Introduction to the Digital Storage Oscilloscope

by Richard N. Tarrant

Experiment Overview

This experiment serves as an introduction to the Digital Storage Oscilloscope (DSO), which is the modern version of the cathode ray oscilloscope (CRO). DSOs are standard instruments in any physics lab, and familiarity with it is an essential part of a physicist's training. The experiment introduces the students to the DSO through careful explanations of its various features, technical details and functions, before two simple tasks are given to the students to allow them to interact with the DSO and use it to make simple measurements and calculations, which require that the students have reached a certain level of understanding of the instrument.

The second of the two tasks has the subsidiary aims of teaching the students some basic circuit theory (measuring current and voltage, capacitors, RC circuits) as well as the concept of exponential decay and its application to RC circuits, partially disguised as learning how to use the DSO.

Learning Experience

In the School of Physics at the University of Sydney, we are continuing our review of our entire undergraduate electrical circuits / electronics teaching program, following concerns raised that many of our 3rd year physics students had little understanding of the most basic electrical circuits (for example, the time constant of an RC circuit). Part of this review is to re-examine our 1st year laboratory experiments.

Additionally, we have standardised on a single model of oscilloscope (Agilent DSO1002A) in the laboratories across all three undergraduate years, with the hope the throughout students' undergraduate progression, the physics of the experiment will be less obscured by the operational idiosyncrasies of complex equipment.

Whilst written for a specific DSO (Agilent DSO 1002A), the experiment is easily adaptable to other DSOs, for example, the Tektronix TDS 1000 series.

This experiment was presented at the Adelaide 2010 ASELL workshop and has been extensively rewritten in response to feedback. We hope to submit this experiment for formal ASELL approval, subject to the feedback we receive at this year's workshop.

Aims and Objectives

On completion of this session students should:

· understand the concept of time-varying voltages and currents,

· understand the operational principles of the major oscilloscope controls, and have the basic skill to control the display of a waveform on an oscilloscope,

· be able to identify and measure on an oscilloscope waveform characteristics such as amplitude, peak-to-peak voltage, frequency and period,

· understand the concept of charging and discharging a capacitor in an RC circuit,

· understand the concept of a time constant in an RC circuit and be able to measure it with an oscilloscope.

· use the measured time constant and the resistance of the RC circuit to determine the capacitance of a capacitor

Level of Experiment

This experiment is designed for first year students in their second semester of university Physics. It is the second last experiment to be undertaken by students in the Environmentals stream (which has a life science focus). Most (but not all) of the students have come through our first semester Physics Fundamentals course, which has been developed for students who have not studied Physics in year 12, our those who obtained poor results (< 65). Again, most of these students are studying physics only because their course of study requires it (often to their surprise and consternation!).

The experiment introduces a relatively complex instrument – the DSO – which is one of the most versatile and important instruments available to physicists (and scientists from other disciplines).

Keyword Descriptions of the Experiment

Domain
Electrical circuits, Instrumentation

Specific Descriptors
Digital Storage Oscilloscope (DSO), voltage, current, measurement, electric circuits, analysis

Course Context

PHYS 1004 Physics 1 (Environmental & Life Sciences) – Semester 2, 2009

Module 2 – Electricity and Magnetism

This module is one of 3 comprising PHYS 1004 Physics 1 (Environmental & Life Sciences). This document describes details of this module and should be read in conjunction with the more general unit of study outline for PHYS 1004 Physics 1 (Environmental & Life Sciences).

GENERAL GOALS OF THIS MODULE

• To investigate the concept of charge, the conservation of charge and the forces between charges.

• To investigate the nature of electric and magnetic fields, how they can be produced and the interactions between

them.

• To examine simple electrical circuits and concepts of voltage, current and resistance.

• To discuss applications of these concepts to the environmental and life sciences. Such applications include

capacitance of cell membranes, nerve conduction, the earth's magnetic field, and the principles of operation of

MRI.

Prerequisite Knowledge and Skills

This is a second semester unit, all students will have undertaken Physics Fundamentals in first semester as a minimum requirement. A few may have done more advanced first semester physics courses.

Time Required to Complete

Prior to Lab: 1 hour
In Laboratory: 3 hours
After Laboratory: none

Experiment History

An experiment with similar aims (learning how to use an oscilloscope) has been used within the School of Physics with little change for many years previous to my involvement. Due to a combination of the electrical circuits laboratory review and the purchase of and standardisation to a single model of DSO across was all undergraduate labs., the experiment was revised before the Adelaide 2010 ASELL workshop, and rewritten again in response to the Adelaide 2010 ASELL feedback.

Comments

The students carry out the preparatory work downloaded from The University of Sydney *eLearning* site and completed prior to beginning the laboratory session. Students who have not completed the prework prior to the laboratory session lose 1 (of a possible 4) checkpoints for the session.

The students perform the experiment in teams of three using a single team logbook. The laboratory notes are in the bound laboratory manual, containing all of the semester's experiments, as well as general introductory material including OH&S requirements, laboratory rules, notes on experimental methods, and some sample logbook entries. At back of the manual (which each student is required to purchase) are extensive pages of relevant formulae, methods of data analysis including calculation and propagation of errors, drawing of graphs, and a brief primer on using Microsoft EXCEL for analysing and plotting data.

The experiment notes in the laboratory manual are written as a series of logbook points, designed to encourage the students to think, discuss and work as a team. At each of the several checkpoints, a tutor discusses the logbook entries with the group and provides feedback. If the work is satisfactory the checkpoint is awarded and the group may then proceed. If not, the work is revised until a checkpoint is awarded.

References

R.D. Knight, B. Jones & S. Field, *College Physics: A Strategic Approach,* Pearson, *2nd ed. 2010*