Laboratory Exercise 1
Measurement Errors

Student Name and Surname	Student Number

1. Introduction

The laboratory experiment is concerned with the evaluation of errors in an electric circuit through the use of basic circuit analysis methods. The student will have to use known relationships between voltage and current to discover how errors within a system can accumulate. The understanding of the errors within a measurement system is crucial thus this lab exercise is meant to help students appreciate the effect of errors and error propagation when conducting measurements. This lab has a pre-laboratory component which should be completed before the student can do the experimental exercise.

2. Some Theory

A measurement error is expressed by equation (1)

$$\varepsilon = \tilde{A} - A \qquad (1)$$

where: ε is the measurement error, $\tilde{A}$ estimated quantity and A true value. However, a true measurable quantity is usually unknown since if it was known then there would be no need of a measurement. Thus measurement errors are by themselves estimations by the use of indirect data [1]. Necessary components of any measurement are the method of measurement and the measuring instrument. Thus measurement is generally performed with the participation of a person. Imperfection of each component of a measurement contributes to the measurement error and thus (1) can be seen as follows in (2) [1]:

$$\varepsilon = \varepsilon_m + \varepsilon_i + \varepsilon_p \qquad (2)$$

where, ε_m is the **methodological error**, ε_i is the **instrumental error** and ε_p is the **personal error**. Methodological errors could arise due to inadequate theory of the phenomena on which the measurement is based. Instrumental measurement errors are caused by the imperfection of the measurement instrument. Whereas personal errors are due to incorrect readings of the values from the measurement instrument. The advent of digital instruments has contributed in the reduction of personal measurement errors immensely. Students may look at other errors such as random errors and systematic errors as a self-study.

3. Objectives

The lab objectives will be met if the student can:

- Make use of scientific and engineering principles to complete the laboratory
- Make use of engineering tools, both hardware and software tools to demonstrate accumulation of data for error alanysis.
- Demonstrate understanding of the impact of errors within a system
- The student can provide sound methods/suggestions of reducing errors when conducting measurements

4. Pre-Laboratory work

Students will not be allowed to conduct this lab if they have not done their pre-lab. The pre-lab can be done by using one of the circuit simulator tools such as PSPICE, Multisim, etc. The circuit is composed of four resistors (R1, R2, R3 and R4) and a single voltage source as shown in Fig 1.

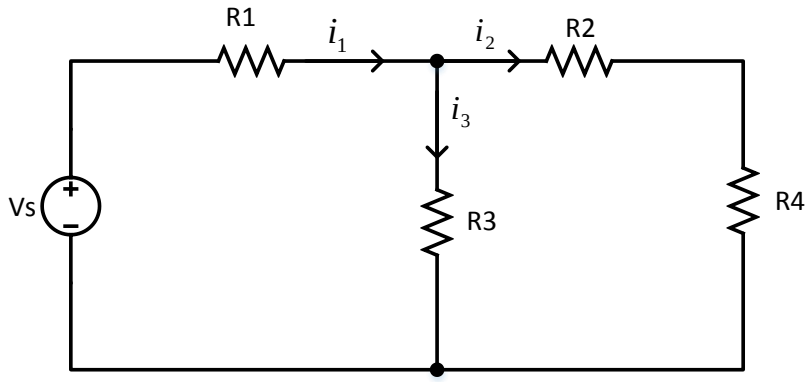

Figure 1: Circuit diagram of the system

Choose any random resistor values between 1k and 10k Ohms and for each resistors (**make sure that the resistors chosen are standard values which can be used during the laboratory experiment**). Note: All the resistor values must be different. Students should conduct the following:

- Using circuit analysis theory formulate some equations which can model the behavior of the circuit in Fig. 1.
- Obtain all the parameters of the circuit through the PSPICE simulation tool (use Vs =10V), i.e. currents and voltages across all the resistors.
- How would you validate/prove Kirchoff's Voltage Law (KVL) and Kirchoff's Current Law (KCL)?

Please present your work to the laboratory demonstrators for approval.

5. Laboratory Work

The simulated circuit (Fig. 1) should be implement on the circuit board for analysis.

5.1 Validate KCL and KVL

- Is KCL and KVL laws true, do they hold?

5.2 Follow Table 1 in order to meet the objectives of this laboratory.

Table 1: Laboratory objective

Steps	Description	Activity
1	On the four resistors…	…measure the resistances using a multimeter
2	From measured resistances…	…measure the voltage and currents across each resistor
3	From the measured currents and voltages…	…calculate the resistances
4	From calculated and measured resistances…	…compute the error between measured and calculated values

Please comment on the following:

a) Errors on the measured resistances, which resistor was there more measurement errors?
b) What could be the cause for b)?
c) Source of the errors?
d) What could be done during measurements to reduce the errors?

References

[1] S. G. Rabinovich, Measurement Errors and Uncertainties, Springer, 2005, pp 31-33.

Laboratory Results:

5.1

5.2

Table R: Error computation

Resistors	Nominal value	Measured	Calculated	Error (%)
R1				
R2				
R3				
R4				

a)

b)

c)

d)