AC 2010-1545: A NEW APPROACH: USING ELECTRONICS LABORATORY MORE EFFICIENTLY AND SAFELY

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A New Approach: Using the Electronics Laboratory More Efficiently and Safely

Abstract

Use and administration of the electronics laboratories are very important due to safety concerns and variety of parts and equipment. There are a variety of components and devices which need to be organized and monitored for different lab experiments. Electronics laboratories serve a variety of students with different knowledge levels for their lab classes and various projects that are taught to major/minor and non-major students. Lab sections of the classes are taught on different levels from basics to advance. The type and electronics knowledge of students differs depending on their major/minor and students come with differing abilities to operate the various electronic devices on the workbenches. Some students enroll for lab sections of classes, accidently or purposefully try to operate or relocate different devices without knowledge of working operations of a device. It is also common to see scattered or misplaced electronics components. Students may not be able to find the right components because of misplaced parts and instead use the wrong components if that component was not checked in right place or to the instructor. To locate required components sometimes takes students' lab time and is usually not considered when deadline of lab submission arrives. To reduce safety concerns, develop component organization, prevent time wasting to locate the parts and include time to locate components, faculty and students developed a novel plan to use workbenches, lab components and testing devices/equipment more efficiently. In addition to fundamental laboratory safety measures and component management, unique lab management demonstrations are explained by reorganizing the lab to meet the criteria of the proposed arrangements. Students and faculty in the program can thus save time and reduce safety concerns by novel administration and organization in the lab environment since Fall 2008 semester.

1. Introduction

Laboratory safety is very important, particularly in undergraduate laboratories where students develop practices and habits initially that they may carry with them throughout their future careers [1-3]. Because this importance is generally agreed upon, undergraduate engineering labs include some amount of safety training, encompassing at a minimum a long list of safety rules [4-5]. These rules are often explained on the first day of lab, along with the course syllabus. Despite of safety precautions, however, some accidents, near misses, and laboratory rule violations continue to occur either intentionally or accidently. Two major causes for these continuing safety violations are forgetfulness and complacency, the latter of which can be considered as forgetfulness of the importance and significance of the rules, as opposed to forgetfulness of the rules themselves. The bottom line is that safe practices are not retained in students' memory as well as we all would like[1].

Safety in the electronics laboratory requires that the student have knowledge of potential hazards, safety precautions, and common sense. The most common hazard is electric shock, which can be fatal. Observing safety precautions is critical due to hazards found in any electronics laboratory. A fatality is usually certain when 0.1A or more flows through the head or upper thorax. The current depends on body resistance, the resistance between body and ground (moisture and wet

conditions), and the voltage source. If the skin is wet and the body contact with ground is large and direct, then 50V could be fatal [6-7]. Students should consult the laboratory demonstrator or technical assistant for guidance if any safety questions arise. Students should also acquaint themselves with the location of safety items such as fire extinguisher, first aid kit, and telephone and emergency numbers within the laboratory [8-17]. The instructor should read the safety statements in front of the class at the beginning of each semester, to make sure students are aware of safety guidelines. These guidelines should always appear in the instructor's syllabi.

Electric shock is caused when an electric current passes through the human body. The severity of the shock depends primarily on the amount of current and is less a function of the applied voltage. The threshold of electric shock is about 1mA which usually gives an unpleasant tingling. For current above 10mA, severe muscle pain occurs and the victim can not let go of the conductor due to muscle spasm. Current between 100mA and 200mA causes ventricular fibrillation of the heart and is most likely to be lethal [8]. The actual measure of a shock is the amount of current that flows through the body. Table 1 below lists the impact of AC (alternating) current on the body [18].

Table 1. Impacts of AC current on the body

Current	**Effect**
1 - 5 mA	Threshold of sensation
5 - 20 mA	Involuntary muscle contraction ("can't-let-go")
20 - 100 mA	Pain, breathing difficulties
100 - 300 mA	Ventricular fibrillation (changes in heart beat), *possible death*
> 300 mA	Respiratory paralysis, burns, unconsciousness

The amount of the current flowing through the body during an electric shock depends on the voltage and the resistance between the terminals of the voltage source. This resistance consists of [12]:

- resistance of the contact point between body and circuit (e.g., a ring or a watch)
- skin resistance at the point the current flows into the body,
- internal resistance of the body,
- skin resistance where current flows out of the body (e.g., shoes).

In addition to aforementioned common sense hazard, safety procedures differ from lab to lab depending on what equipment is available in the electronics lab. Instructors usually give extra information of equipment operation that is used in the specific classes. Not every student is exposed to use of any equipment in the lab and usually should not operate the equipment without proper training and instructor supervision. However, in the crowded classes it is not very easy to control every student working on the electronics workbenches. Students accidently energize some equipment without appropriate knowledge and this sometimes causes electrical hazard. It is sometimes difficult for the instructor to prevent these attempts especially in the laboratories where there is no laboratory assistant. These attempts and hazard can be easily reduced by some safety steps that are explained the following sections of the paper.

Another common problem in the electronics laboratories is part management because of the high number of small components. It is possible to misplace those small components after laboratory assignments and projects. This may cause next students to use wrong components in their assignments or projects if an attention is not given to part number. If there is no lab assistant on duty then it may be a waste of time for instructor to organize parts after each of the laboratory assignment or project. This maybe is not a common problem in all electronics laboratories where there is employed staff in the laboratory to organize lab equipments and components. A novel solution to address this issue also was demonstrated in the following sections. All three common sense concerns in the electronics lab such as general safety, equipment operations, and part managements are addressed with new demonstrations to prevent or reduce these attempts.

2. Electronics Workbenches

The locations of testing equipment, testing leads, and related components are important in order create a hazard-free lab and workbench. There are variety of laboratory workbenches available and manufacturers can produce custom-made products according to the needs of the laboratories. In our electronics lab, different levels of electronics classes are taught and every day there are students from different classes completing their lab assignments. The equipment is organized to be used efficiently for each lab and is not moved by the students unless instructed. The testing leads, breadboards, jumper wires, banana jacks, and alligator clips etc. are kept in the drawers and the drawers are labeled. Each class has its own components in the labeled drawer. Common components used for each of the class are placed in top drawer for convenience. Students can do their assignments without wasting time looking for related components or equipment for the lab and can return them to the proper drawers easily. Students are grouped in pairs and assigned a workbench at the beginning of the semester. These pairs are responsible for their components and equipment until semester ends, and each pair are responsible for keeping their workbenches clean and free of components after their lab assignments. The photograph of a workbench is shown in Figure 1. The remaining workbenches are identical to the one shown in Figure 1.

Figure 1. An organized electronic workbench

3. Power Control of the Laboratory Testing Devices

Some of the equipment in the workbenches are hazardous and can produce high voltages if not used properly. Students are often capable of using these devices until all preliminary course work has been completed. Freshman level major/minor and non-major students use the same workbenches for their lab assignment. Some of the equipment on the workbenches should not energized by the freshmen level students due to safety measures. In order to prevent this, a power control system is suggested to energize equipment from the instructor's desk. This way, students can use only the required equipment while doing their lab assignments and projects. The Instructor energizes equipment depending on the class and student knowledge levels. The block diagram in Figure 2 shows how the instructor controls the equipment on the workbenches.

In the lab, there are twelve workbenches and the power diagram shows how each workbench is separately powered. Once a workbench is energized equipment can be energized separately with on/off buttons. Unless all the equipment is needed for an assignment or project, only necessary equipment is powered. Using this method, safety concerns and hazards are reduced dramatically.

4. Electronics Parts

Another important issue for an electronics lab is the location of parts, because students sometimes misplace the parts by returning them to wrong drawers or place elsewhere. This can cause major problems where limited laboratory components are available in the lab. If there is no lab technician or assistant, it becomes a recurring issue for the instructor to find the components and place them where they belong. Keeping track of electronics components becomes a time consuming task for the instructor. Usually, bins are adequate for holding all of the small electronic and other assorted hardware and can be used to hold resistors, capacitors, inductors, diodes, transistors, screws, wires, connectors and many other components. Plastic bins with small dividers are commonly used in electronics laboratories. Plastic bins with dividers are divided and labeled but not sorted to be used in any project or labs. Accidently dropping a bin causes components to spill all over the floor, because students sometimes rush to get lab components to finish their lab assignments and then quickly leave the lab. To avoid from these issues, a plastic bins cabinet consisting many different size small drawers is placed on each workbench. Each bin drawer is filled with lab related components by the students or lab assistant at the beginning of the semester. These plastic bins as storage cabinets are on the workbenches through the semester and are only used by the students assigned to those workbenches. Students spend their first lab day placing all laboratory components in the plastic bins with the help of instructor. Once this task is complete, students can easily reach the related components while working without losing time in the lab looking for the required parts. A parts list for the plastic bin is prepared and inventoried at the end of the semester to see if all the parts are in order.

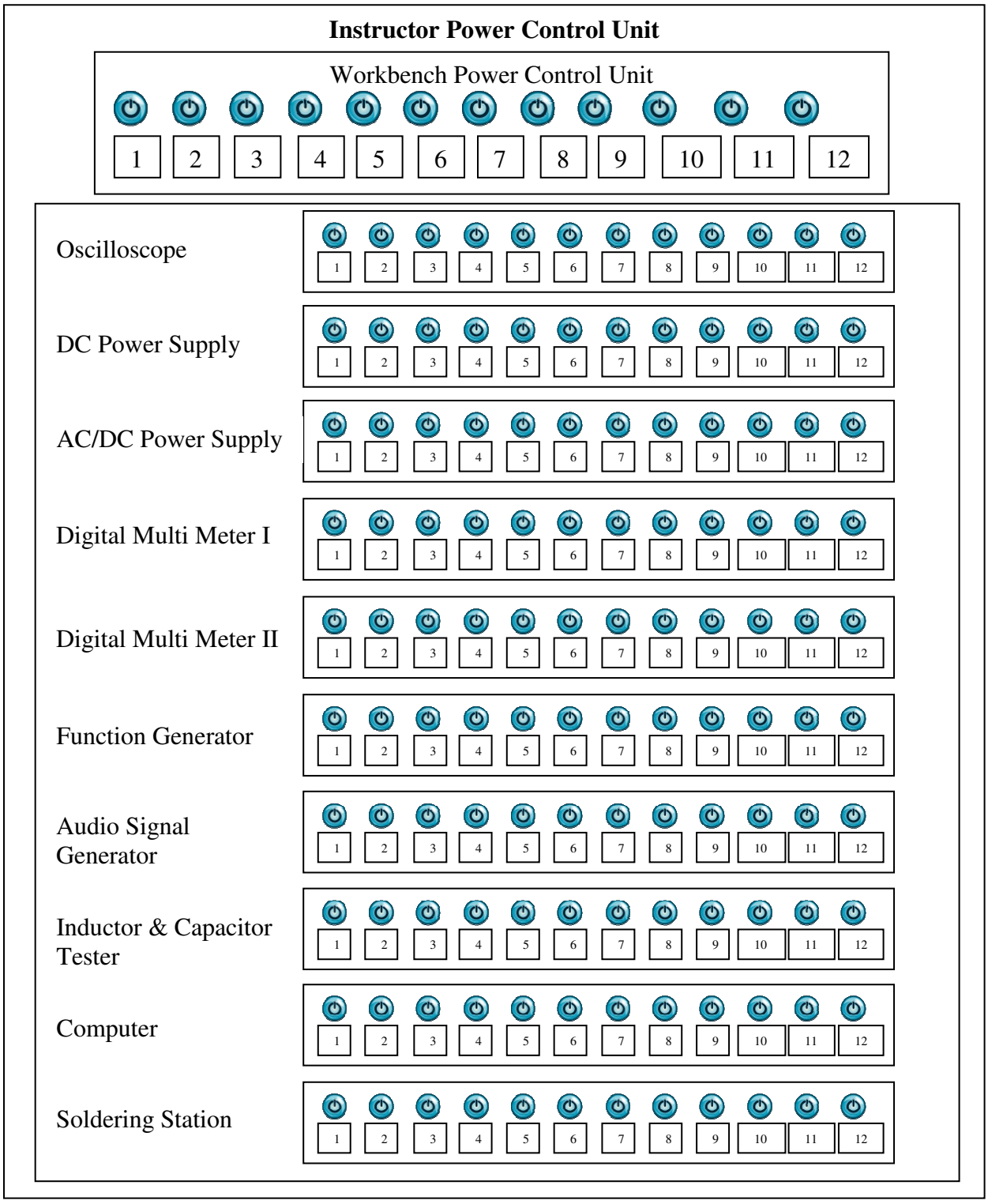

Figure 2. Instructor Workbench Power Control Unit Block Diagram

Figure 3 shows a labeled plastic bin parts cabinet used in five different electronics class experiments that is placed on each workbench in the lab.

Figure 3. Part cabinet on the workbench

5. Classes

There are presently seven different classes and each class has a lab section. The components in the plastic bins serve five classes per semester. The subjects include a) DC Circuits b) AC Circuits c) Solid State Electronics d) Digital Electronics, and e) Industrial Electronics. Using the components in the part cabinet, 45 different lab assignments can be accomplished without searching for parts in the lab. Parts that do not fit in the plastic bins are stored in the workbench drawers and labeled with the class names. Bigger components such as wires, breadboards, test leads, connectors, alligator clips, small tools, etc. are placed in the bigger drawers of the workbenches (Figure 4).

Figure 4. Workbench drawers for bigger components and tools

Each instructor unlocks the workbench drawers before the class and students use the necessary parts during the lab. At the end of the class, the instructor checks the workbenches and the parts to ensure that everything is in order before locking the drawers back.

6. Discussions & Conclusions

In this paper several steps were explained to reduce safety concerns, to make the parts easy to reach, and to make the lab clean and tidy with the help of electronics major/minor students in the electronics lab at Sam Houston State University. This system has been used for three semesters, with no problems reported thus far. Students and faculty have been using the system and finding

necessary components for the lab assignments without any problem and locating parts are no longer an issue as reported in the past. However, safety concerns are always there; the responsibility for being safe and working safely falls to the laboratory personnel themselves. The laboratory instructor or supervisor, who may or may not be an active participant in the routine work of the laboratory, still must set the standards of performance expected of everyone within the laboratory. The laboratory supervisor must make it clear by an example and by direction that carelessness in safety is never acceptable. Laboratory work will never be totally free of risk, but this should always be the goal of everyone. All reasonable and practical steps should be taken to minimize risks.

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