Session 3550

An Introduction to an EET and Projects Course with Unique Learning Experiences

Russell A. Aubrey, Stanley A. Dick

Purdue University School of Technology at Anderson

Abstract

EET 196 introduces entering students to EET and to projects by presenting numerous electrical/electronic laboratory opportunities. A number of these exercises are unique to the Anderson location. The course combines focused short lectures with a great deal of structured hands-on laboratory experience. The exercises involve several weekly project assignments as well as a major electronic construction project to be completed by the end of the semester. These assignments range from an introduction to conventional house wiring to Printed Circuit Board (PCB) layout and etching, culminating with the fabrication of a variable voltage DC power supply. Providing a course with well defined objectives within the constraints of a project-oriented atmosphere serves as a major confidence builder for students with little or no previous electrical/electronic experience. The course's philosophy, objectives, assignments, learning platforms and student evaluations are presented.

Introduction

Electrical Engineering Technology (EET) on most campuses has a reputation for being tough on students in the early semesters. The introductory course, EET 196-Introduction to EET and Projects, provides an opportunity for entering students to gain insight into the electrical/electronic field early in their academic careers. At the Anderson location of Purdue University School of Technology, EET students enter the program with a variety of backgrounds and abilities. It is not unusual to have age ranges from 18 to 50 years old in the same class. Their experience with hand tools, mechanical layout and the technical aspects of electrical/electronic systems usually is as varied as their age spread. It cannot be taken for granted that all entering technology students have had repair experience with their parents on cars, bikes or homes. This course utilizes defined learning and teaching objectives coupled with extensive hands-on projects that should provide a snapshot of what life is like as an EET graduate.

Course Philosophy

The basic philosophy of the course is to provide a "get acquainted to EET" experience in a relatively non-threatening, interesting manner. Diverse issues such as engineering ethics, job satisfaction, marketing issues, life long learning and global market pressures are presented as part of the class assignments and project development. Student involvement in all aspects of technical and non technical areas is stressed in a non intimidating manner. There are no pre-requisites for the course, so it can be included in a soft start student schedule to allow a student to affirm his/her career goals while attaining required remediation in other non technical areas.

The EET 196 course description specifies that the course introduces EET projects and the EET program. Included topics are EET options, university services, study techniques and employment opportunities. Also introduced are the techniques for proper use of hand and machine tools. The process of fabricating, assembling and testing printed circuit boards (PCB) and small electronic systems are also presented.

EET 196 is a 2 credit hour class presented as class for one hour and lab for three hours. The flexibility exists to stretch the lecture portion to become lab preparation time when necessary. The intention at the Anderson location is to end up with a lecture/lab scenario which ensures the two activities are seamless. Purdue/Anderson has the advantage (sometimes a disadvantage) of small class size and limited space, which mandates that students and faculty work in close proximity.

Course Objectives
Course learning objectives state that the successful student will be able to:

- State the principles of lab safety.
- Describe basic power supply regulation.
- Apply the principles of soldering to create acceptable solder joints.
- Understand the principles of testing, and use those principles to test a basic power supply circuit board and assembly.
- Describe basic assembly procedures for surface mount parts.
- Describe basic procedures of IC fabrication.
- Apply basic project planning principles to the class project.
- Understand the EET department, culture, and appropriate decorum.
- Describe EET as a career.
- Develop their plan of study for their EET degree.
- Describe university resources as they apply to student welfare.

Course Assignments
The teaching and laboratory presentation topics are:

- Orientation to Purdue, the EET Department and curriculum (2 class hrs.)
- Orientation to EET career opportunities at the AS and BS levels (2 class hrs.)
- Introduction to Purdue resources and student welfare (3 class hrs.)
- Laboratory safety and wiring (1 class hr.)
- Residential wiring techniques and the National Electrical Code (3 class hrs.)

- Introduction to electrical and mechanical print reading (1 class hr.)
- Soldering/desoldering and reworking techniques (2 class hrs.)
- Projects: An Overview of Project and Planning (1 class hr.)
- Power supplies: Basic design criteria and implementation (2 class hrs.)
- Testing of circuit boards: Bare-board, in-circuit, and functional tests (2 class hrs.)
- Surface Mount Technology (1 class hr.)
- PC board fabrication techniques (1 class hr.)
- Semiconductor fabrication basics (2 class hrs.)
- Tests and exam (3 class hr.)

The philosophy of the course is centered around the concept of learning by doing.[1] EET topics, issues or theory are introduced to the students in lecture and then applied to a practical situation in a lecture/lab experience. Several two to three-week lab projects are assigned that coincide with the lecture schedule and prepare the students to start the final project.

Learning Platforms

Residential Wiring Project
A sample portion of the weekly class schedule is shown in Figure 1 to illustrate how the course presents the technical aspects of EET with lecture and then a hands-on laboratory experience. As the students become familiar with the terms current, voltage, power etc. in lecture and lab prep, they are applying them in the lab by making lights turn on and doorbells ring. In the limited amount of time allocated to residential wiring the intent is to provide only a survey look at that part of the EET world.

Purdue University School of Technology at Anderson

ECET 196 EXPLORING EET   Fall 2003

Fall 2003 Schedule

Week	**Date**		**Lect/lab Prep Topics**	**Lab Activity**		**Comments/Assignment**
1	8/26/2003		Orientation & Intro	Lab. Orientation, Safety &		Read "Advanced Wire"
			to EET Purdue/Anderson	Basic Lab Practices		pg. 1-63
2	9/2/2003		Electrical/Electronic Lect.	Residential Wiring Proj. 1		See Res. Wire
			Residential Wiring Lect.			Pass out Assignment
3	9/9/2003		EET Opportunities, Issues,	Residential Wiring Proj. 2		Read "Advanced Wire"
			Show & Tell, Elect. Wire			pg. 64-128, Review Sheet
4	9/16/2003		Projects/Schedules, NEC	Residential Wiring-3 &		Search Internet for PCB, EET,
			Basic Semi Conductor Intro	**Res. Wiring Quiz**		SMT Read & Bring Info
5	9/23/2003		PCB/SMT Lecture	Dark Room Demo		Search Internet for Photo
			Layout Basics/Photo Resist	PCB trial Etch		Resist, Electronic Manuf.
6	9/30/2003		Intro to	PC Board Software		PCB Pass out Assignment
			ExpressPCB Sftware	PCB Board Project		
7	10/7/2003		Power Supply Theory &	Fabricate Base Plate		**Read** LKM Instructions for
			Lab. Kit Manual (LKM)	See LKM for details		Construction Tech.
8	10/14/2003		**October Break–No Class**			

Figure 1. Sample portion of the EET 196 weekly schedule

Shown in Figure 2 is a corner section of the laboratory area dedicated to residential wiring. Samples of electrical connections are displayed and discussed as the students prepare for their projects. Assignments are made that coordinate the lecture/lab prep with assigned reading material. As stated in the philosophy of the course, it is not the intent of this course to overwhelm the student with outside class work, but rather to whet their interest in EET topics. These assignments require simple (not elaborate) hand drawn wiring diagrams prior to connection. Circuit functions such as a doorbell system, light switches, GFI receptacles, two and three way switch control can be implemented and tested on the wall mounted circuits. Mounting the panels vertically allows five separate boards to be installed in a minimum of space. Typical student population for this work area can range from five to ten at a time, depending on whether or not team work is allowed. Larger classes are split into separate work groups and the schedule is adjusted to allow adequate lab time for both groups. Power (120v) is supplied to the panel by a power cord that plugs into a GFI outlet directly below each panel. This cord delivers the 120v ac to the switch box that is used by the student as their central power box. In place of the conventional screw in fuse in this box, a 100 watt light bulb is installed as a short detection device. The load light bulbs used are low wattage (25 watts) and in the event of a short circuit in the wiring, the 100 watt bulb will light when the power switch is turned on. Troubleshooting using receptacle testers, VOMs and voltage sniffers is facilitated by having the entire circuit laid out in front of them. Since an instructor is always in the immediate area, a circuit failure turns into a lecture/lab opportunity to guide the students through a hands-on troubleshooting experience. Sometimes the circuits operate, but not as required. This event provides additional opportunities for students to experience hands-on troubleshooting as a learning experience. Figure 3 shows a typical student connection of a two way switch control circuit.

Figure 2. Residential wiring and display panel

Figure 3. Student wiring exercise

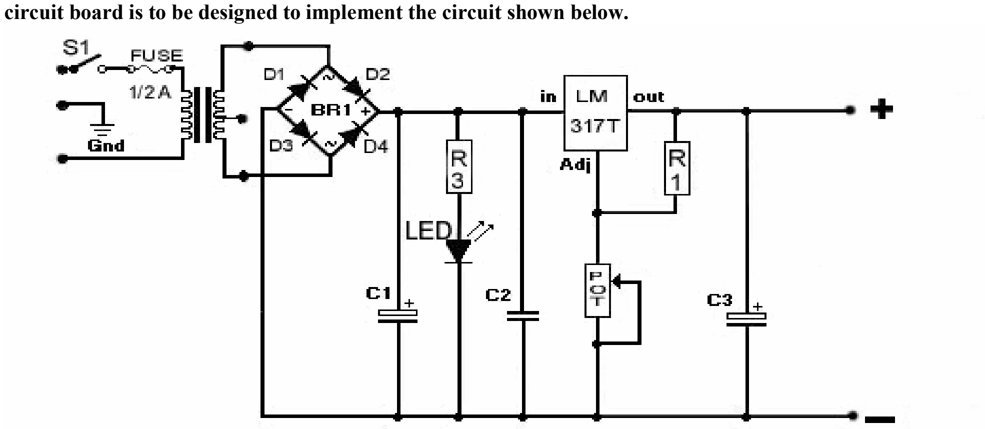
PCB Layout

A second student design project provides the platform for the introduction to PCB layout and fabrication techniques. The goal of this two week project is to allow students to start with a schematic, make a hand drawn component layout and then convert it to a usable PCB layout drawing using Computer Aided Design (CAD) software. Several CAD programs were evaluated, but were rejected due to the steep learning curve that did not fit our time and interest requirements. ExpressPCB, proprietary free software available on the internet, was selected for its ease of use, extensive on line instructions, and a lack of bells and whistles (no auto routing).

A short introductory lecture combined with reading assignments based on the help information available from the ExpressPCB web site prepares the students for the lab exercise. A portion of the PCB design exercise is shown in Figure 4. The end result of the intense hands-on CAD lab experience is a printable PCB layout that can be used as artwork for an in house or ExpressPCB PCB fabrication process. These layouts are then checked and graded, but not fabricated for the final project. We do not use the student designs. A locally made board is used because of the desire to maintain uniformity of dimensions and predictability of operation in the final testing of the power supply. A sample ExpressPCB layout is shown in Figure 5.

EET 196 **Printed Circuit Board Design Exercise** **Purdue/Anderson**

A circuit board is to be designed to implement the circuit shown below.



The circuit board has the following specifications:

1) **The physical size is to be 3 inches by 4 inches, with grounded mounting holes at the four corners. A 3/8 in minimum copper ground plane should be in place on the outside edge where possible.**
2) **The following components are to be used:**

a.	**D1, D2, D3, &D4**	**1N4007**
b.	**U1**	**LM317 Voltage Reg. TO220 (no hole like 7805)**
c.	**C2**	**Cap Decoupling 0.1 uf ceramic**
d.	**R1, R3**	**½ wt 0.5 in space**
e.	**LED**	**T1**
f.	**Pot**	**Bourns 3006D**
g.	**C1, C3**	**Filter Cap. 1.2 in spacing, 1000 uf**

3) **AC voltage should enter from the left side of the board, DC voltage should be available from the right side (top view).**
4) **The board is to made of single layer 1 oz copper and have a Silk Screen mask available for component placement. The silk screen mask should be readable and contain any annotation need to stuff the board.**
5) **The primary current carrying traces should have an ampacity of 2.0 amps and all signal traces should have an ampacity of at least 0.5 amps. All traces should maintain a minimum spacing of 0.01 in.**
6) **U1 needs to be placed on the back edge so that its heat sink can be mounted to the case.**
7) **ExpressPCB is to be used (see passouts for further information).**

Figure 4. ExpressPCB exercise

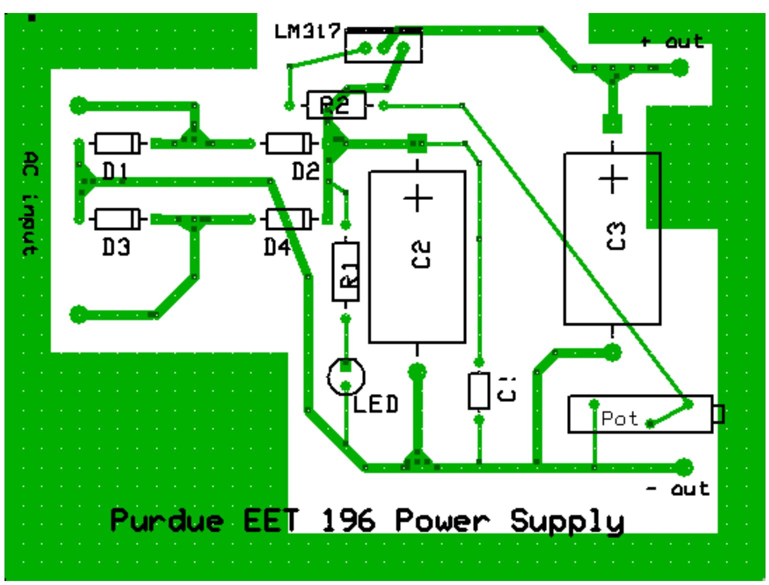


Figure 5. Sample ExpressPCB layout

Power Supply Final Project

The final project provides a structured hands-on learning experience that reinforces material covered in previous lectures and lab exercises. This exercise starts with a very basic parts kit that contains essentially flat metal, electronic parts, dimensioned drawings and a detailed set of fabrication instructions. Shown in Figure 6 is a view of the kit materials as presented to the students. Over the next six to eight weeks they will drill, cut, bend, solder, interpret dimensions and instructions to turn this box of parts into a working electronic system.

Figure 6. EET 196 parts kit

Figure 7 displays sample instruction and drawing excerpts from the EET 196 Lab Kit Manual (LKM). As the students progress through the project, references are made to drawings or special instructions contained in the Appendix.

Kit parts were selected based on cost, local availability and ease of installation. The project's output was designed to be zero to fifteen volts at a current rating of at least five hundred milliamps. During the final phases of fabrication, opportunities were presented for the instructors to rehash various technical aspects of the design covered in earlier presentations. Mounting and insulating the LM 317 heat sink tab of the back wall of the enclosure for example provided an opportunity to discuss expected heat dissipation in the IC as the output voltage and load are varied. A power supply test procedure was also discussed with the students and a test data sheet was designed for the final project verification.

Steps and Tips for Building the EET 196 Power Supply

NOTE: The aluminum parts in your kit will have sharp edges.

" Please!" "HANDLE WITH CARE"

I. **CHASSIS FABRICATION**

A. Circuit Board mounting procedure. Find the 1/8" X 6" X 7" aluminum plate. **(Refer to Chassis Base Appendix C)**

1. Carefully remove burrs and sharp edges from the plate with a file.
2. Mark the top and front of the plate with tape or pen. (Will be removed when finished)
   a. Locate a hole that is 4.250" from right rear and .500 " toward front, Measure, Mark and Center-punch hole. (Look at chassis-base drawing from back or bottom of diagram)
   b. Set up drill press using drill speed chart for #6-32 tap drill.
   c. Verify that drill is unplugged and install belts for correct drill speed.
   d. Drill and tap hole for #6-32 screw. (**<u>Clean the drill and/or tap after each hole</u>**)
   e. The small drills and taps are very delicate. Handle gently.
3. Install circuit board with a #6-32 X ¼" bolt.
   a. Square board up with chassis-base plate.
   b. Mark center of other 3 mounting holes in circuit board (Suggest rotating a 9/64 drill, by hand, in the mounting holes)
4. Remove the circuit board, center-punch holes, lay the circuit board over holes and verify the centers.
5. Drill, and tap the holes for #6-32 screws. (**<u>These four holes are critical to the final assembly</u>**)
6. Locate a hole (looking from front to back) that is .750 x .375 inch from right rear side. Measure, Mark, Center punch and drill hole for #6-32 tap.

_________ Please have an instructor inspect and sign off.

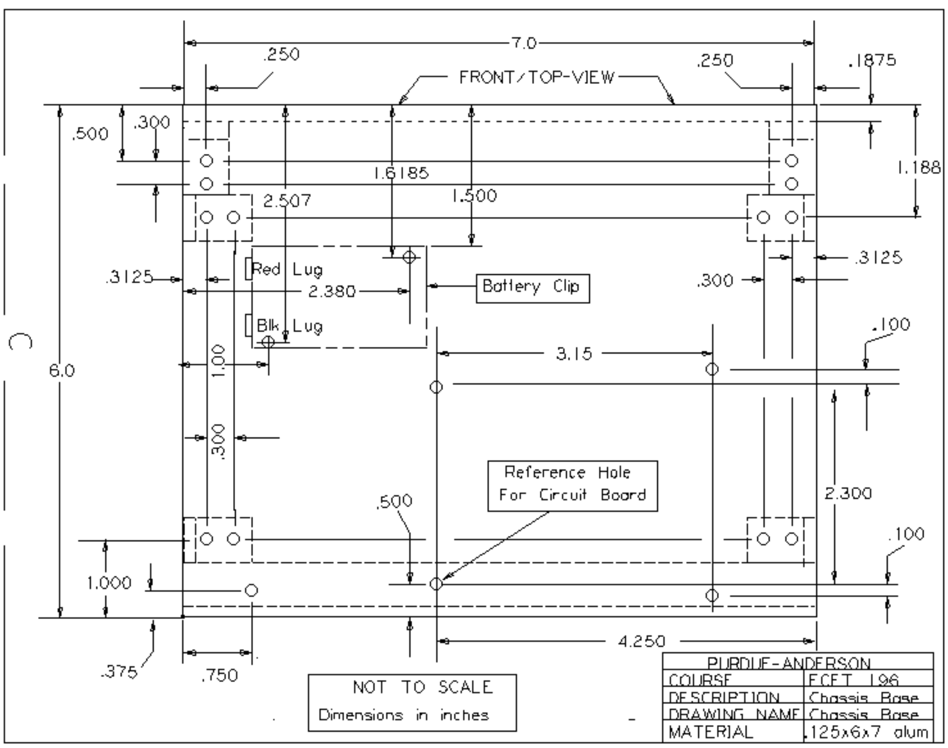


Figure 7. Sample instruction and drawing excerpts from the EET 196 Lab Kit Manual

Shown in Figure 8 is the schematic and PCB that is provided as part of the student kit.

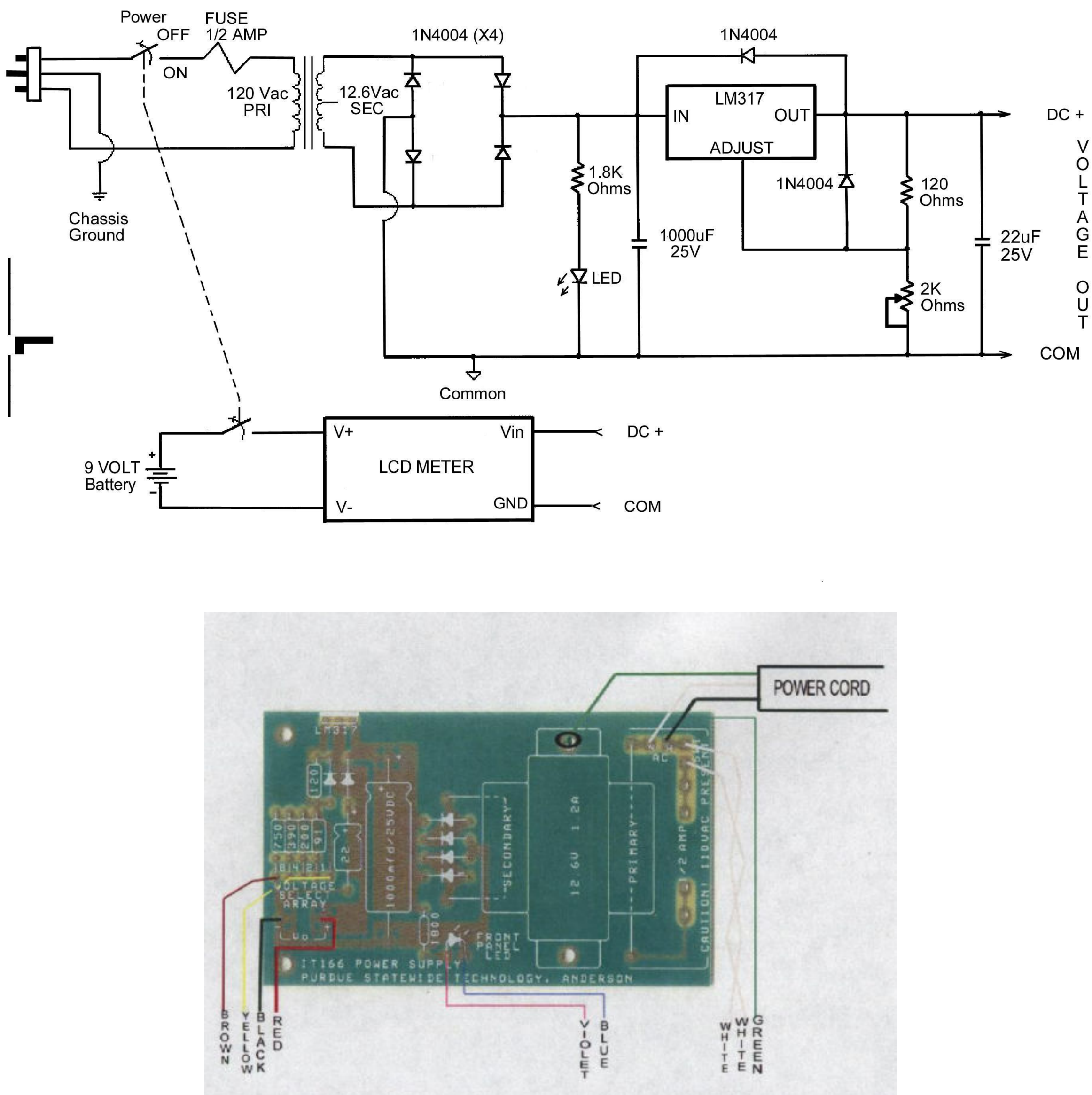


Figure 8. Power supply schematic and PCB

The last step in the power supply fabrication project is the ultimate one. The supply must be turned on to see if it will function when tested to the required load specifications—better known as the smoke test. Indeed, in a few cases there was smoke or no output which then provided an opportunity for student troubleshooting. Once you have experienced this part of the course, the earlier decision not to install the student designed PCBs as opposed to a proven one becomes a wise one.

Samples of completed power supply projects are shown in Figure 9.

Figure 9. Completed power supply projects

Student Evaluations of the Course

This course was revised to its current format in the Fall of 2001 and has been taught each fall and one spring semester since then. Table 1 below indicates how well the course has been accepted by the students. The average class size during this time was six students. The rating options for the student evaluation form are Strongly Agree (5) to Strongly Disagree (1).

ECET Course Student Evaluation	F'01 196	S'02 196	F'02 196		F'03 196
C01 Instructor motivates me	4.5	4.2	5.0		4.5
C02 Instructor explains difficult material	5.0	3.8	4.4		4.5
C03 Assignments are interesting	4.9	4.5	5.0		4.5
C04 Best course I have taken	4.5	5.0	5.0		4.7
C05 Best instructor I have known	4.8	5.0	5.0		5.0

Table 1. Student course evaluations

Also in response to the question, "What part of the course interested you the most?" comments included:

- Lab fabrication, hands on experience
- Soldering and residential wiring

In response to the question, "What suggestions do you have to improve the course?" comments included:

- This course needs no improvement
- Spend more time on test equipment and software usage
- consider additional voltage outputs (± 15 volts)

Our course assessment process provides us with the opportunity to evaluate the results of our surveys each semester and modify the course as seems prudent for the following year. However, we pursue only the course changes that adhere to the learning and teaching objectives as well as make the course more student friendly. The goal of providing a serious hands-on learning experience must never be soft pedaled for the sake of good student evaluations.

Summary

Based on student and faculty feedback on the project, future plans are to increase the transformer output specification to provide a higher output current across the voltage range and consider additional voltage ranges to make the power supply more useful for student home projects. Also under consideration is a redesign of the circuit board to allow the use of several surface mounted components to the board.

EET 196 at the Anderson location of the Purdue University School of Technology has achieved its objectives of providing entering students an opportunity to apply theoretical electrical/electronic concepts and fabrication techniques. The concept of learning while doing has been successful and well accepted by the students and faculty. Positive feedback from students entering the next level (EET 296) of project orientated courses also supports this conclusion.

Bibliography

1. L.E Carlson, J.F. Sullivan, "Hands-on Engineering: Learning by Doing in the Integrated Teaching and Learning Program," *International Journal of Engineering Education Vol. 15 No. 1 pp. 20-31(1999).*
2. W. Branzhaf, A. Gold, "The Evolution of an EET Program's Introductory Course in Electricity/Electronics," *2003 ASEE Annual Conference Proceedings*, June 2003, Session 2548, Nashville, TN.
3. N.T. Le, "The Coin Detector Circuit," *2003 ASEE Annual Conference Proceedings*, June 2003, Session 2526, Nashville, TN.

RUSSELL A. AUBREY
Russell A. Aubrey is a Professor of Electrical and Computer Engineering Technology at Purdue University Programs at-Anderson. He received the B.E.E. degree from the University of Virginia, and the M.S.E.E. and Ph.D.E.E. from Virginia Polytechnic Institute and State University. His industrial background includes technical staff assignments with NASA-Langley Research Center, Texas Instruments & Seyberts Electronics. His primary teaching interests lie in the areas of analog circuits and systems.

STANLEY A. DICK
Stanley A. Dick is Lab Assistant of the Electrical and Computer Engineering Technology at Purdue University Programs at Anderson. He received the A.A.S. degree in Electrical Engineering Technology from Purdue University. He was employed with General Motors working as a Journeyman-Electrician and in Management positions prior to his appointment to the Purdue Faculty.
196 F03 Paper Dft5adrv2b 2/25/04