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Computer Simulation as Preparation for Electronics Laboratory

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Abstract

This paper presents the effectiveness of computer simulation application as a medium for students to implement the task or preparation before physical experiment in electronics laboratory can be carried out. This approach is proposed as an alternative for written pre-laboratory questions which has been put into practice previously. Students are given pre-laboratory questions in a form of computer simulation which related to the experiment, in order to assist the students in their preparation prior to entering the laboratory and be able to understand the experiment objectives. As a result, based on conducted survey on 55 students registered for Electrical and Electronics Laboratory course, the proposed approach has proven its effectiveness in assisting student's preparations to understand experiment methodology in laboratory since a virtual experiment has been done prior to the laboratory experiment. Moreover, this method also saves a lot of laboratory experimental time, and able to develop a self-confidence among students in doing electronics laboratory experiment by themselves

Keywords: Pre-lab; computer simulation; inverting amplifier; survey

1. Introduction

Students performance in electrical engineering laboratory can vary depending on their prior competencies, and knowledge of the basic concepts of the laboratory, motivation and expectations (Watai & Brodersen, 2005). There are indications where students are ill-prepared prior to enter practical laboratory experiment. A previous study reported that students were unfamiliar with laboratory contents and concepts, and they spent time waiting for instructor's attention (Mosterman et al, 1996). Moreover, because of time limitations, students often rush through the experiments in order to finish on time, which unfortunately prevents them from obtaining a true feeling of doing experiments and from appreciating what has been accomplished during the laboratory practice (Ayasun & Nwankpa, 2005). To overcome this problem, pre-laboratory (pre-lab) method is introduced. Pre-lab is a form of a task given to students to do revision and preparation before a practical laboratory experiment takes place. An effective preparation prior to practical class is essential if meaningful learning is to occur (Jones & Edwards, 2010). Usually, students are given a few questions that are related to the experiment to be performed. It is understood that several universities in United States and Germany put a great emphasize on pre-lab task. It is because a complete and good pre-lab is a

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prerequisite to perform an experiment. In case of a student cannot fulfill the designated prerequisite, he is not allow to conduct a laboratory experiment. This aspect most probably will not be put into practice in Malaysia, but on the other hand it is a good practice to discipline students and can motivate them to study hard.

1.1. Written-based pre-lab question

The conventional approach (written based pre-lab question) may assist students to perform preparation before the experiment session. For instance, typical questions for written-based pre-lab usually consist of explanation, calculation, drawing circuit or expected waveforms and so on. It is not really challenging and interesting since the answers can be found from the manual itself. As a result, there are a few shortcomings which have been identified for this kind of pre-lab for electronic laboratory experiment. Among the shortcomings are as follows:

- A same written-based question is given every year.
- Lack of students' understanding on method or a way on how to conduct electronic laboratory experiment.
- Students require a lot of time to perform experiment because they need to understand several type of components used, assembling method and circuit connection.
- Students cannot imagine how to conduct the experiment.
- Lecturer and instructor frequently dealing with unnecessary questions from students.

Hence, an alternative method or approach should be introduced so that more effective and efficient preparation on laboratory experiment can be carried out. Intended alternative pre-lab method can bring imagination to students on how real experiment method is carried out visually (using visual aids), and then capable to attract students interest in doing experiment themselves.

1.2. Computer simulation-based pre-lab question

By taking advantage from the advanced development and proliferation in information technology and software engineering, computer simulation applications has been a standard requirement in almost engineering fields recently. Computer simulation method is performed to help in designing system, reducing development cost, testing on a complex and hazardous system, calculating mathematical equations or complex algorithms, besides it is an interactive method which capable to save time and energy also. In addition, there are a few courses such as power electronics course that stressed on students capability to do power electronics circuit's modelling and simulation (Yushaizad & Nasrudin, 2010). Among the software that can be used in simulation and modelling electronic circuit are Tina, CircuitMaker and Orcad Pspice (Sahoo et. al, 2008). These types of software are circuit level software, which are very interesting, interactive and easy to use.

Computer simulation is no stranger to faculty's students, in fact they had been exposed towards computer software application such as Matlab and C programming since they are in the first year, thus students do not need a lot of time to do revision and usually they can complete computer simulation-based pre-lab tasks on time. Therefore, the question is straight and simple, basically doing a simulation which is related to the experiment. Hence, for the purpose of computer simulation examples in this article, the CircuitMaker software is selected, since it is a powerful simulation tool and easy-to-use schematic capture at a fraction of the cost (Protel, 1988). By implementing CircuitMaker's advanced schematic capability, electronic circuits can be easily designed and constructed, which in many aspects is equal to the real electronic circuits hardware. It was observed that with the help of simulation results, students can increase their understanding of DC motor characteristics and dynamic behaviour beyond the understanding they gain from classroom and textbooks (Ayasun & Karbeyaz, 2007).

1.3. Electrical & Electronic Laboratory II

KL2082 Electrical & Electronic Laboratory II course is offered to Electrical, Electronics & System department's undergraduate students in semester IV (Fakulti Kejuruteraan Alam Bina, 2010). The electronics laboratory schedule

is divided into 8 experiments, a group project, a mid-semester examination and a final examination. The experiments will expose students mainly on practical electronics analog knowledge. This course is compulsory for all students in second year. Thus, the students without excuse need to be persevered to accomplish all the tasks given in the course, in order to obtain good marks. Although pre-lab marking percentage is only counting for 10% out of total marks, but pre-lab results substantially influence the students understanding and the effectiveness in performing the physical experiment also greatly influenced by pre-lab task.

The arrangement of this article is as follows, after introduction in section I, section II describes inverting amplifier experiment briefly, and then in section III students response based on survey questions result is analyzed and evaluated before conclusion and discussion take place in section IV. Finally, the article is closed by reference in section V.

2. Inverting Amplifier Experiment

Since there are 8 topics altogether provided for students in the laboratory manual, only one topic from the laboratory manual is preferred as an experiment example in this article, which is an operational amplifier or op-amp as it is commonly known. Op-amp is the single most important integrated circuit for analog circuit design where it is a versatile interconnection of transistors and resistors that vastly expands our capabilities in circuit design, from engine control systems to cellular phones (Irwin & Nelms, 2008). Typical op-amp is used to provide voltage amplitude and polarity changes, oscillators, filter circuits and many types of instrumentation circuit (JKEES, 2010). Usually, op-amp is found in the form of 8 pin DIL (dual in line) package, and the one that is used in the laboratory is LM741. Based on the topic about op-amp in the manual, students need to perform 4 different experiments which is quiet huge to be included in this article, yield, only inverting amplifier experiment will be selected as an example where the correspond schematic circuit is illustrated in Figure 1. Hence, the relationship between input and output voltage for inverting amplifier experiment can be concluded in the following equations in order to obtain a voltage gain, A_v,

$$V_s = iR_s \tag{1}$$

$$V_o = -iR_f \tag{2}$$

$$A_v = \frac{V_o}{V_s} = -\frac{R_f}{R_s} \tag{3}$$

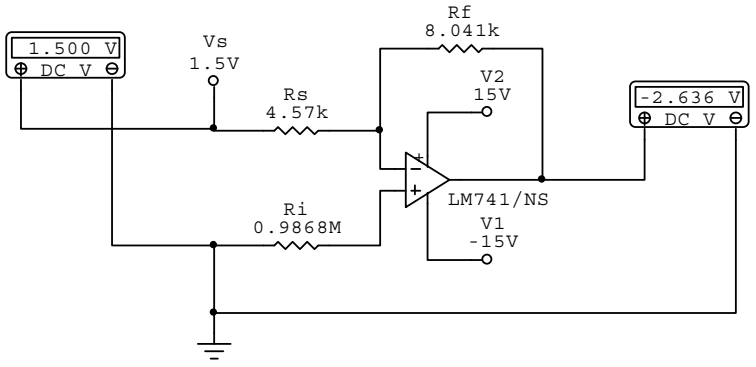


Figure 1. Schematic circuit of inverting amplifier in CircuitMaker

2.1. The methods applied

Basically there are 3 methods for students to study and understand the electronics experiment. To make things easy to understand, a flow chart in Figure 2 below indicates the procedure that is practiced in electronics laboratory. The first method is by calculation based on given equations (1)-(3), this is the easiest way to gain results since it is directly based on theory (where students learned in classroom) and it can be a reference for the other methods. The second method is based on computer simulation using CircuitMaker software, part where the pre-lab task being implemented. This method is done by students before they can perform their physical laboratory experiment. The computer simulation method is the best way for students to do revision and be prepared since they can see and experience visually on how to connect the circuit and roughly know the shape of the voltage waveforms. Finally, the third method is to conduct the physical experiment in the laboratory, where the students will be given some components and are assigned to do the experiment according to instruction and procedure provided in the manual book using the components and the equipments.

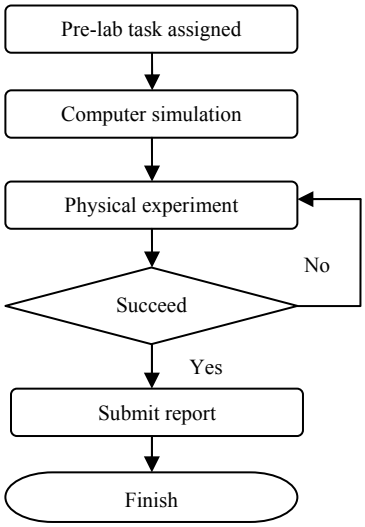
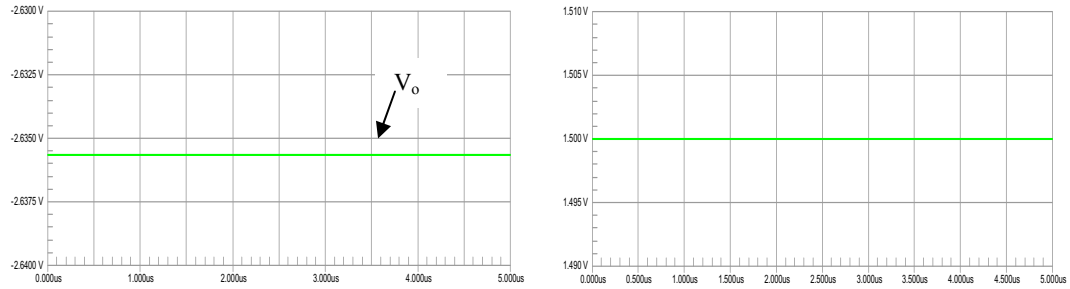


Figure 2. Flow chart for electronics laboratory procedure

Type of components and equipments used in the experiment is given in Appendix A. The first and the third methods are the traditional method, while the second one is a new method introduced. Hence, Table 1 shows the results demonstrated by those 3 methods and also used to compare the inverting amplifier gain values. Usually in electronics study, the result obtained from simulation is verified through a hardware experiment. In this case, the result from computer simulation is required to agree with the result gained from physical experiment in order to proof that the study is validated. To do so, Figure 3 and Figure 4 below indicate the simulation result and the experiment result respectively.

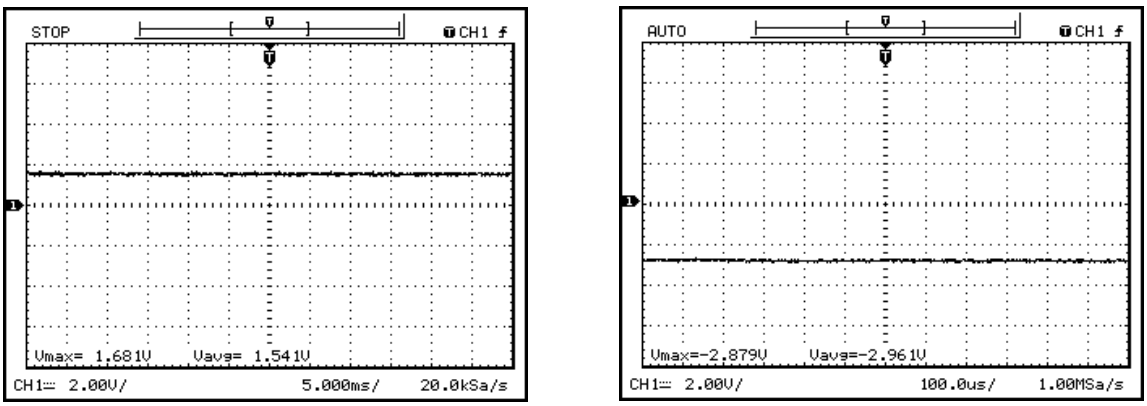
Table 1. Results for calculation, simulation and measurement of inverting amplifier gain

R_s	R_f	Calculation (A_V)	Simulation (A_V)	Measurement (A_V)
4.457 kΩ	8.041 kΩ	1.7595	1.7573	1.9214



(a) (b)

Figure 3. Computer simulation results on inverting amplifier (a) V_s and (b) V_o



(a) (b)

Figure 4. Experimental results of inverting amplifier (from oscilloscope) (a) V_s (scales: 2 V/div; 5 ms/div) and (b) V_o (scales: 2 V/div; 0.1 ms/div)

2.2. Comparison and evaluation between the methods

To evaluate and analyze the results of inverting amplifier A_v on Table 1 above, clearly shown that the results from the first two methods are exactly similar, while on the other hand the result obtained from the experiment is quiet different compared to the previous two methods. If the differences are interpreted in term of percentage and by taking the first method as the reference, can be found that the error of the second method is only 0.125%, while the error of the third method is 9.201%. The outcomes are as expected because computer simulation method applies ideal components without taken into account any external disturbances same like the theoretical method, but for the real experiment the same situation cannot be considered since other external factors will affect the results such as temperature (environment and circuit condition), voltage drops, environmental humidity, charging and discharging of capacitors, equipment conditions etc. Nevertheless, the bigger error gained from the third method is common and always happened, therefore the students will be asked to explain the differences between the theoretical result and the physical measurement result in their report.

3. Survey and Students Feedback

In order to find out students response and feedback regarding to computer simulation application as pre-lab task, a survey has been conducted. Basically, the survey aims to determine whether the students agree with the given computer simulation-based pre-lab task and whether the new pre-lab task helps them in understanding the electronics laboratory experiment. The survey also tries to find out the students opinion on their level of preparation after performing the computer simulation-based pre-lab task. Hence, the students were asked to fill out a questionnaire which requires them to answer yes or no, at the last week of laboratory experiment. Among the questions were presented to students are as follows:

a) Do you agree if the pre-lab task is based on computer simulation?
b) Do you prefer written-based pre-lab task than computer simulation- based pre-lab task?
c) Is the preparation based on computer simulation-based pre-lab task time-saving?
d) Are you confident that the computer simulation result is true and as expected?
e) Do computer simulation-based pre-lab task delivers better understanding about laboratory experiment than written-based pre-lab task?
f) In general, do you think that pre-lab task based on computer simulation is burdensome?
g) Do you agree if pre-lab task is carried out exclusively based on computer simulation?

By means of the answer from the questionnaire sheets returned back by 55 students who registered for KL2082 course in semester II session 2010/201, Figure 5 which is a graph bar in the form of percentage illustrates the students' feedback and response based on the survey result in order to compare the computer simulation-based and written-based pre-lab task.

According to Figure 5, for question (a), 81% of the total student agreed to use pre-lab task based on computer simulation, while the remaining did not agree. Then for question (b), 60% of the students prefer computer simulation-based pre-lab, whereas as far as question (c) is concerned, 69% students admitted that their preparation using computer simulation method is time-saving. While, students reply for question (d) shows that 78% out of 55 students admitted the computer simulation result in their opinion is true and as expected. Then, from question (e), 63% students acknowledged that computer simulation method gives better understanding, whilst for question (f) about 65% students selected yes as an answer for agreeing that the proposed pre-lab method is burdensome. Finally result from question (g) indicates that more students (around 55%) did not agree if the pre-lab task is carried out exclusively based on computer simulation.

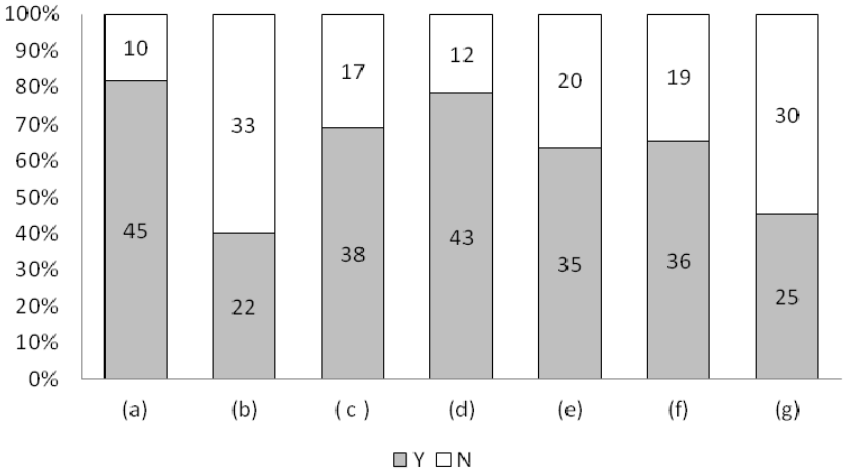


Figure 5. Comparison on computer simulation-based and written-based pre-lab task based on students' response survey

4. Conclusion

In this article, the authors present a study on pre-lab task based on computer simulation method and compare it with written-based method. From the study, it can be concluded that the computer simulation method for pre-lab task, in general, is capable in helping the students to understand better and effective than written-based method which has been put into practice previously in electronics laboratory experiment. In addition, from the point of students' view, their preparation and knowledge level prior to physical experiment is better with computer simulation method compare to written-based method. However, there are some students selected written-based as their preferred pre-lab task; this still cannot reject the proposed method since its advantages outnumbered the previous practiced method in many aspects. Hence, other opinion on question (g) which is not in favour of proposed method, most probably is because the students are confused with the question or they think that by doing a new task will add to their assignment load, which is not their favour. Nevertheless, in such manner, computer simulation method for pre-lab task using CircuitMaker software can give initial imagination or illustration to students about the way physical experiment is performed. This has been validated from both the theoretical (calculation) result and experimental result, where the computer simulation result on inverting amplifier gives similar result as both mentioned methods. Thus, the real experiment result expectation can be done, since the computer simulation result is true and reliable. On the other hand, students confidence level is seen increasing, as a result of just a few unnecessary question arise by students to demonstrator and from students' ability to accomplish the laboratory experiment faster and with confident. Moreover, the computer simulation method has been a must and widely accepted in academic world particularly in engineering field. In fact, a student with computer simulation ability, will has a bigger advantage when he or she seeking for job in the future.

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Appendix A

Table 2. Equipment and components used in experiment of inverting amplifier

Equipment	**Components**
Power supply	1 x 4.57 kΩ resistor
Circuit board	1 x 0.9868 MΩ resistor
Digital multimeter (DMM)	1 x 8.041 kΩ resistor
Oscilloscope	1 x op-amp LM741