This is the published version:


Available from Deakin Research Online:

http://hdl.handle.net/10536/DRO/DU:30018265

Reproduced with the kind permissions of the copyright owner.

Copyright: 2008, AARE
A New H.E.L.P. Kit for Teaching Practical AC Electronics to Undergraduate Distance Students

J.M. Long, L.L. De Vries, R.M. Hall, and A.Z. Kouzani
School of Engineering and Information Technology, Deakin University, Geelong, Victoria, 3217
{john.long, lee.devries, robynn.e.hall, abbas.kouzani}@deakin.edu.au

Abstract: An important part of educating students in electronics and electrical engineering is laboratory practicals. Providing effective practical experience to students by distance education has always been a significant challenge to the engineering educator. Deakin University has for many years taught practicals in basic digital electronics to off-campus students by means of a kit. The same students have performed related exercises in analogue electronics, which require generating and measuring AC signals, by means of either software simulations or on-campus attendance at lab classes. This year, for the first time, off-campus students are being provided with a new kit, which contains a low-cost, battery-powered AC signal generator, and an interface that allows a PC to be used as an oscilloscope. This kit allows the off-campus student further flexibility in learning basic electronics.

Introduction

In any engineering course, an essential element is the laboratory practice. Being able to apply engineering “hands-on” is just as important as an understanding of its theoretical aspects (Anido and Llamas, 2001). This is especially true in electronics and electrical engineering. Thus any course in electronics must have a strong practical component, where the student learns skills in building, designing, and testing electronic components and systems. In the more traditional university electronics course, students learn the necessary practical skills in on-campus lab classes, with a dedicated teacher and appropriate test equipment.

The past 30 years or so have seen the development of distance education and the concept of an “open university” (Holmberg, 1981). Through distance education, students are able to complete university courses partly or completely at home. Distance education is particularly suited to students who are unable to attend normal classes during working hours, because of work or family commitments, or because of physical isolation from the university campus. Thus distance education enables many students to undertake tertiary studies who formerly were unable to do so.

Teaching science and engineering by means of distance education has always been a challenge. For instance, Anastasiadis and Metaxas (2006) review the issues of importance in engineering education and distance learning. They present the main principles and tools which can be used in engineering education in a distance-collaborative approach. These include an explanation of a pedagogical goal in the education philosophy, the improvement of communication model to promote critical thinking, collaborative skills enhancement via methodological choices and technical support, and inclusion of a collaborative method. One of the chief challenges is that teaching practical skills this way is difficult (Alexander and Smelser, 2003). In past years the average distance student has had very limited access to the necessary equipment required in a science or engineering course. This is certainly true in electronics, where the student needs to learn how to use test equipment such as multimeters, oscilloscopes, power supplies, logic probes, and signal generators. The obvious solution to this problem is to run lab classes in the evening or on weekends, and require distance students to attend them. For those students who live near the campus, this is generally not a problem. But for students who reside far away or interstate, such a requirement is generally beyond their means.

A number of solutions have been devised to overcome these difficulties. One simple solution is to have distance students perform computer simulations (See for instance, Margalef, Vicent, Senmarti, Bou, and Anguera, 2007; and Parush and Hamm, 2002). However, a simulator’s chief disadvantage is
that it only simulates electronic circuits and does not teach real hands-on skills. Another more recent solution is for distance students to perform real electronics experiments by remote control. This has become a popular approach even for teaching on-campus students with greater flexibility, especially with the advance of the Internet and electronic control packages such as LABVIEW. (Examples include Colace, De Santo, and Pietrosanto, 2004; Eppes and Schuyler, 2004; Lindsay, Liu, Murray and Lowe, 2007; Sapijaszko and Sapijaszko, 2004.) The many advantages and disadvantages of these approaches to teaching practical skills in electronics have been reviewed previously by Long and Hartas (2005).

For teaching practical skills in first-year electronics to distance students, over many years, Deakin University has provided an electronics kit, containing the necessary components to perform at home a series of digital experiments and a limited set of analogue exercises (Long, Florance and Joordens, 2004). The chief limitation of the kit has always been its lack of equipment to perform proper AC experiments, the sorts that require an AC signal generator and an oscilloscope. Experiments precluded from the students in this case include half and full-wave rectifiers, amplification of AC signals, frequency response, and bandwidth measurements. These are all very important experiments in any electronics curriculum, and there are of course many others.

Our earlier solution was for the students to simulate the AC components of the practicals. This of course had the disadvantages noted above. More recently we have been running weekend lab classes for the analogue experiments, whilst allowing the digital exercises to be performed at home with the kit. Interstate distance students have been encouraged to obtain access to laboratories containing the necessary test equipment, which for many students working in industry, has been possible. Other interstate students took the time and expense of travelling to Deakin for the weekend classes.

In an attempt to provide off-campus students with inexpensive and versatile equipment to perform basic measurements in AC electronics, Long and Hartas (2005) developed a prototype, battery-powered AC signal generator; and an interface that together with some freely available software, allowed a PC to be use as an a oscilloscope. The signal generator was based on the EXAR XR-2206 function-generator IC, and the oscilloscope software was freely available on the Internet. Input to the PC was via the sound card. The PC-oscilloscope package had the disadvantage that only relative voltage measurements were possible, and input voltages had to be limited by a buffer to levels safe for the sound card to receive. Low-cost, commercial packages were not then readily available.

As time passes, however, electronic components and test equipment have become more widely available and less expensive for the average student. The necessary test equipment is now commercially available for completing a wide range of AC experiments and measurements. Basic AC signals are easily generated by a hand-held, battery-powered device, and an improved PC-oscilloscope package allows AC measurements by means of a PC’s USB port. Both devices exist at prices the average student can afford.

The H.E.L.P. kit

This year, for the first time, in addition to the usual electronics kit (Long, Florance, Joordens, 2004), off-campus students studying first-year electronics are being issued with the Home Electronics Laboratory Pack (H.E.L.P.), figure 1, consisting of the following test equipment:

- A two-channel PC-USB oscilloscope and accessories.
- An audio signal generator.
- A digital multimeter (Digitech model No. QM1535).
- A logic probe.
- Documentation and a CD that contains software and manuals.
- Assorted probes and test leads.
Students are issued this kit on loan for the semester, with the option to purchase it outright. Central to the kit are the signal generator, and the oscilloscope interface and software. The remaining components make the package more complete.

The audio signal generator

The signal generator is by Digitech, model No. QT2302 (figure 2). Powered by a nine-volt battery, it supplies sine and square waves at variable frequencies and amplitudes. Its specifications and features include:

- Output frequencies (setting 1) 20 Hz to 1.50 kHz in 23 discrete steps.
- Output frequencies (setting 2) 2 kHz to 150 kHz in 23 discrete steps.
- The maximum output voltage is 4.4 volts peak-to-peak sine wave, ±3.6 volts square wave.
- Output control: 0 dB, −20 dB, plus fine adjustment.
- Output impedance: 600 ohms.

The PC oscilloscope

The PC-oscilloscope is the PoScope, by PoLabs, (distributor model No. QC1930, figure 2). It allows a PC to act as a standard two-channel oscilloscope by means of a USB-port interface, with both AC and DC coupling. Its sampling rate can vary from 100 Hz to 200 kHz. Figure 3 shows a screen shot of a typical application from a basic first-year practical. Software driven, it also performs some mathematical analysis of the measured signals. For instance, two signals may be observed simultaneously to measure their amplitude and phase differences. Mathematical analysis can also be done on a signal to measure the frequency, amplitude and period.
Figure 2: Digitech battery-powered AC signal generator (left), and the PoScope interface (right).

Figure 3: Screenshot of input (red) and output (blue) signals from a half-wave rectifier as measured by the PoScope. The input signal was supplied by the Digitech AC signal generator.

The oscilloscope package also has some extra features, which may be incorporated into future educational applications:

- Chart recorder.
- Spectrum analyser.
- Logic analyser with serial protocol decoding.
- Square-wave and pulse-width modulation generators.
- Logic generator.

The complete practical package, the original electronics-components kit plus the H.E.L.P. kit, allows the student to perform the first-year electronics practical experiments entirely at home, in a manner that closely resembles real-word applications, without the expense of purchasing a professional signal generator and oscilloscope. Since the signal generator is powered by a nine-volt battery and not from the mains, the corresponding experiments have a degree of safety that would be required for inexperienced students working at home. Also, its high output impedance protects it against accidental short circuits – a common occurrence in any undergraduate electronics laboratory.

Discussion

In addition to the signal generator and the PoScope, we added to the kit a standard digital multimeter and a logic probe. The multimeter ensures that all students have one and its use is uniform across all students. We added the logic probe because it complements nicely the existing digital experiments and introduces the student to one of the electronics’ most widely-used tools. Indeed, for practical electronics, the logic probe is as important as the signal generator and the oscilloscope, as it allows the rapid testing of logic levels, locates high impedance conditions, indicates dynamic signals, and captures very short pulses.

The H.E.L.P. kit is being used at Deakin University for the first time in semester two, 2008. We plan to use evaluations of the package by both students and instructors to determine its usefulness and make further improvements. Further documentation will be produced and made available on a dedicated website.

There is also plenty of scope to extend the use of the H.E.L.P. kit to other subjects, particularly second-year Analogue Electronics. This latter subject includes experiments on small-signal transistor amplifiers and analogue signal processing (such as differentiators and integrators). Currently second-year students attend weekend lab sessions to perform their practicals. Prior to 2000-2001, off-campus students performed second-year analogue practicals by means of computer simulations.

A recent development in engineering education in Australia is the introduction of curricula concerning engineering professional practice (Engineers Australia, 2005; Palmer and Bray, 2005). Universities that provide distance education in engineering, including Deakin University, are now required by Engineers Australia to have distance students to attend residential schools for two weeks in each full year of study. Deakin offers its first-year residential school in semester one, which matches nicely with teaching introduction to engineering management, and first-year physics. Distance students perform the physics practicals on-campus at the residential school. First-year electronics is taught in second semester. There is no residential school in second semester of first year. Thus for off-campus electronics students in semester two, the electronics kits make it unnecessary for them to travel to the university a second time in the same year. This means substantial savings and increased convenience for interstate students in particular.

Conclusion

Practical hands-on experience is an essential element of any university electronics curriculum. Providing practical exercises in electronics has always been a challenge for the education of distance students, mainly due to the high cost of essential test equipment, in this case AC signal generators and oscilloscopes. For the first time, Deakin University is able to deliver to off-campus students a complete practical course in basic electronics, by means of an existing electronics kit and a new H.E.L.P. kit that contains a battery-powered AC signal generator, and software and hardware that allow a student’s PC to be employed as an oscilloscope. The package allows distance students to complete a series of experiments in analogue electronics without the need to attend on-campus lab classes or rely completely on computer simulations.
References


Engineers Australia Accreditation Board (2005). P04 Engineers Australia Policy on Accreditation of Programs Offered in Distance Mode, Engineers Australia, Canberra.


PoLabs, Slovenia, website: www.poscope.com; distributed in Australia by Electus Distribution P/L.


Acknowledgement

The authors thank H.M. Trinh for his valuable assistance in this work.

Copyright statement

Copyright © 2008 J.M. Long, L.L. De Vries, R.M. Hall, A.Z. Kouzani: The authors assign to AaeE and educational non-profit institutions a non-exclusive licence to use this document for personal use and in courses of instruction provided that the article is used in full and this copyright statement is reproduced. The authors also grant a non-exclusive licence to AaeE to publish this document in full on the World Wide Web (prime sites and mirrors) on CD-ROM and in printed form within the AaeE 2008 conference proceedings. Any other usage is prohibited without the express permission of the authors.