ECE 214 - Lab #9 — Astable Multivibrator

11 April 2017

Introduction: In this lab, you will design, simulate, build, and test an astable multivibrator oscillator. This is an alternative oscillator to Schmitt trigger – inverting integrator oscillator that was built in Lab #5.

Pre Lab:

The basic astable multivibrator oscillator circuit using ideal switches is shown in Figure 1.

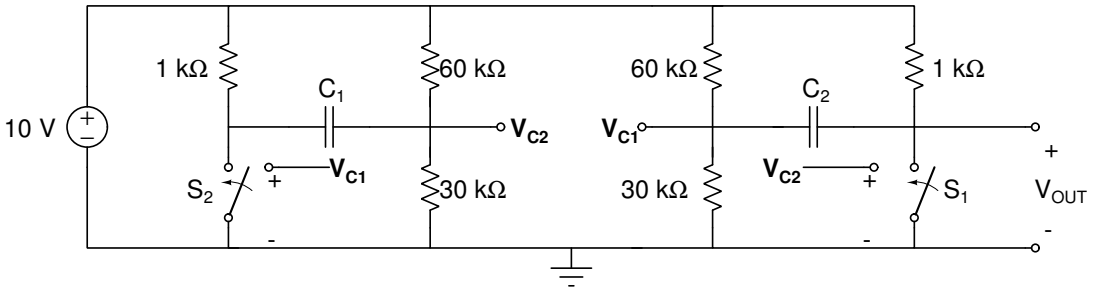

Figure 1: Astable multivibrator circuit using ideal switches.

1. Assume the voltage-controlled switches (S_1 and S_2) are closed when their control voltages (V_{C2} and V_{C1}) are > 2.2 V and open when their control voltage are < 2.2 V. Analyze this circuit and explain how it works.

2. Derive an equation for the frequency at the output as a function of the capacitors C_1 and C_2.

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

4. Use NGspice to analyze the operation of this circuit. Replace the ideal switches with 2N7000 NMOS transistors as shown in Figure 2. The NMOS transistor acts as a voltage controlled switch. In a NMOS transistor, current only flows between the drain (D) terminal and the source (S) terminal. When the voltage (V_{GS}) between the gate (G) and the source (S) is greater than the threshold voltage (V_t), the D and S terminals are shorted; when $V_{GS} < V_t$, the D and S terminals are open.

5. Plot the output voltage as a function of time? What is the oscillation frequency and voltage swing of the simulated output signal? Does the simulated circuit oscillate at the frequency predicted above in step 3?

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 at each end of the capacitor? Record the simulation results in your notebook to compare with what you will measure in lab.

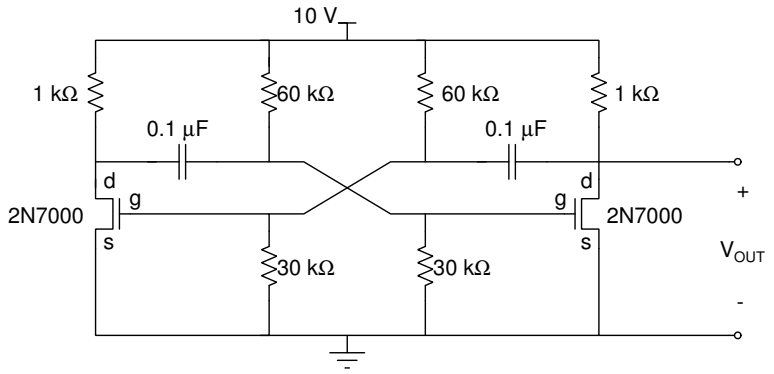

Figure 2: Astable multivibrator circuit of Figure 1 with 2N7000 transistors used as voltage-controlled switches.

Lab Procedure:

1. Build the multivibrator half–circuit circuit shown in Figure 3.
2. Set the function generator to produce a triangular wave with a voltage from 0 to 5 volts and a frequency equal to that found in step 5 of the Pre Lab. Use the scope to watch the voltage at the gate (G) and the drain (D) of the 2N7000 transistor. At what gate voltage does the transistor turn-on and turn-off?
3. Examine the voltage at each end of the capacitor with respect to ground. How do these voltages compare with the simulation results from step 6 in the Pre Lab?
4. Build the full astable multivibrator circuit shown in Figure 2. This circuit should oscillate when power is supplied.
5. Measure the frequency and voltage swing of the output waveform. How do these compare to the simulated results? Explain and discrepancy in your notebook.
6. Modify the oscillator to produce the frequency and the duty cycle needed for the boost converter #2 designed 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 3. The values of the capacitors determine the frequency while the ratio of the capacitors determine the duty

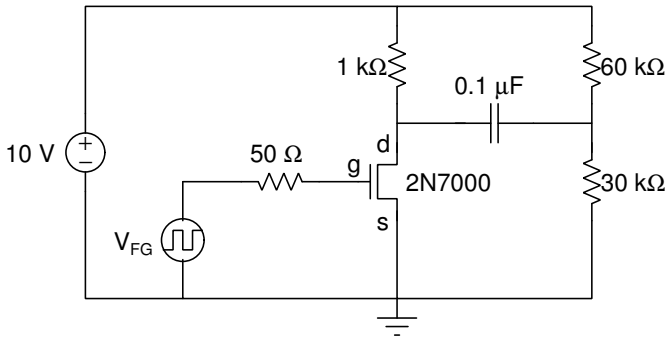

Figure 3: Multivibrator half–circuit.

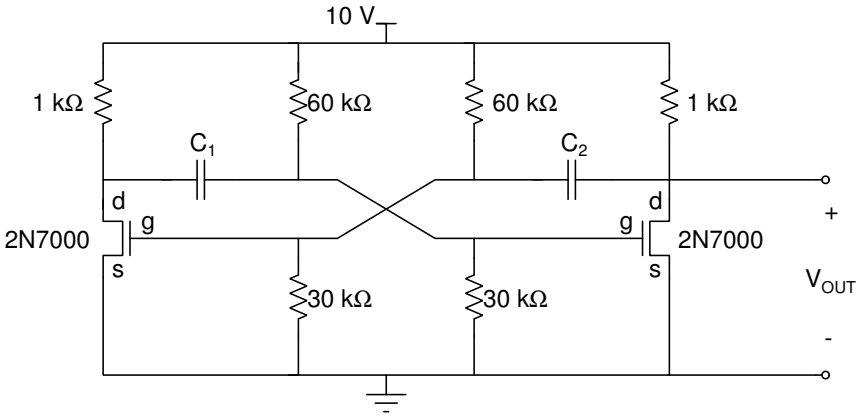

Figure 4: Astable multivibrator circuit.

cycle. Use hand–calculations, verified by NGspice simulations, to determine the values of C_1 and C_2 so that:

(a) the output frequency matches the frequency found in Lab #8 to produce a 25 ± 1 V output for your boost–converter, and

(b) the output duty cycle matches the duty cycle found in Lab #8 to produce a 25 ± 1 V output for your boost–converter.

7. Use the astable multivibrator circuit to drive the boost–converter circuit you built and tested in Lab #8.

8. Record the final capacitance values and a photograph of the output waveform from the oscilloscope in your lab notebook. Create a reference for this information in the table of contents.

9. Do not disassemble the astable multivibrator circuit. You can use the oscillator again as part of Lab #10.

Post Lab:

1. Use NGspice to simulate your final astable multivibrator design using the measured values of the components you used in lab. Plot the output voltage as a function of time. Calculate the frequency, duty cycle, and voltage swing.

2. Compare the simulated results to the measurements you made in lab.

3. Reference this Post Lab in the table of contents of your notebook.