about, take a look at www.hp.com/info/college_lab101. Select Spectral Simulation, then AC Circuits.

Java-Jazzed AC Circuits Lab

The first part of the lab exercise is to pulse circuits and watch the energy slosh back and forth between two capacitors. Further parts of the exercise include: 1) observing the interaction between two oscillators, 2) using a function generator to excite an oscillator with a sinusoidal wave and then measuring the response of a second oscillator, and, 3) sweeping the frequency of the function generator to see both oscillator peaks as a function



Viewmark created this virtual oscillator with Java. When students visit the Coupled Oscillators online lab (www.tmo.hp.com/tmo/ia/edcorner/English/Jex1.html), they can vary the tunable capacitor and adjust the timebase and vertical sensitivity of the scope by clicking on the control buttons with a mouse.

of frequency. (Other exercises on the website show generating waveforms with vectors and generating pulses to show the huge number of harmonics necessary to reproduce a low duty-cycle pulse train).

Here's a thumbnail sketch of how we developed this Coupled Oscillators interactive lab for Educator's Corner website.

Our team's first task was to select an experiment that was well suited to Java. We looked for a theoretical experiment with an infinite number of solutions that could be determined mathematically.

The next step was to model the lab's electrical circuit mathematically. This allowed the circuit's behavior to be programmed with Java. The circuit included inductors, capacitors and resistors.

Then the virtual oscilloscope was programmed to accept virtual "electrical" inputs and to show a moving trace just like a real oscilloscope. Basic functions such as horizontal sweep rate, volts-per-division and position were enabled, including numerical information.

Because Java is an object-oriented programming language, steps 2 and 3 could be designed as independent modules. The final step was to program the interconnections so the "oscilloscope" could operate and "react" as it

would with a real circuit. Students can change the values of components in the circuit and apply driver signals. The virtual oscilloscope probes programmed points for its readout, and displays a moving trace across its screen just as if an independent instrument were measuring the circuit.

We included the introduction and explanation of the virtual lab experiment as .pdf files (written in Adobe Acrobat, in this case).

A graphic designer from Viewmark polished up the image of the oscilloscope, and the experiment was published on HP's Educator's Corner website.

This is just one example of the potential for using Java to create labs with "virtual instruments." Take a look at Java, and consider jazzing up your own favorite labs.

Getting Started

Check out some examples of Java programming. In addition to the HP's Educator's Corner link listed on page 10, visit www.jhu.edu/~virtlab to see Johns Hopkins University's virtual lab. Also visit www.viewmark.com for more sample multimedia presentations including Java.

For Java programming tools, see www.sun.com. Select Java Computing, and Software Solutions. Sun offers downloadable modules for getting started right away – including Java Studio for those who don't have prior experience with programming.

Why Java is Hot

- **It's a universal language. True "open computing" means Java programs can be downloaded onto any kind of computer, whether Windows, Macintosh, Unix or any other platform. Its "write once/run anywhere" ability means that one version of an application or lab can be deployed on a wide array of systems.**
- **It's easy to develop new programs. If you have experience with C or C++ programming languages, you even have a head start. But even if you've never programmed before, Java provides an interactive authoring environment to make it easy. (See 'Getting Started,' left).**
- **It's an object-oriented programming language, so it's easy to design independent, reusable modules.**
- **Because Java was designed to be downloaded from the Internet, it has a number of built-in security features that protect your computers from viruses or failure due to corruption. Its features include strong memory protection, encryption and signatures, rules enforcement and run-time verification.**

Why It's Not

- **Because Java is still relatively new, it lacks the maturity of a well-established programming language.**
- **Despite claims to the contrary, Java applets run differently depending on the browser used for viewing. This means you may have to spend considerable time tweaking your code to get it optimized for all viewing environments.**
- **The language is not as well-documented as it should be. That means you're likely to spend a lot of time figuring things out through trial and error – which can be extremely time-consuming.**
- **Even though Sun offers tools for beginners, writing programs in Java can be slow going if you don't have structured programming or object-oriented design experience.**

Web Update

Get your Free copy of the New HP Educator's Corner CD-ROM

Shortly after we introduced the HP Engineering Educator website, we gathered up all the materials it contained and published it in CD-ROM format to make it

easier for you to access all of the multimedia content. That was about a year ago. Since that time we've almost doubled the size of the website, adding a wealth of new material, including dozens of lab experiments, spectral simulations, tutorials, cartoons and other materials designed to save you time, keep you informed and help you get your job done effectively.

Because we wanted you to have easy access to all the new material, we've once again compiled the Educator's Corner contents onto a CD-ROM. To get your free copy, just check the appropriate box on the business reply card enclosed in this newsletter or visit the Educator's Corner website (www.hp.com/info/college_lab101) to submit your request.



New material you won't want to miss:

- **RF Basics Tutorial** - See sidebar on page 7 for details.
- **Measurement Uncertainty Spectral Simulation** - Use this interactive applet to teach your students about the uncertainty that results from interfering signals.
- **Superheterodyne Spectrum Analyzer Simulation** - Shows, in an animated format, how an analog spectrum analyzer works. You can use it to demonstrate what an "IF" is, or how "LO feedthrough" is created.
- **A whole series of new FFT experiments** from Colorado State University.
- **HP VEE-based experiments** from Carnegie Mellon University that simulate a satellite in trouble. Have your students solve the problem remotely via a LAN connection to the HP Basic Instruments.
- **Electronics and Electric Circuits Theory labs** from Boston University and much, much more!

HP Educator's Corner wins WMA award

The Web Marketing Association (WMA) recently awarded the Educator's Corner website a Standard of Excellence Award. The WMA gives this award to sites that are judged as

setting a standard of excellence for which all corporate websites should strive. Criteria used for judging websites included design, innovation, content, use of technology, interactivity, navigation, ease of use, and usefulness to target audience.

We are delighted to receive this award. But even more important to us is your judgment of the HP Educator's Corner. Do you find the material on the site useful? What do you like best about it? What could we add that would be a big help to you? Please visit the feedback page at: www.hp.com/info/college_lab101 to send us your comments or send e-mail to Marsh_Faber@hp.com.



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