

## **APPENDIX 1 – Lab Report Format**

Laboratory reports are important tool to communicate and present experimental results. In an educational point of view, those reports help lab instructor to analyze the understanding, performance, and organization and analysis of results from students. On the other, in industry, company decisions are often made according to experimental work and result presented in a laboratory report to management.

For engineering technology students, lab report can be written according to the course lab requirement. The most commonly used organization for laboratory reports are:

- Cover page
- Abstract
- Introduction
- Brief description of procedure
- Experimental Results
- Discussion
- Conclusion
- Appendices and Reference

### **Abstract**

The abstract presents a synopsis of the experiment. It should be written concisely in normal rather than highly abbreviated English. The author should assume that the reader has some knowledge of the subject but has not read the paper. Thus, the abstract should be intelligible and complete in itself; particularly it should not cite figures, tables, or sections of the paper. The opening sentence or two should, in general, indicate the subjects dealt with in the paper and should state the objectives of the investigation. It is also desirable to describe the treatment by one or more such terms as brief, exhaustive, theoretical, experimental, and so forth.

### **Introduction**

The "Introduction" of a laboratory report identifies the experiment to be undertaken, the objectives of the experiment, the importance of the experiment, and overall background for understanding the experiment. The objectives of the experiment are important to state because these objectives are usually analyzed in the conclusion to determine whether the experiment succeeded.

### **Procedures**

The "Procedures," often called the "Methods," discusses how the experiment occurred. Documenting the procedures of your laboratory experiment is important not only so that others can repeat your results but also so that you can replicate the work later, if the need arises. Historically, laboratory procedures have been written as first-person narratives as opposed to second-person sets of instructions. Because your audience expects you to write the procedures as a narrative, you should do so.

## **Results and Discussion**

The heart of a laboratory report is the presentation of the results and the discussion of those results. In some formats, "Results" and "Discussion" appear as separate sections. However, P.B. Medawar [1979] makes a strong case that the two should appear together, particularly when you have many results to present (otherwise, the audience is faced with a "dump" of information that is impossible to synthesize). Much here depends upon your experiment and the purpose of your laboratory report. Therefore, pay attention to what your laboratory instructor requests. Also, use your judgment. For instance, combine these sections when the discussion of your first result is needed to understand your second result, but separate these sections when it is useful to discuss the results as a whole after all results are reported.

For experiment where data is recorded in tables and/or presented in graphs, those information should be organized and link to the discussion to support the experiment findings. In discussing the results, you should not only analyze the results, but also discuss the implications of those results. Moreover, pay attention to the errors that existed in the experiment, both where they originated and what their significance is for interpreting the reliability of conclusions.

## **Conclusions**

In longer laboratory reports, a "Conclusion" section often appears. Whereas the "Results and Discussion" section has discussed the results individually, the "Conclusion" section discusses the results in the context of the entire experiment. Usually, the objectives mentioned in the "Introduction" are examined to determine whether the experiment succeeded. If the objectives were not met, you should analyze why the results were not as predicted. Note that in shorter reports or in reports where "Discussion" is a separate section from "Results," you often do not have a "Conclusion" section.

## **Appendices**

In a laboratory report, appendices often are included. One type of appendix that appears in laboratory reports presents information that is too detailed to be placed into the report's text. For example, if you had a long table giving voltage-current measurements for an RLC circuit, you might place this tabular information in an appendix and include a graph of the data in the report's text. Another type of appendix that often appears in laboratory reports presents tangential information that does not directly concern the experiment's objectives.

One sample of an Appendices for *Design of a Temperature Measurement and Display System Using the 68HC11 Microcontroller* is:

### **Appendix A: Hardware Schematic**

Figure A-1 presents the hardware schematic for the temperature circuit. The circuit was designed according to the specifications obtained from the Computer Engineering Laboratories web site for ECPE 4535 [Lineberry, 2001].

## **References**

A **reference** gives the readers details about the source so that they have a good understanding of what kind of source it is and could find the source themselves if necessary. The references are typically listed at the end of the lab report.

References from a book and article are written as: Authors' name (Listed in an alphabetical order if there is more than one author), book title, title, department or book publisher, page number, publication year.

H.S. Crawford, R.G. Hooper, and R.F Harlow, *Woody Plants Selected by Beavers in the Appalachian and Valley Province*. Upper Darby, PA: U.S. Department of Agriculture, 1976.

Spasov, Peter, *Microcontroller Technology: The 68HC11*, 2nd ed. (Englewood Cliffs, NJ: Prentice Hall, 1996), pp. 107, 355-359, 460.

References from the website are written as: Authors' name (Listed in an alphabetical order if there is more than one author), date of retrieved, name of website, name of webpage, hyperlink.

Alley, M. (2017, January 5). *Writing Guidelines for Engineering and Science Students*. Retrieved from Laboratory Report: [writing.engr.psu.edu/workbooks/laboratory.html](http://writing.engr.psu.edu/workbooks/laboratory.html)

Wallece, R. (2005, May 16). *North Caroline State University*. Retrieved from Lab Write Resources: Citations and References: <https://www.ncsu.edu/labwrite/res/res-citsandrefs.html>

Lineberry, Bob, "Computer Engineering Laboratories Website at Virginia Tech," <http://www.ee.vt.edu/cel> (Blacksburg, VA: ECE Department, 1998), ECpE 4535: Laboratory Assignments, Lab X.

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**ET 110/H5 – Introduction to Circuit Analysis Laboratory**

**LAB EXPERIMENT 4**  
**Series Resistance**

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Fall 2010 (10/15/10)

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**ABSTRACT**

The physical construction of a series configuration circuit in a protoboard was build according to the rules of series connectivity. The total resistance of a series circuit was measured first using digital multimeter, DMM. The measured values were later compared with the calculated total resistance, which was found by the principal of Ohm’s law and Kirchhoff’s voltage law. At the end, the percent of difference was determined to be between 0.022% and 0.11% for two and three resistors connected in series configuration.

## INTRODUCTION

According to circuit topology, two or more elements are connected in series if they exclusively share a single node and consequently carry the same current. Due to it, an equivalent resistance of resistors connected in series is found by the fundamental circuit laws, Ohm's law and Kirchhoff's law. As it is stated in Ohm's law, where the current through the conductor between points is directly proportional to the potential difference across the two points:

$$I = V/R \quad (1)$$

and Kirchhoff's voltage law, KVL, where the sum of all voltages is zero volts, then is found that the equivalent resistance of any number of resistors connected in series is the sum of the individual resistance:

$$R_{eq} = R_1 + R_2 + R_3 + \dots R_N \quad (2)$$

where  $N$  is the total number of resistors connected in series configuration. In this experiment, we determine, by measurements and calculations, the equivalent resistance of different resistors connected in series. The percent of difference between the measured and calculated, using equation 1 and 2, is also states with the following:

$$\% \text{ Difference} = \frac{R_{T(\text{measured})} - R_{T(\text{calculated})}}{R_{T(\text{calculated})}} \times 100\% \quad (3)$$

## II. EXPERIMENT AND PROCEDURE

The components used in lab were:

- Resistors: one of 220  $\Omega$ , 330  $\Omega$ , 1 k $\Omega$ , 100 k $\Omega$  (1/4 W), three of 100  $\Omega$  (1/4 W)
- Breadboard/protoboard
- Jumper wires

The Equipment used in lab was:

- DMM
- dc power supply

Post to lab experiment, the total resistance was calculated for part 1, two resistors in series, and part 2, three resistors in series, using equation 2. Calculated results were recorded in Table 4.1.

For the first part of the experiment, two series resistors, we took a  $220\ \Omega$  and  $100\ \Omega$  resistor and a protoboard from our lab components kit. The measured value of each resistor, using a digital multimeter, were recorded in the lab manual. Later, both resistors were connected in series configuration in a protoboard: one connected one terminal of the  $220\ \Omega$  was connected to the positive lead of the digital multimeter and one terminal of the  $100\ \Omega$  was connected to the negative lead of the digital multimeter. The measured total resistance was recorded in Table 4.1.

After it, the leads for the power supply was obtained from the lab technician and the power supply was set to 8 V: the positive lead of the power was connected to the  $220\ \Omega$  resistor, and the negative lead to the other terminal of the  $100\ \Omega$  resistor. After it, the digital multimeter was set to measure current in a milli-amperes scale. Then, the positive lead of the multimeter was connected in series with the circuit by connecting the positive lead of the multimeter with the positive terminal of the power supply, and the negative lead of the multimeter with one terminal of the  $220\ \Omega$  resistor. The measured the current was 25.1 mA. To confirm the accuracy of the experiment, on a sheet of paper, the total resistance of the circuit was calculated using Ohm's law, equation 1, and the percent of difference, using equation 3, between the measured total resistance,  $318.8\ \Omega$ , and the calculated total resistance using equation 1,  $319\ \Omega$ , and equation 2,  $318.7\ \Omega$ . All calculations were recorded in Table 4.1

For the second part of the experiment, a  $330\ \Omega$  was included to the experiment and its measured resistance value was  $325\ \Omega$ . This resistor was connected in series with the previous series circuit. The total resistance of this series circuit was measured using a digital multimeter and measurement was recorded in Table 4.2. Once the total resistance is measured, an 8-volts power

supply is applied to power up the series circuit. After it, an ammeter was connected in series with the circuit and the total current was measured and recorded in Table 4.2. Once again, to confirm the accuracy of the experiment, on a sheet of paper, the total resistance was calculated using equation 2, and the percent of difference between the measured total resistance, 644.7  $\Omega$ , and the calculated total resistance using equation 1, 644  $\Omega$ , and equation 2, 645.2  $\Omega$ . All calculations were recorded in Table 4.2.

## TABLES

**Table 4.1** – Total resistance of two resistors connected in series and % difference between the measured and calculated value: Total resistance value found my measurement using digital multimeter, and by calculation using equation 1 and 2; % difference found using equation (3)

$R_T$ (Calculated)	$R_T$ (Ohmmeter)	% difference	I (Measured)	$R_T$ (Ohm's Law)	% Difference
319 $\Omega$	318.9 $\Omega$	$6.3 \times 10^{-2} \%$	25.1 mA	318.7 $\Omega$	$2.2 \times 10^{-2} \%$

**Table 4.2** – Total resistance of three resistors connected in series and % difference: Total resistance value found my measurement using digital multimeter, and by calculation using equation 1 and 2; % difference found using equation (3)

$R_T$ (Calculated)	$R_T$ (Ohmmeter)	% difference	I (Measured)	$R_T$ (Ohm's Law)	% Difference
644 $\Omega$	644.7 $\Omega$	$1.1 \times 10^{-1} \%$	12.4 mA	645.2 $\Omega$	$7.0 \times 10^{-2} \%$

## CALCULATION

### *Part 1: two series resistors*

$$R_1(\text{measured}) = 218 \Omega$$

$$R_2(\text{measured}) = 101 \Omega$$

$$R_T = R_1 + R_2 = 218 \Omega + 101 \Omega$$

$$R_T = 319 \Omega$$

$$\% \text{ Difference} = \frac{318.8 \Omega - 319 \Omega}{319 \Omega} \times 100\% = 0.063\%$$

$$R_T = \frac{E}{I} = \frac{8\text{ V}}{25.1\text{ mA}} = 318.73\ \Omega$$

$$\% \text{ Difference} = \frac{318.8\ \Omega - 318.73\ \Omega}{318.73\ \Omega} \times 100\% = 0.022\%$$

### ***Part 2: Three series resistors***

$$R_1(\text{measured}) = 101\ \Omega$$

$$R_2(\text{measured}) = 218\ \Omega$$

$$R_3(\text{measured}) = 325\ \Omega$$

$$R_T = R_1 + R_2 + R_3 = 101\ \Omega + 218\ \Omega + 325\ \Omega$$

$$R_T = 644\ \Omega$$

## **QUESTIONS**

**1. For a circuit with a constant resistance, what happens to the current as the voltage increases?**

If there is a constant resistance in the circuit, the current is directly proportional to the voltage and will increase as the voltage increases.

**2. For a circuit with a constant resistance, what kind of relationship (e.g., inverse, linear) does the current have to the voltage?**

For a circuit with a constant resistance, current will have a directly proportional and hence linear relationship with voltage. This can be proven by looking at Ohm's law  $V=I \times R$  and also by looking at the graphs of this experiment.



### III. RESULTS AND DISCUSSION

For part 1, two series resistors configuration circuit, 100  $\Omega$  and 220  $\Omega$  resistors, was built to find the total resistance. The total resistance was found by calculation, using equation 1 and 2, and measurement, using a digital multimeter. Table 4.1 presents the total resistance of two resistors connected in series and the percent of difference between the measured and calculated value. Rearranging from equation 1, indicates that the total resistance of a series configuration circuit is directly proportional to the voltage source and inversely proportional to the current source. According to it, the calculated total resistance was found to be 318.7  $\Omega$ . Also, from equation 2, the total resistance of a series configuration circuit is the sum of the individual resistance connected in series, giving a calculated value of 319  $\Omega$ . In connection to it, the percent of difference between each calculated value and measured value is found to be 0.022 %, for total resistance calculated using equation 1, and 0.063%, for total resistance calculated using equation 2.

For part 2, Table 4.2 gives the total resistance of three series resistors connected in series configuration, 100  $\Omega$ , 220  $\Omega$ , and 330  $\Omega$  resistors, and the percent of difference between the measured and calculated value. The total resistance is found using equation 1, 645.2  $\Omega$ , equation 2, 644  $\Omega$ , and by measurement, 644.7  $\Omega$ , using a digital multimeter. At the end, the percent of Difference between each calculated value and measured value is found to be 0.07 %, for total resistance calculated using equation 1, and 0.11%, for total resistance calculated using equation 2.

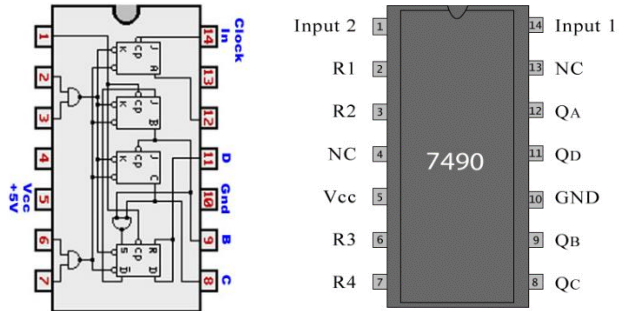
### IV. CONCLUSION

We can conclude from our results in part 1 and 2 that the total resistance is directly proportional to the voltage source and inversely proportional to current source, equation 1. Also, in a series resistors circuit, since all resistors share the same current flow, and by applying the principles of Kirchhoff's law, the total resistance of resistors connected in series is the sum of its individual

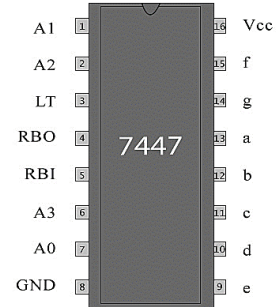
resistance, equation 2. At the end, the percent of difference between the calculated value and measured value is found to be between 0.022% and 0.11%. This indicates that the founding of the total resistance by experiment is almost equal to the calculated value, using different approach theories of resistance in series resistors configuration.

## APPENDIX 2 – Pin number of 74LS90N and 74LS47D

74LS90N - Decade and 4-bit Binary Counters: Type of digital counter which can count from 0 to 9.

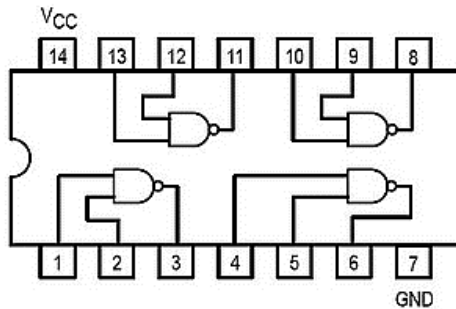


74LS47D - BCD to 7- Segment Decode: It is an encoding in which each digit of a number is represented by its own binary sequence of 4-bit

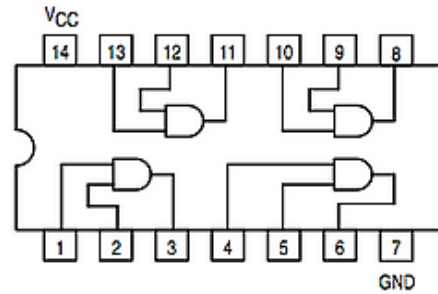


## APPENDIX 3 – Basic Logic Gates Pin Diagram

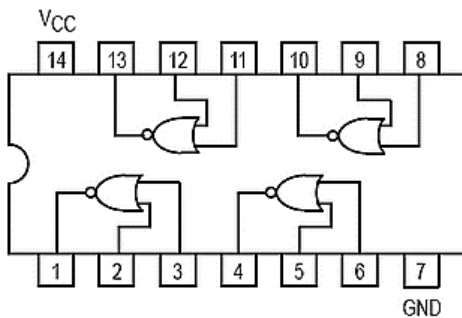
**74LS00 is a QUAD NAND gate**



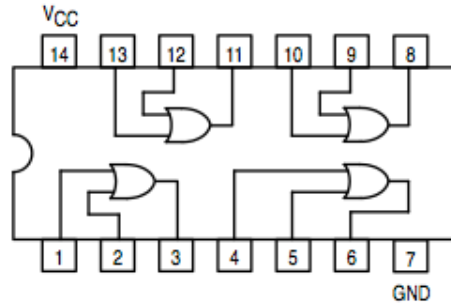
**74LS08 is a QUAD AND gate**



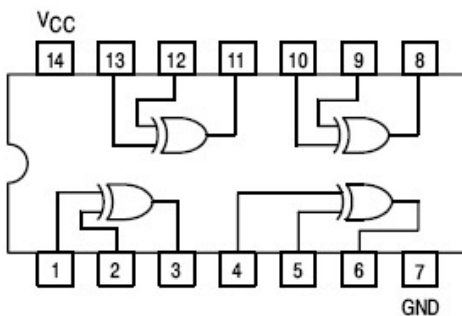
**74LS02 is a QUAD NOR gate**



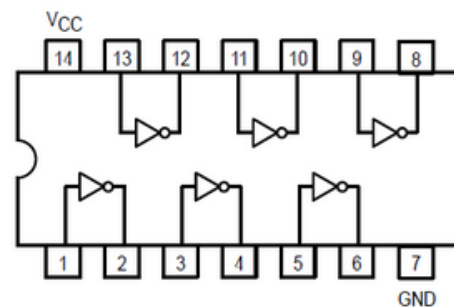
**74LS32 is a QUAD OR gate**



**The 74LS86 is a QUAD XOR gate**



**The 74LS04 is a HEX Inverter gate**



## APPENDIX 4 – How to make a timing diagram using tables

If we want to create the following timing diagram

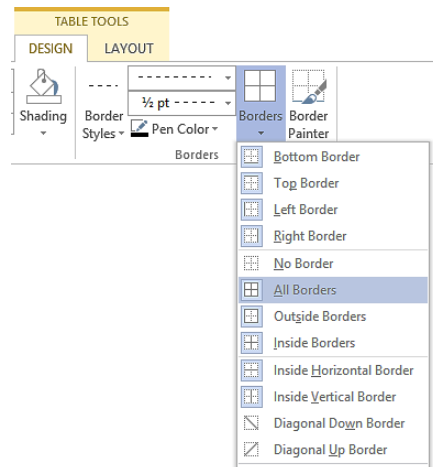
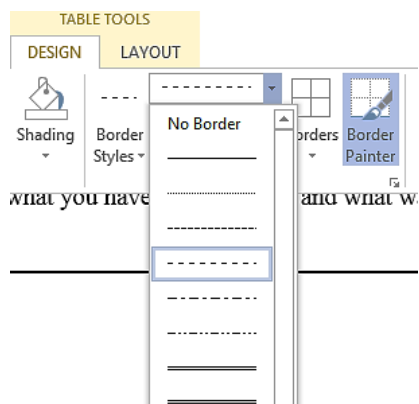


One way to reproduce the timing diagram above is using tables in Microsoft Word → Open a Word document and Insert a table with the number of columns and rows needed for the timing diagram. In our case, we need 6 columns and 1 row

Insert/Table/Insert Table/Number of rows = 6, Number of columns = 1

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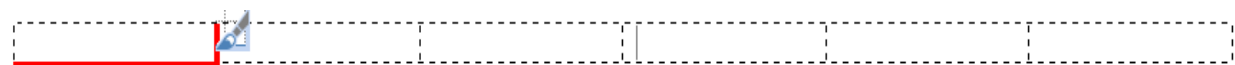
Now we can make all borders of the table to be broken lines → Click anywhere on the Table, select Design from the Table Tools, select **broken line** from Line Style, and **All Borders** from Borders



You should have the following table

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Now, you can add solid lines to our diagram → Click anywhere on the table, click on **Design** from the Table Tools menu, select **Solid Line** from Line Style, change the **Pen Size** to **3 pt**, and select the **Pen Color** to **Red**. Having the Pen active, click on the table border where we want to place the solid line.



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## References

Alley, M. (2017, January 5). *Writing Guidelines for Engineering and Science Students*. Retrieved from Laboratory Report: [writing.engr.psu.edu/workbooks/laboratory.html](http://writing.engr.psu.edu/workbooks/laboratory.html)

Wallece, R. (2005, May 16). *Lab Writing Resources* North Caroline State University. Retrieved from Lab Write Resources: Citations and References: <https://www.ncsu.edu/labwrite/res/res-citsandrefs.html>