Enhanced Suitcases for Upper Division Electronics Laboratories

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Abstract

Inexpensive ($200 - $350) attaché cases filled with equipment pertinent to a basic electronics test laboratory have revolutionized basic electronic laboratory courses. These are called electronics trainers or mini labs by two of the manufacturers. At a minimum, the cases contain a prototyping board, power supplies (± 5v, ± 12v, and variable), function generators, potentiometers, and switches, LEDs, and clocks, for analog and digital circuit laboratories. More elaborate cases include coaxial connectors and DB25 connectors for connection to computers or oscilloscopes, enhanced function generators, AM and FM signal generators, and multimeters. These suitcases allow students to prepare for (or perform) laboratory experiments at home. In addition they are excellent for speeding students to success in circuit building and analysis in lower division courses. However, in upper division courses, such as communications and controls, circuits get so complex (greater than 100 connections) that laboratory experiences become troubleshooting and continuity experiences rather than investigations into circuit and system behavior. Thus, the suitcases lose value in the upper division. At the University of Texas at Brownsville, we are adding printed circuit modules to the cases. These modules contain the support circuitry for circuits to be investigated. This permits investigation of relatively small circuit units in the context of larger systems. This paper discusses the use of suitcase laboratories in lower division circuits courses and then explores the needs for “suitcase enhancement modules” for upper division courses. Finally, the design concepts and applications for some of the enhancement modules are presented.

Introduction

The University of Texas at Brownsville (UTB) is the newest component of the University of Texas System. Established by the state in 1992, UTB currently enrolls more than 9,000 students, of whom greater than 95% are Hispanics, mainly of Mexican-American descent. As part of an ambitious expansion to better serve an underrepresented community, UTB received state approval four years ago to start new programs in Chemistry, Computer Science, Engineering Technology, and Physics.

Introductory courses in electronic engineering technology have been presented four or five times, upper division courses have been presented once or twice. Some elective courses have not been presented yet. Early on, we saw the advantage of using Mini-Lab prototyping trainer systems that come packaged in attaché cases. We call them suitcases. Each suitcase Mini-Lab comes complete with a solderless prototyping board, power supplies, a function generator, and LED indicators and switches for digital circuits. The suitcase used in the advanced courses additionally includes a digital multimeter, BNC and DB25 connectors for ease of input/output access, and its large solderless breadboard is attached to the surface of the trainer by Velcro strips. These mini-labs are available from three different manufacturers, for prices ranging from $200 to $400 each.

Introductory Courses

Students are expected to fabricate and troubleshoot circuits outside of class. Figure 1 shows three different circuits fabricated by the students outside of class in one of the advanced suitcase "Mini-Labs" for our Introduction to Electronic Circuits course.

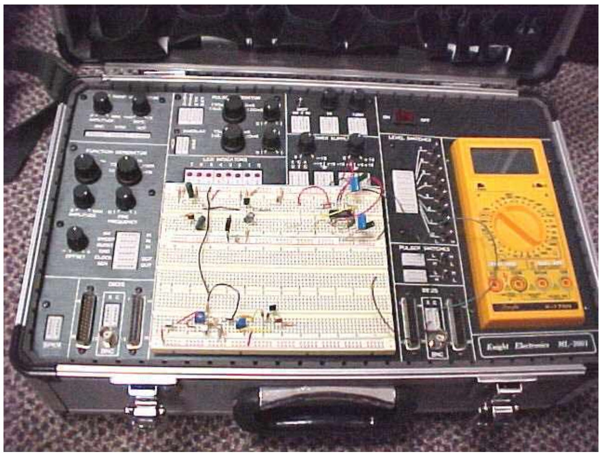


Figure 1

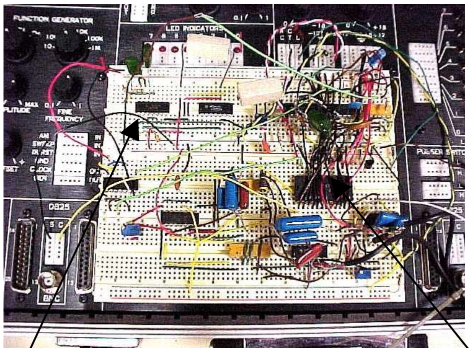
These circuits are fairly simple, involving less than a score of interconnections each. Students can build these outside of class and ring them through for continuity, then use laboratory time for examining the circuits with oscilloscopes under the guidance of the instructor. Suitcases and prototyping boards work very well in introductory courses and with small circuits where continuity can be checked visually.

Advanced Courses

It was intended that the subsystems shown in Figure 2 and Figure 3 be fabricated by the students in the sixth semester Instrumentation and Controls course outside of class. However, the student teams discovered the fabrication task to be very time consuming. Several teams completed fabrication of just the Strain Gage Signal Conditioner, but only one team successfully completed the troubleshooting phase. Completion of fabrication and troubleshooting for each of the three subsystems shown in Figures 2 and 3 required about 18-24 hours of instructor intervention. Due to the fragile nature of the solderless fabrication technique, the instructor, rather than the students conducted the 10-15 experiments for the instrumentation portion of the course. The experiments were very successful and received "high marks" from the students; however, these experiments would have been *"world class"* had the students been able to conduct the measurements themselves. These circuits are illustrative of the complex circuits found in "real world" systems.

The difficulties encountered constructing these circuits make computer simulations of circuits attractive.

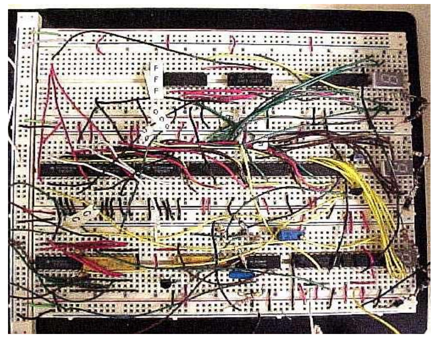
It is tedious and time consuming to build large circuits on the solderless prototyping boards. Small circuits are built in introductory courses where students learn prototyping and troubleshooting of wiring. These activities are irrelevant to the higher level courses. As a result, laboratories for these courses degrade into demonstrations of instructor-fabricated subsystems.



Phase Locked Loop

Strain Gage Signal Conditioner

Figure 2



Dual Slope Analog to Digital Converter (ADC) with Display

Figure 3

The circuits depicted in Figure 2 and Figure 3 are available as inexpensive integrated circuits or sealed modules. The same is true of communications circuits. It is useful to demonstrate how these circuits work in a circuit where critical components can be changed or adjusted and the resulting system behavior observed. We suggest that there are three ways of doing this circuit work. One way is the mathematical way, the engineering way. Drawings of the schematics can be analyzed using mathematical tools and the results calculated. Another way is the computer simulation way. The circuit diagram can be created in Electronics Workbench, PSpice, or other simulation program. Component values can be changed in the simulation and the results calculated by the program and displayed. The final way is to build the circuit using real components and to inspect the circuit directly with real instruments. We believe this last method is most appropriate to the “hands-on, brains-on” nature of engineering technology.

Our Approach

Laboratory budgets are limited. It is easy and inexpensive to do computer simulations. It is labor intensive to have the instructor build demonstration circuits on solderless prototype boards, and then the circuits are difficult to see through the nest of wiring. There are pre-built modular demonstrators of instrumentation and communications circuits built expressly for college laboratory use but these are expensive. (Thousands of dollars.)

We are embarking on building Velcro-backed printed circuit board modules that will be interchangeable with the Velcro-backed solderless prototyping board found in the suitcase system. Such modules would utilize the suitcase facilities for input and output. They would also have plenty of solderless terminals for students to install jumpers and exchange components in order to observe circuit behavior under a variety of conditions.

Implementation

Figure 4 shows a mockup of the same ADC circuit shown in figure 3. The mockup consists of the same components as the Figure 3 circuit, but the components are inserted into perforated board. In this mockup, the components are not connected, but do illustrate the advantages of using a built model. The little “dots” scattered all over the board are solderless terminals.

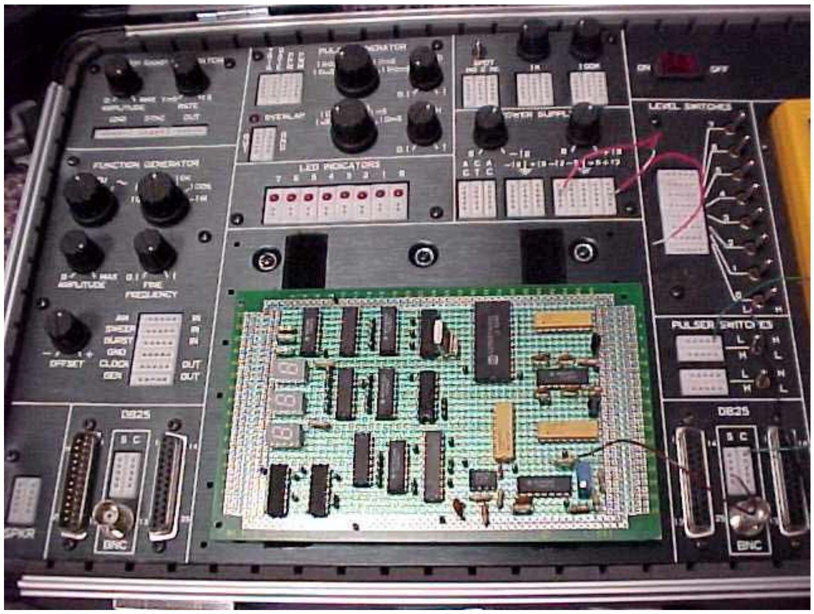


Figure 4

The idea is to remove the solderless breadboard in the mini-lab and replace it with a sub-system module that is much easier, and much less time consuming, for the student (and instructor) to work with. Note that the circuit area in this printed circuit board (pcb) mock-up could have been 50% larger and still have fit the area provided by the mini-lab.

In our final design, each module will be packaged on a larger pcb measuring approximately 6.5”X5.5”. Each pcb will have three layer construction (two circuit sides plus ground plane), and will be silk screened to identify individual circuits, test points, and solderless component connections.

Other modules planned for development during the next two year project period are listed below. Each module developed under this program will be identical as to “form and fit,” and will have similar numbers of solderless connections and test points. Each new module type will add many more unique circuits, thus providing the user with a large inventory of experiments that can be performed at the circuit level.

- *Storage Register, Digital to Analog Converter (DAC), and Post Filter Module*—This module will accept the ADC output and allow observation of a variety of sample data system errors.

- *General Purpose High Gain Instrumentation Amplifier, Precision Current Sources, and Presample Filter Module:* This module will allow measurement of temperature (thermocouples), stress (strain gauges), and any other resistance or voltage source. This module will allow study of various types of error sources

- *Frequency Synthesizer Module* – This module will allow the study of phase locked loops, unwanted "spurs," and frequency multipliers.

If these modules are successful, more modules for other courses will be developed.

The basic design for each of the proposed modules already exists. To a large degree, these functions are now produced in chip form. Our design task is "reverse engineering" the packaging and component selection to allow student access to internal circuit connections. An advantage to using these pcb modules rather than either "bird's nest" prototyping boards or circuit simulation programs is that the pcb modules will most realistically demonstrate real issues in circuit design and construction. By contrast, simulation programs go to one extreme by idealizing the circuit, and solderless boards go to the other extreme by turning every interconnection wire into an antenna.

A manufacturer of suitcase prototyping systems has expressed to us their strong interest in producing these modules to be enhancements to their products.

Benefits to Electronic Engineering Technology Education

Enhancement of education for Associates and Bachelors degree students in the Technology fields is directly proportional to the quality of their laboratory experience. Software for computer generation of Virtual Electronic Circuits with waveform measurement simulation does exist from a number of industry sources. Indeed, for some colleges, Virtual Circuits have replaced Real Circuits for courses in fundamental electronics. We think this is due in part to the "frustration factor" faculty and students experience during fabrication of Real Circuits.

In our opinion, every institution that offers degrees in Electronics Technology should have quality, wide-band laboratory test equipment. At UTB, students are taught the use of this equipment near the beginning of the multi-semester circuits course sequence.

Laboratory measurement of complex circuit or subsystem parameters in the presence/absence of environmental error sources enriches the laboratory experience. Being able to observe the effects of stray inductance/capacitance (spurious oscillations, bandwidth limitations) and device imperfections (linearity, rate limiting, gain, impedance) enriches the laboratory experience. Spending 10% of the time fabricating and troubleshooting, leaving 90% of the time for measurement and testing, *greatly* enriches the laboratory experience.

We are looking forward to incorporating these modules in our laboratories.

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Dr. Berg has been Associate Professor of Engineering Technology at UTB since 1997. Since then, he has been continuously developing improvements in electronics engineering technology curriculum in the Department of Engineering Technology. During 1986-1997, Dr. Berg was Associate Director of the Center for Sustainable at the University of Massachusetts Lowell. He holds a Ph.D. in Applied Physics and Energy Engineering form the University of Massachusetts Lowell, and a Bachelor of Engineering degree from Stevens Institute of Technology.

MORRIS BOUGHTON
Mr. Boughton has over 20 years of hands on design engineering experience in signal conditioning, instrumentation, and microwave communication and control systems for aerospace industries and major commercial television networks, plus an additional 14 years of marketing and management experience in entrepreneurial ventures. Since 1995, he has been teaching at UTB, setting up the engineering technology laboratories, and assisting with the refinement of syllabi for multi-semester course sequences in the electronic engineering technology program. He earned two degrees in Electrical Engineering, an M.S. from the University of California at Los Angeles, and a B.S. from the Michigan State University.