ECE214: Electrical Circuits Laboratory

Lab #9 — Astable Multivibrator

Week of 7 April 2015

1 Introduction

This is the second of three labs that will culminate in a circuit that will convert a 9 Volt DC source into a 45 Volt DC source. In this lab you will design, simulate, build and test an astable multivibrator oscillator that will be used to drive the boost circuit you built in Lab 8.

2 Pre-Lab

A basic astable multivibrator oscillator circuit is shown in Figure 1.

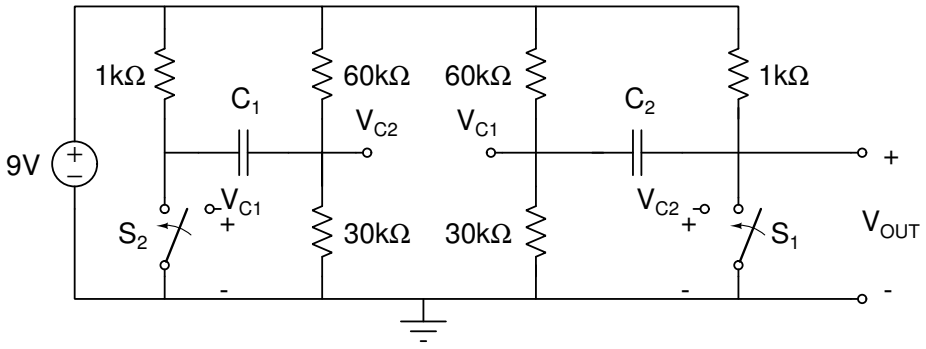

Figure 1: A basic astable multivibrator circuit.

1. For this circuit, assume the switches are closed when the control voltage is > 2 V and open when the control voltage is < 2 V. Analyze this circuit. Explain the function of this circuit and describe how it works. Reference the description in the table of contents of your laboratory notebook.

2. Derive an equation describing the frequency of the output as a function of the component values. Reference the equation in the table of contents of your laboratory notebook.

3. If $C_1 = C_2 = 0.1\mu F$, what is the expected output frequency?

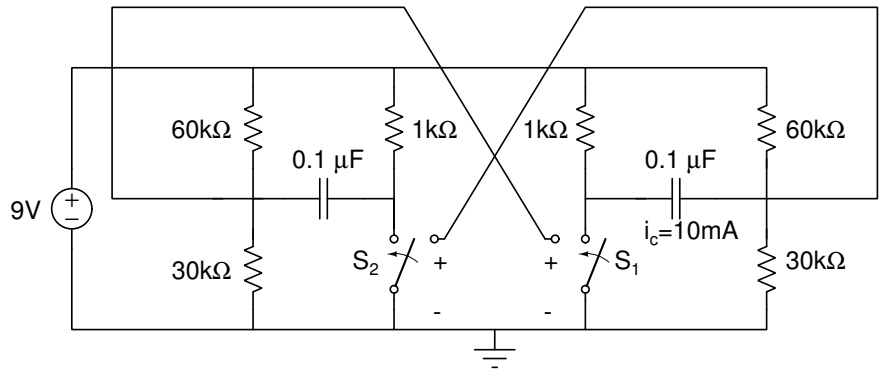

Figure 2: Astable multivibrator Micro-Cap test circuit.

4. Use Micro-Cap to analyze the operation of this circuit using the test circuit shown in Figure 2.
   For the voltage-controlled switch (V-Switch), set the resistance of the switch to 1Ω when the switch is closed and set $V_{on} = 2.1V$ and $V_{off} = 2.0V$.
   Make sure to include the indicated initial conditions on the capacitors.

5. Does the circuit oscillate at the frequency predicted above? If not, explain the discrepancy.

6. Plot the voltage at each end of one of the capacitors with respect to ground (it does not matter which capacitor you choose).
   Are the voltages the same for each capacitor?
   Include this plot in your notebook for later comparison with your lab measurements.

3 Lab Procedure

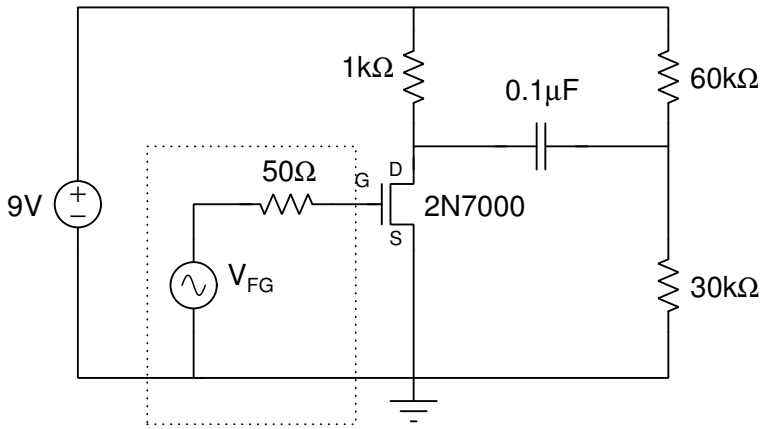

Figure 3: Multivibrator half-circuit to build.

1. Build the multivibrator half-circuit circuit shown in Figure 3.

2. Set the function generator to produce a triangular wave with a peak voltage of 5 volts and a frequency equal to what you found in the pre-lab. Use the scope to watch the voltage at the gate of the MOSFET and at the drain of the MOSFET. Adjust the DC offset of the function generator until the signal at the

drain looks like your pre-lab plot.
At what gate voltage does the MOSFET turn-on?
At what gate voltage does it turn-off?
Record these values in your notebook.

3. Examine the voltage across the $30K\Omega$ resistor. How does it compare with the simulation results from the pre-lab?

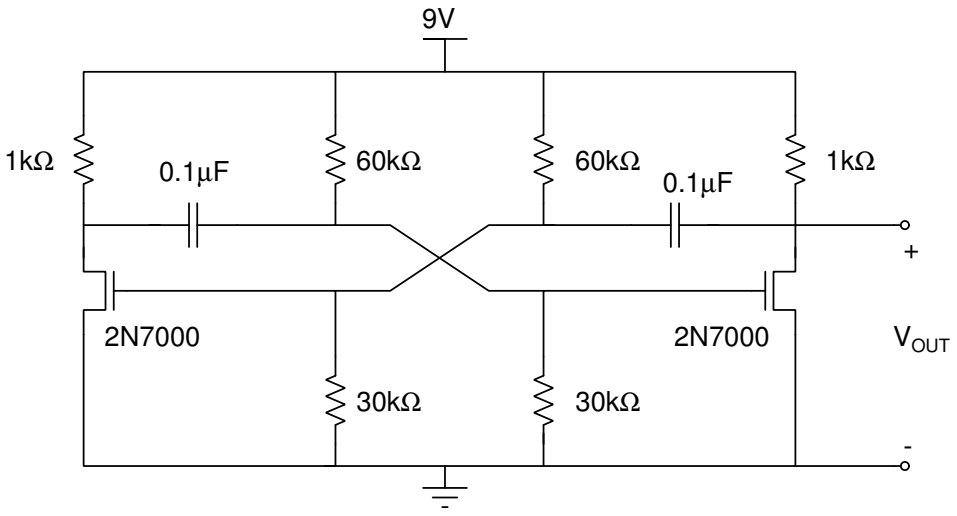

Figure 4: Full astable multivibrator circuit to build.

4. Expand your half-circuit to be the full astable multivibrator circuit as shown in Figure 4. This is the complete multivibrator circuit and it should oscillate when the power is supplied.

5. Measure the frequency of the output waveform. How does the previous simulated frequency compare to the measured frequency? Explain any discrepancy in your notebook.

6. In your Micro-Cap test circuit, change the turn-on voltage of the voltage controlled switch to match the measured turn-on voltage for the transistors.

7. Simulate the modified Micro-Cap test circuit. How does the simulated frequency now compare to the measured frequency? Explain any discrepancy in your notebook.

8. The multivibrator circuit will be used to drive the boost-circuit you built and tested in Lab 8.
   Modify the design of the multivibrator to match the best frequency and duty cycle determined in Lab 8. This is best accomplished by keeping the resistor values constant and adjusting the capacitance values C_1 and C_2 shown in Figure 5.

   The values of the capacitors determine the frequency while the ratio of the capacitors determine the duty cycle. Use hand-calculations, verified by Micro-Cap simulations, to determine the values of C_1 and C_2 so that:

   (a) Output frequency matches the frequency found in Lab 8 needed to produce a 20 V output for your boost-circuit.

   (b) Output duty cycle matches the duty cycle found in Lab 8 needed to produce a 20 V output for your boost-circuit.

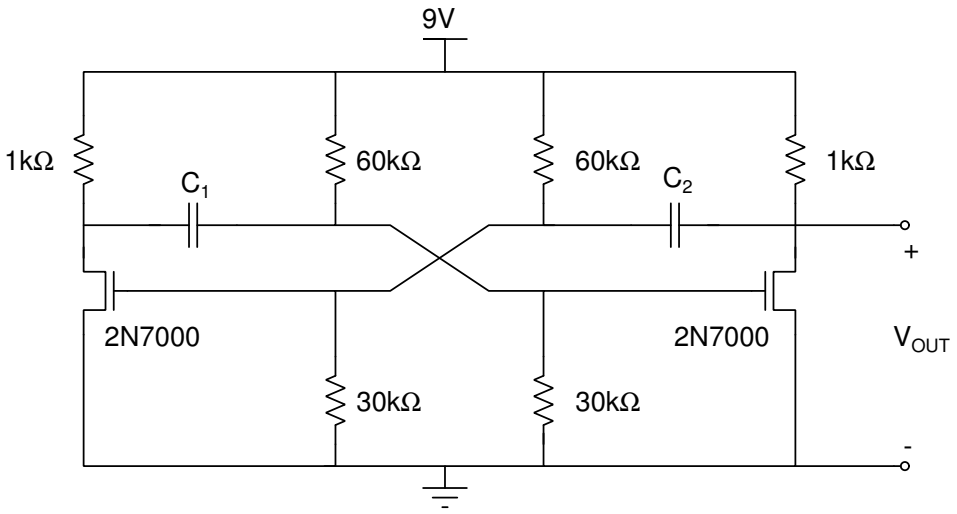

Figure 5: Astable multivibrator circuit with custom capacitors.

Record the final capacitance values and include a photograph of the output waveform from the oscilloscope in your lab notebook. Create a reference for this information in the table of contents. Do not disassemble the multivibrator circuit. In Lab 10 you will attach the multivibrator circuit to the boost circuit from Lab 8 and add a second boost-circuit to increase the output voltage to 45 V.

4 Post-Lab

None, but your final results will be looked at as part of the post-lab grading.