Digilent Analog Discovery and Bench-top Instruments: A Comparison

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Shaghayegh Abbasi received her Ph.D. in Electrical Engineering from University of Washington in 2011. In her thesis, titled 'Integrating top-down and bottom-up nanomanufacturing: Controlling the growth and composition of seeded nanostructures', an innovative nanomanufacturing method is explored and optimized. Upon graduation, she started her career as Senior System Design Engineer at Lumedyne Technologies. She worked on design, simulation, and testing of a Time Domain Switched (TDS) accelerometer.

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Digilent Analog Discovery 2™ and Bench-top Instruments: A comparison

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Abstract

The Digilent Analog Discovery 2™ (DAD2) is a multi-function instrument that allows users to measure, visualize, generate, record, and control mixed signal circuits of all kinds [1]. In this paper, the use of DAD2 in an Introductory Electrical Circuits Laboratory is investigated as the primary tool for measurement and signal generation. Data is collected on student level of understanding, comfort, and successful use of DAD2 as well as bench-top instruments through a comprehensive survey. The results are summarized to provide a quantitative measure of advantages and disadvantages of DAD2 over bench-top instruments.

I. Introduction

Laboratories are an important part of curriculum in any engineering discipline, and particularly in Electrical Engineering (EE) [2-4]. Measuring quantities such as voltage, current, and power is an inseparable part of most EE labs. Measurements are typically necessary in AC, DC, and transient form depending on the circuit and the experimental setup. In addition, all electrical circuits need a power supply in order to function, which can be a DC power supply or a function/waveform generator, depending on the application.

Until recently, bench-top instruments have been used dominantly in EE labs, both for measurement purposes and to supply power to the circuit. While bench-top instruments have been the only option for electrical measurements and power supplies in the past, they are not always accessible due to high prices, and only some versions have the potential to be connected to and controlled through a computer, which is essential in today's world. In addition, creating portable laboratories for online courses or courses taught abroad are nearly impossible with bench-top instruments as they are normally bulky and heavy.

In order to make EE labs portable, cheaper, and more accessible, portable multi-functional Instruments such as DAD2 are being used more frequently. However, a quantitative study which compares such instruments with bench-top instruments in terms of students' learning and ease of use is missing.

It is essential to study the effects of using instruments such as DAD2 on student learning and compare the results to the use of regular bench-top instruments. This comparison allows educators to understand the advantages and compensate for possible disadvantages of DAD2 and similar devices. Here an experiment is designed to compare the use of DAD2 and bench-top instruments in an Introductory Electrical Circuits Laboratory, and multiple questionnaires are used to collect student data. Results show that for measurement purposes (oscilloscope) DAD2 is chosen as easier to use by students. However, for power supplying purposes (waveform generator) it is unclear whether the DAD2 or bench-top instrument is easier to use. Further experimentation and data collection is required in order to make a more clear conclusion in that regard.

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II. Laboratory Instruments

II. A. Bench-top Instruments

The bench-top power source used here is an Agilent Function/Arbitrary Waveform Generator (33220A).

The bench-top measurement device used here is an Agilent Digital Storage Oscilloscope (DSO-X 2024A). This devices can be connected to a PC through USB for downloading the data points.

II. B. Digilent Analog Discovery 2™

DAD2 is used both as a power source and a measurement device (Fig. 1). DAD2 can be easily connected to a PC through a USB cable, and it works with a software called WaveForms, which can be downloaded through Digilent website. This software allows for analyzing as well as exporting the data. DAD2 contains many functionalities desired for Electrical Engineering labs, including two oscilloscope channels and two function/arbitrary waveform generators.

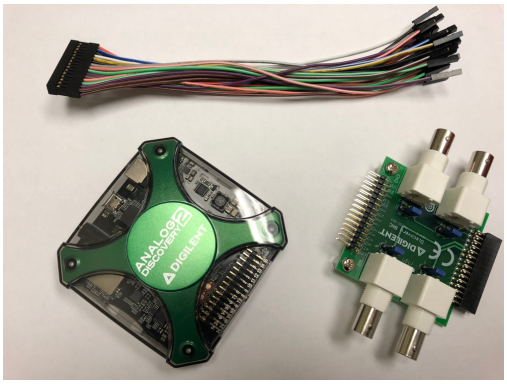

Figure 1: Digilent Analog Discovery 2™ along with the connectors.

III. Experimental Setup

Two separate but closely related experiments in Electrical Circuits lab are used to compare the use of DAD2 and bench-top instruments based on student feedback. Each experiment is explained briefly in sections III. A and III. B.

III. A. Transient response in an RL circuit- use of bench-top instruments

In this experiment students observe transient behavior of an RL circuit and calculate the time constant of the circuit through experimental results. The basic circuit for this experiment is shown in Fig. 2. The input voltage is a square wave generated by a bench-top function generator. Students measure the voltage across the resistor using a bench-top oscilloscope, download the data points to a computer, and use Excel curve-fitting feature to calculate the time constant of the circuit.

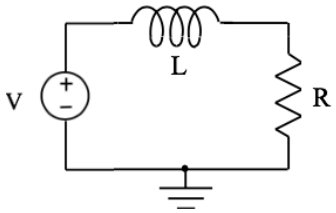

Figure 2: Circuit schematic used for the RL circuit behavior analysis.

III. B. Transient response in an RLC circuit- use of DAD2

In this experiment students observe transient behavior of an RLC circuit and calculate the response characteristics through experimental results. The basic circuit for this experiment is shown in Fig. 3. The input voltage is a square wave generated by DAD2. Students measure the voltage across the capacitor using DAD2 oscilloscope feature, download the data points to a computer, and use Excel to estimate the characteristics of the underdamped response by altering the parameters of a self-generated decaying sinusoid.

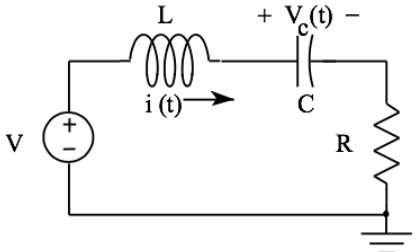

Figure 3: Circuit schematic used for the RLC circuit behavior analysis.

IV. Assessment Methods

A 3-part questionnaire was designed to quantitatively study student feedback on the use of DAD2 vs. bench-top instruments. Part 1 of the questionnaire, which was focused on bench-top instruments, was filled out by students after the first lab (part III. A). Part 2 of the questionnaire, which was focused on DAD2, was filled out by students after the second lab (part III. B). Part 3 of the questionnaire, which was focused on direct comparison of bench-top and DAD2 was also filled out by students after the second lab. In parts 1 and 2 students were asked to rate the level of difficulty for completing each task using the corresponding instruments based on the following rating system:

1 : very easy
2 : easy
3 : neutral
4 : difficult
5 : very difficult

In part 3 students were asked to choose which instrument they found easier to use in performing each task, where they could choose only one of the following 3 options:

- Bench-top instruments
- DAD2
- No difference

Tasks 1 through 6 were related to using the instruments for measurement (oscilloscope) and tasks 7 through 9 were related to using the instruments for supplying power to the circuit (function/waveform generator), as listed below:

1. Connecting the measurement device to the circuit
2. Obtaining a clear signal on the screen
3. Scaling the signal to the desirable size
4. Y-axis measurements (signal amplitude)
5. X-axis measurement (time intervals)
6. Transferring data from the device to your computer
7. Connecting the power generator device to the circuit
8. Choosing the wave shape
9. Specifying signal parameters (amplitude, frequency, duty cycle, etc.)

The questionnaires were filled out by 28 students in 2 lab section of Electrical Circuits class. The summary and analysis of the results are shown in section V.

V. Assessment Results and Summary

The summary of data for parts 1 and 2 of the questionnaire is shown in Fig. 4. The explanations for tasks and rating systems can be found in section IV. Based on this data it can be seen that the level of difficulty in using the devices for different tasks is very similar for bench-top instruments and DAD2. However, it is important to note that a direct comparison between bench-top instruments and DAD2 may be difficult using these data sets as the students filled out the questionnaire for each device separately and did not directly compare the levels of difficulty in their mind. A more clear comparison between the two devices is evident from part 3 of the questionnaire, as students are directly asked to compare the two devices.

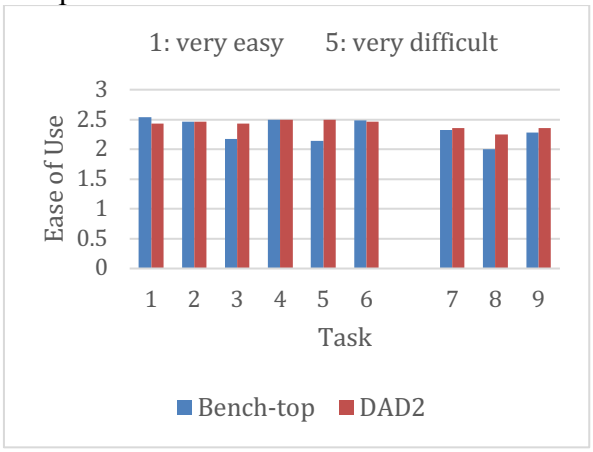

Figure 4: Data summary for parts 1 and 2 of the questionnaire. The explanations for tasks and rating systems can be found in section IV.

The summary of data for part 3 of the questionnaire is shown in Fig. 5. The explanations for tasks and the rating systems can be found in section IV. It can be seen that for the first 5 tasks (corresponding to oscilloscope use) the highest number of students have declared DAD2 easier to use. This suggests that it is beneficial to replace bench-top oscilloscopes with DAD2 not only due to lower price and smaller size, but also due to ease of use by students.

On the other hand, this advantage (ease of use) is not as clear for tasks 7 through 9, which correspond to waveform generator use. In this case, while the advantages of lower price and portability still hold for DAD2, it is not clear that the waveform generator functionality is easier to use for students.

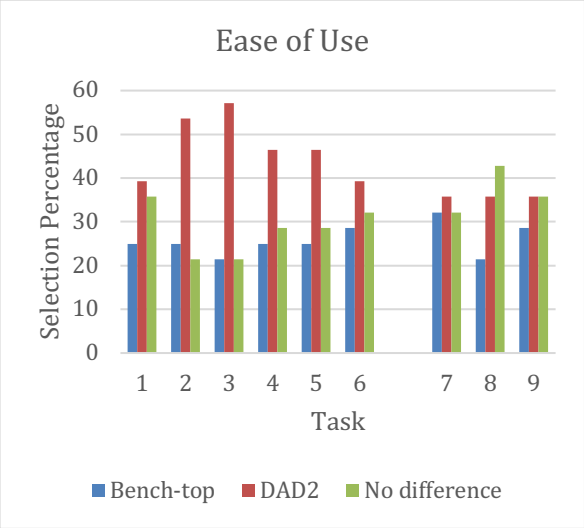

Figure 5: Data summary for part 3 of the questionnaire. The explanations for tasks and rating systems can be found in section IV.

Figure 6 displays the data from part 3 in a different way. Here the ratio of DAD2 selections over bench-top selections for ease of use is displayed, to make the direct comparison easier. As it can be seen in Fig. 5, all the ratios are above 1, declaring DAD2 easier to use by students. Also, the areas where the difference is highest are "obtaining a clear signal on the screen" and "scaling the signal".

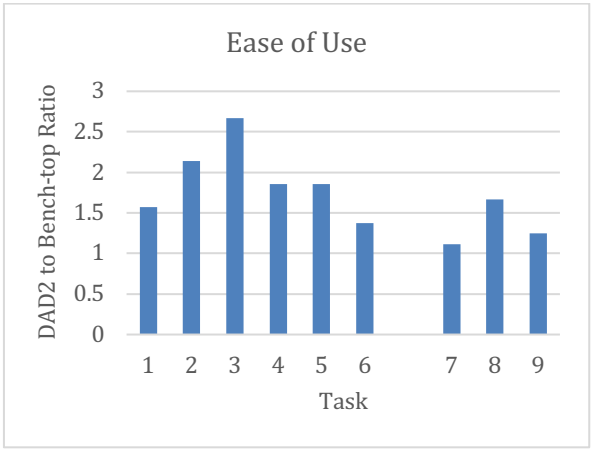

Figure 6: Direct comparison between DAD2 and bench-top instruments based on part 3 of the questionnaire. The explanations for tasks and rating systems can be found in section IV.

In order to achieve more conclusive results both for waveform generator and oscilloscope functionalities of DAD2 in comparison to bench-top devices, our next step would be to repeat similar questionnaires for Electrical Circuits lab which utilize other aspects of oscilloscopes and waveform generators. This will make a more comprehensive analysis and comparison between the options possible.

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