

Astable Multivibrator

1. Introduction

The student will analyze and construct an astable multivibrator. The circuit will be simulated using nominal component values selected by the student to provide for specific operations. The circuit component parameters will be measured and theoretical calculations of the multivibrator's performance will be made. The multivibrator will be constructed to observe actual performance.

2. Background

A multivibrator is an electronic circuit used to implement a variety of simple two-state systems such as oscillators, timers and flip flops (*e.g a clock signal*). An astable multivibrator has two states, neither one stable. The circuit therefore behaves as an oscillator with the time spent in each state controlled by the charging or discharging of a capacitor through a resistor.

The astable multivibrator may be created directly with transistors or with the use of integrated circuits such as operational amplifiers (op amps) or the 555 timer. Most operational amplifiers are powered by a positive and negative rail voltage—the output is never able to exceed these rail voltages. An example circuit is shown in Figure 1. Depending upon the initial conditions, the op amp's output will be driven to either the positive or negative rail. Upon this occurrence, the capacitor will either charge or discharge through resistor R_2 (its voltage slowly rising or falling). As soon as the voltage at the op amp's inverting terminal is equal to the voltage at the non-inverting terminal (the op amp's output voltage divided between R_1 and R_2), the output will be driven to the opposing rail. This process then repeats with the capacitor discharging if it had previously charged and vice versa. Once the inverting terminal reaches the voltage of the non-inverting terminal, the output again is driven to the opposing rail voltage and the cycle begins again. Thus, the astable multivibrator creates a square wave with no inputs. The period of the astable multivibrator displayed in Figure 1 is:

$$T = 2C_1R_3 \ln\left(1 + 2\frac{R_2}{R_1}\right)$$

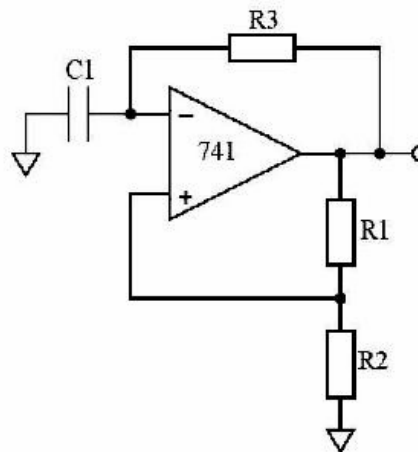


Figure 1: Astable Multivibrator

3. Prelab: Theoretical Procedure

Fill in Table 1 and the value for R_3 in Table 2 with the appropriate values for the circuit in Figure 1 to produce a 250 Hz square wave. Before you begin lab, obtain your instructor's signature for these values.

4. Experimental Procedure

4.1. Equipment

- Tektronix TDS 3012B Digital Phosphor Oscilloscope
- Agilent 33120A Waveform Generator
- Agilent E3631A DC Power Supply
- Fluke 8050A Digital MultiMeter (DMM)
- Resistors, Capacitors, and LM/μA741 Op Amps as Needed

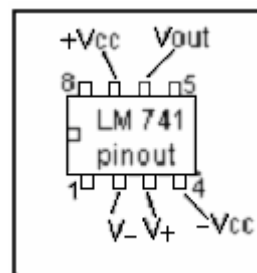


Figure 2:
LM741 Pin Layout

4.2. Procedure

With the parts available in lab, select resistors and capacitors with nominal values that are as close to your theoretical calculations as possible. Measure each of the resistors and the capacitor (with the LCR meter) and **record the measured values in Table 2.** Lastly, recalculate the frequency with your measured values and **record this value in Table 2.**

Construct the astable multivibrator displayed in Figure 1 using a 741 operational amplifier and the components selected in the theoretical procedure (prelab).

The operational amplifier should be powered with rail voltages of +/- 12 Volts using the DC power supply. Set the power supply before connecting to the operational amplifier. Do not connect the DC power supply to the circuit with the current on. Turn the power on and observe the operation of the multivibrator. **Record the amplitude and frequency of the square wave in Table 3.**

Save the oscilloscope screenshot for use in your lab report. Obtain your instructor's signature for the oscilloscope display.

5. Simulated Procedure

Construct a PSpice[®] schematic of the astable multivibrator displayed in Figure 1 using your measured component values and the "op amp" part—set the rail voltage of the op amp to those used in lab. Set the initial condition (IC) of the capacitor to 0.001 Volts.

Double-click on the wire connecting the capacitor to the negative terminal of the op amp and enter an appropriate label. Repeat this for the output of the op amp, also. Simulate the astable multivibrator in transient (time-domain) mode and add traces of both the

output and the capacitor voltages. **Record the amplitude and the frequency of the square wave in Table 4.**

Save a schematic screenshot and a screenshot of the transient analysis for display in lab report.

Modify the initial condition of the capacitor to -0.001 volts. Simulate the astable multivibrator in transient mode and add traces of both the output and capacitor voltages. **Record the amplitude and the frequency of the square wave in Table 5.**

Save a screenshot of the transient analysis for use in the lab report.

6. Conclusions

This concludes the lab. Make sure to return all components to their appropriate bins and in your lab report, answer the following questions:

1. In your report, refer to your recorded values of frequency and amplitude for the theoretical, experimental and simulated portions of the lab and describe any distinctions between the theoretical, experimental and simulated results.
2. What differences can be noticed between the experimental and simulation waveforms? Think in terms of the wave shape, noise, rise and fall times, etc.
3. What difference is noticed in the transient analysis when the initial condition of the capacitor is modified slightly to a negative voltage? Why does this change occur?
4. What could have affected the initial condition of your experimental circuit, assuming that the capacitor had no initial charge across it?
5. Using the knowledge from the second Op Amp lab, what could be added to Figure 1 to generate a triangular waveform? Draw an appropriate schematic for the circuit to achieve this (you do not need to give components specific values).

Data Entry and Lab Instructor Signature Page

Attach this page to your write-up.

Table 1: Values for the Astable Multivibrator (Prelab)

Value	Freq. (Hz)	Period (sec)	Amplitude (VPP)	+/- Vcc (V)
Theoretical	250			+/- 12

Table 2: Values for the Astable Multivibrator (Prelab + Beginning of Lab)

Value	Freq. (Hz)	R ₁ (Ω)	R ₂ (Ω)	R ₃ (Ω)	C (F)
Theoretical	250	10 k	100 k		0.1 μ
Measured					

Signature for Prelab Values _____

Table 3: Measured Values for the Astable Multivibrator

Amplitude (VPP)	Frequency (kHz)

Signature for 4.2. – Astable Multivibrator Output _____

Table 4: PSpice® Simulations, $V_c(t = 0) = 0.001$ V

Amplitude (VPP)	Frequency (kHz)

Table 5: PSpice® Simulations, $V_c(t = 0) = -0.001$ V

Amplitude (VPP)	Frequency (kHz)