Name: Cayce Beames
Date: September 2, 2019
Professor Steven Gillette

Abstract

Using a protoboard trainer, I constructed a simple circuit using that alternated 2 LEDs on and off. I constructed the circuit, calculated the on-off oscillation frequency at 1.418 Hz, calculated an observed oscillation frequency of 1.2Hz and calculated an error rate of 15.37%. Additionally, the circuit construction required troubleshooting that is described in the report.

Introduction

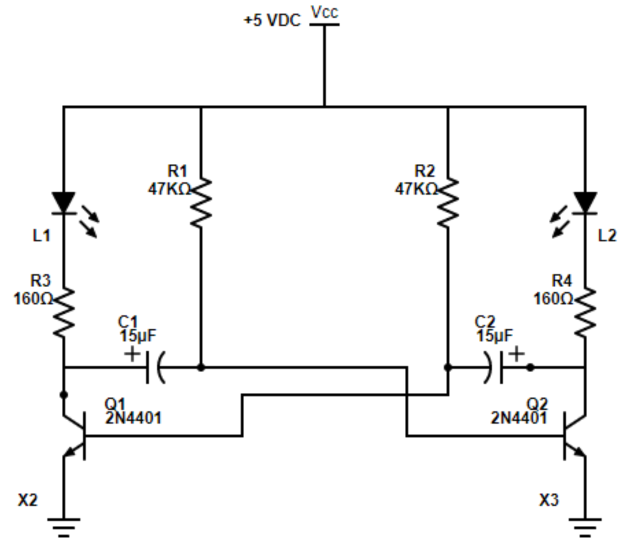
Learning Objectives

- Become familiar with electronic circuit construction using a proto-board trainer.
- Calculate the theoretical output frequency for an astable multivibrator circuit.
- Measure the output frequency for an astable multivibrator circuit through direct observation.
- Create a problem statement that accurately describes a problem associated with the circuit, trainer or test equipment performance
- Identify critical thinking skills required to write an effective problem statement

Materials

Quantity	Description
1	Global Specialties Circuit Trainer
1	Digital multimeter
2	160 Ω resistor 180 Ω resistors were substituted
2	47K Ω resistor
2	15 µF polarized capacitor
2	Light emitting diodes (LED)
2	2N4401 bipolar junction transistor

Schematic Diagram



Experiment –
Circuit Assembly, Test and Data Results:

1. Constructed the ***astable multivibrator*** circuit as shown on schematic diagram above. Paid close attention to the proper orientation of polarized components (transistors and capacitors in this lab).
2. Connected the circuit to the +5 V power supply. Connected the circuit ground to the trainer ground bus.
3. Verified that the LED's alternate on-off. ***Lab signoff in Appendix A – Lab Notes and Signoff***
4. ***Calculated and recorded*** the expected oscillation frequency using the ***frequency*** formula in the Formulas section below.

$$f = \frac{1}{RC}$$

Where;
f = frequency (Hertz)
R = circuit resistance (Ohms)
C = circuit capacitance (Farads)

$$f = \frac{1}{47000\Omega * 15 * 10^{-6}}$$

$$f = \frac{1}{705000 * 10^{-6}}$$

$$f = \frac{1}{.705}$$

$$\boxed{f = 1.418Hz}$$

Frequency formula in online version of lab document includes a 0.7 multiplier which was not shown in the printed copy of the lab assignment. This affects the frequency results calculated as well as error calculation.

5. ***Measure and record*** the number of flashes of one LED over a 30-second period. __$\boxed{37}$__ **Cycles**
6. ***Calculate and record*** the number of flashes per second __$\boxed{1.2}$__ **Hertz.** This is your measured value.

$$flashes = 37/30seconds$$

Hertz (Hz) = cycles per second

$$flashes = (37 * 2)/60sec$$

$$flashes = 74/60sec$$

$$flashes = \left({}^{74}/_{60}\right)/1sec$$

$$flashes = 1.2/sec$$

$$\boxed{flashes = 1.2Hz}$$

7. ***Calculate and record*** the expected value using the formula on the next page.

$$f = \frac{1}{RC}$$

Where;
f = frequency (Hertz)
R = circuit resistance (Ohms)
C = circuit capacitance (Farads)

$$f = \frac{1}{47000\Omega * 15 * 10^{-6}}$$

$$f = \frac{1}{705000 * 10^{-6}}$$

$$f = \frac{1}{.705}$$

$$\boxed{f = 1.418Hz}$$

Frequency formula in online version of lab document includes a 0.7 multiplier which was not shown in the printed copy of the lab assignment. This affects the frequency results calculated as well as error calculation.

8. Calculate and record the percent error between expected and measured frequency using the ***%Error*** formula below. __$\boxed{15.37}$__% Error

$$\%Error = \frac{measured - \exp ected}{\exp ected} x100\%$$

Where;
%Error = % change between measured and expected values
measured = a value taken from direct measurement
expected = a value taken from component or process specifications

$$\%Error = \left|\frac{1.2 - 1.418}{1.418}\right| * 100\%$$

$$\%Error = \left|\frac{-0.218}{1.418}\right| * 100\%$$

Added vertical bars to show that the result is an absolute number versus the formula

$$\%Error = |-.1537| * 100\%$$

$$\%Error = .1537 * 100\%$$

$$\boxed{\%Error = 15.37\%}$$

Formulas

$$\%Error = \frac{measured - \exp ected}{\exp ected} x100\%$$

Where;
%Error = % change between measured and expected values
measured = a value taken from direct measurement
expected = a value taken from component or process specifications

$$f = \frac{1}{0.700RC}$$

Where;
f = frequency (Hertz)
R = circuit resistance (Ohms)
C = circuit capacitance (Farads)

Conclusions

a) Write a ***problem statement***, composed of grammatically correct and complete sentences that summarize one operational failure of the circuit, trainer or test equipment. The problem statement must answer the following questions;
   a. **Expected operation** – what is the expected operation of the circuit?
   b. **Failure conditions** – what were the conditions at the time of the failure?
   c. **Failure time frame** – when does the equipment or system fail? Is the failure correlated to a specific time frame?
   d. **Failure indicator** – what components or test equipment demonstrated the operational failure? How did the circuit fail to meet operational requirements?

Problems Encountered
After assembling and powering up the circuit, I expected the circuit to blink between the two lights. LED 1 lit and then faded. The LED didn't light up again. The condition occurred at first power-up. Subsequent power-ups did not exhibit LED 1 behavior, instead, no LEDs lit. LEDs were not lighting as expected.

Expected Operation:
After assembling and powering up the circuit, I expected the circuit to blink between the two lights.

Failure Conditions:
LED 1 lit and then faded. The LED didn't light up again.

Failure Time Frame:
The condition occurred at first power-up. Subsequent power-ups did not exhibit LED 1 behavior, instead, no LEDs lit.

Failure Indicator:
LEDs were not lighting as expected.

b) Select and include two critical thinking skills from the list provided that support the creation of an effective problem statement.

From the problem statement, two critical thinking skills that are included are:
10. Separate relevant from irrelevant information when solving a real-world problem.

13. Identify suitable solutions for a real-world problem using relevant information.

Troubleshooting Results

Investigation of the observed problem led me to wiggle wires to test connectivity between the components, wires and the breadboard, the voltages present at the top and bottom of the circuit, as well as testing continuity with the multimeter.

I discovered that continuity was not present at the lower half of the breadboard the circuit was connected to.

I deduced that perhaps the vertical rails were not continuous and measured with the continuity tester. My deductions were correct, and I re-wired the circuit into the first half of the breadboard.

I then powered up the circuit and it functioned correctly as originally expected.

Final Conclusion

The charging of the capacitors connected to the base of the transistors within the time frame measured led me to question what causes a faster and slower oscillation. Additionally, I observed that some students had one LED staying on for a longer period than the other LED. Was it an issue with their capacitors, or their transistors? I'm interested in learning more about the physics behind the behavior of this circuit.

While creating my lab report, I noticed that the frequency formula was different for the lab instructions available through Canvas and the hardcopy lab instructions given out in class.

Re-calculating the frequency with the formula from the Canvas version of the lab yields:

$$f = \frac{1}{0.700RC}$$

Where;
f = frequency (Hertz)
R = circuit resistance (Ohms)
C = circuit capacitance (Farads)

$$f = \frac{1}{0.700 * \ 47000\Omega * 15 * 10^{-6}}$$

$$f = \frac{1}{0.700 * 705000 * 10^{-6}}$$

$$f = \frac{1}{0.700 * .705}$$

$$f = \frac{1}{.4935}$$

$$\boxed{f = 2.026Hz}$$

Frequency formula in online version of lab document includes a 0.7 multiplier which was not shown in the printed copy of the lab assignment. This affects the frequency results calculated as well as error calculation.

This frequency multiplier would yield a count of about 60 blinks in a 30 second period which was not what was observed.

Applying this calculated frequency to the margin of error calculation yields:

$$\%Error = \frac{measured - \exp ected}{\exp ected} x100\%$$

Where;
%Error = % change between measured and expected values
measured = a value taken from direct measurement
expected = a value taken from component or process specifications

$$\%Error = \left|\frac{1.2 - 2.026}{2.026}\right| * 100\%$$

$$\%Error = \left|\frac{-0.623}{2.026}\right| * 100\%$$

$$\%Error = |-.1.332| * 100\%$$

Added vertical bars to show that the result is an absolute number versus the formula

$$\%Error = .1332 * 100\%$$

$$\boxed{\%Error = 13.32\%}$$

The 0.7 multiplier yields a slightly better margin of error.

Appendix A – Lab Notes and Signoff

Lab.

Built circuit

LED1 lit & faded. then didn't light again

~~test~~ Examined connectors & wiggled wires to see connectivity.

tested voltage & didn't see voltage across Positive & negative terminals

Tested continuity on Positive & ground halves of circuit. found break in 1/2 of the vertical rails. adjusted circuit to ensure only top half was used.

tested circuit & trouble resolved

Oscillation

$$f = \frac{1}{RC} \qquad \frac{1}{47k \times 15 \times 10^{-6}}$$

$$\frac{1}{705k \times .000001}$$

$$\frac{1}{.705} = 1.418\ Hz$$

$$\%e = \frac{1.2 - 1.418}{1.418} \times 100\%$$

$$= \frac{-.218}{1.418} \times 100$$

$$= .1537 \times 100 = 15.37\%$$

SIERRA COLLEGE	MECH 10 - Lab 01 Astable Multivibrator	Mechatronics *Real Skills Real Jobs*
Name Cayce Beames		

Learning Objectives

- Become familiar with electronic circuit construction using a proto-board trainer.
- Calculate the theoretical output frequency for an astable multivibrator circuit.
- Measure the output frequency for an astable multivibrator circuit through direct observation.
- Create a problem statement that accurately describes a problem associated with the circuit, trainer or test equipment performance
- Identify critical thinking skills required to write an effective problem statement

Materials

Quantity	Description
1	Global Specialties Circuit Trainer
1	Digital multimeter
2	160 Ω resistor
2	47K Ω resistor
2	15 μF polarized capacitor
2	Light emitting diodes (LED)
2	2N4401 bipolar junction transistor

Procedure – Circuit Assembly & Test

1. Construct the ***astable multivibrator*** circuit as shown on schematic diagram MECH10-01. Pay close attention to the proper orientation of polarized components (transistors and capacitors in this lab).
2. Connect the circuit to the +5 V power supply. Connect the circuit ground to the trainer ground bus.
3. SDG Verify that the LED's alternate on-off. ***Have the instructor or lab assistant witness your functioning circuit and sign your lab handout.***
4. ***Calculate and record*** the expected oscillation frequency using the ***frequency*** formula in the Formulas section of this lab assignment. 1.418 Hz
5. ***Measure and record*** the number of flashes of one LED over a 30-second period. 37 **Cycles**
6. ***Calculate and record*** the number of flashes per second 1.2 **Hertz.** This is your measured value.
7. ***Calculate and record*** the expected value using the formula on the next page. 1.418Hz
8. Calculate and record the percent error between expected and measured frequency using the ***%Error*** formula below. 15.37 % Error

Formulas

$$\%Error = \frac{measured - expected}{expected} x100\%$$

Where;
%Error = % change between measured and expected values
measured = a value taken from direct measurement
expected = a value taken from component or process specifications

$$f = \frac{1}{RC}$$

Where;
f = frequency (Hertz)
R = circuit resistance (Ohms)
C = circuit capacitance (Farads)

Conclusions

a) Write a ***problem statement***, composed of grammatically correct and complete sentences that summarize one operational failure of the circuit, trainer or test equipment. The problem statement must answer the following questions;
   a. **Expected operation** – what is the expected operation of the circuit?
   b. **Failure conditions** – what were the conditions at the time of the failure?
   c. **Failure time frame** – when does the equipment or system fail? Is the failure correlated to a specific time frame?
   d. **Failure indicator** – what components or test equipment demonstrated the operational failure? How did the circuit fail to meet operational requirements?

b) Select and include two critical thinking skills from the list provided that support the creation of an effective problem statement.

Example Problem Statement

Expected operation – The circuit is expected to produce a square wave output with an amplitude of 5 volts and a frequency of 1 kHz.
Failure conditions – The circuit was constructed on a solderless breadboard with 15 volts DC applied across the circuit.
Failure time frame – The circuit initially produces the expected output, but then fails after a few minutes of operation.
Failure indicators – The failure was noted through observation of the output waveform with an oscilloscope. The output square wave changed from an amplitude of 5 volts to zero volts indicating the failure.

Key Critical Thinking Skills

1	Summarize the pattern of results in a graph without making inappropriate inferences
2	Evaluate how strongly correlation-type data supports a hypothesis
3	Provide alternative explanations for a pattern of results that has many possible causes
4	Identify additional information needed to evaluate a hypothesis/interpretation
5	Evaluate whether spurious relationships strongly support a claim
6	Provide alternative explanations for spurious relationships
8	Determine whether an invited inference in an advertisement is supported by information
9	Provide relevant alternative interpretations of information
10	Separate relevant from irrelevant information when solving a real-world problem
11	Analyze and integrate information from separate sources to solve a real-world problem
12	Use basic mathematical skills to help solve a real-world problem
13	Identify suitable solutions for a real-world problem using relevant information
14	Identify and explain the best solution for a real-world problem using relevant information
15	Explain how changes in a real-world problem situation might affect the solution
16	Deduce conclusions from information or evidence
17	Interpret viability of conclusions, using evidence
18	Evaluate evidence or authority
19	Reframe problems, questions, issues

1. Identify which critical thinking skills are *most* important for your students
2. Of these, which is hardest to achieve?
3. Identify 1-2 strategies for incorporating important skills into your teaching.

Grading Criteria

		Points Possible	Points Earned
Documentation	Abstract, introduction, experiment, data results, conclusions, attachments, clarity, spelling, grammar	**10**	
Circuit Function	Circuit function verified (signature required)	**5**	
Calculations	Expected and measured frequency recorded, percent error accurate	**5**	
Conclusions	Problem statement meets the criteria illustrated above, critical thinking skills identified	**10**	
On-time submittal	Lab report is submitted in accordance with the assignment due date as posted on Canvas	**5**	
	Total	**35**	

Lab Report Format

Abstract - a summary and high-level overview of the lab and its results
Introduction - State the objectives of the laboratory and list the equipment required
Experiment - Describe the procedure used to carry out the lab
Data Results - list data taken in table or graphical format where appropriate
Conclusion - State the conclusions drawn and lessons learned from the laboratory activities. Answer any questions found within the lab procedure.
Attachments – grading criteria, verification signatures, circuit diagrams, lab procedures & notes