## ECE 214 - Lab #8 — Astable Multivibrator

3 April 2018

**Introduction:** In this lab, you will design, simulate, build, and test an astable multivibrator oscillator. This is an alternative oscillator to the 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.

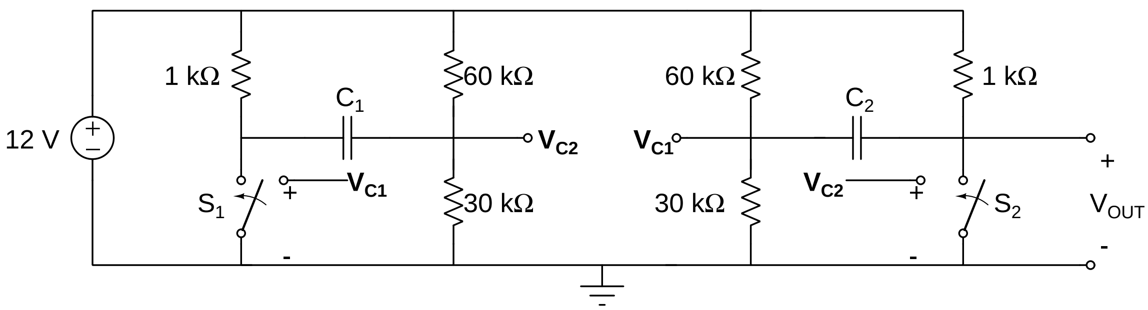


Figure 1: Astable multivibrator circuit using ideal switches.

1. Assume the voltage-controlled switches ($S_1$ and $S_2$) are closed when the control voltages ($V_{C1}$ and $V_{C2}$) are $> 2.2$ V, and open when the control voltages 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 $C_1 = C_2 = 0.1\ \mu$F, 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 flows between the drain (D) terminal and the source (S) terminal when the gate (G) to source (S) voltage ($V_{GS}$) is greater than the threshold voltage ($V_t$) of the transistor; Under this condition, the D and S terminals are shorted together. No current flows between the drain (D) terminal and the source (S) terminal when $V_{GS} < V_t$; Under this condition, the D and S terminals are isolated from each other.

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 capacitor as a function of time. It does not matter which capacitor you choose. Record the simulation results in your notebook to compare with what you will measure in lab.

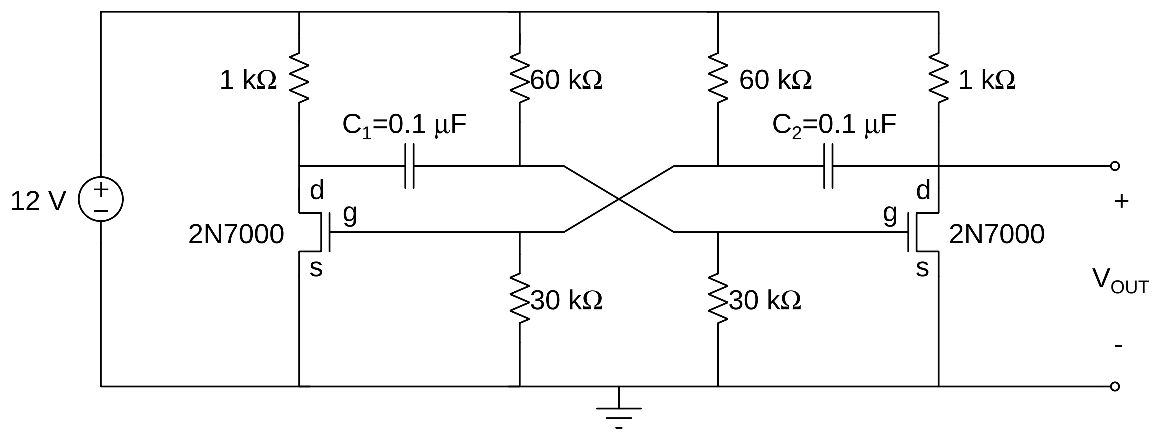


Figure 2: Astable multivibrator circuit of Figure 1 with 2N7000 transistors used as voltage-controlled switches.

**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. Determine the gate voltage that causes the transistor to turn-on and off. Try and find two transistors that have approximately the same switching voltage.
3. Build the full astable multivibrator circuit shown in Figure 2. This circuit should oscillate when power is supplied.
4. Measure the frequency and voltage swing of the output waveform. How do these compare to the simulated results? Explain and discrepancy in your notebook.
5. Examine the voltage at each end of the capacitor with respect to ground. How do these voltages compare with the simulation results in step 6 in the Pre-Lab?

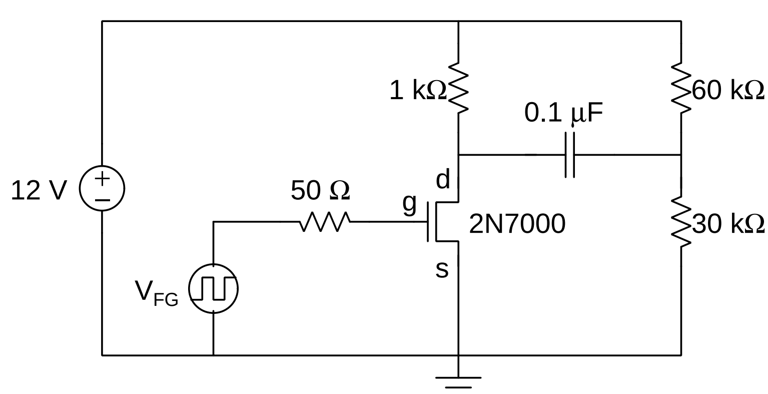


Figure 3: Multivibrator half–circuit.

6. Modify the oscillator to produce the frequency and the duty cycle needed for the boost converter designed in Lab #7. This is best accomplished by keeping the resistor values constant and adjusting the capacitance values $C_1$ and $C_2$. The average value of the capacitors determine the frequency while the ratio of the capacitors determine the duty cycle. Use hand-calculations, verified by NGspice simulations, to determine the values of $\mathrm{C}_1$ and $\mathrm{C}_2$ such that:
   (a) the frequency of the multivibrator circuit matches the frequency needed in Lab #7 to produce a $25 \pm 0.3$ $\mathrm{V}_{\mathrm{DC}}$ output voltage from the boost–converter, and
   (b) the duty cycle of the multivibrator circuit matches the duty cycle needed in Lab #7 to produce a $25 \pm 0.3$ $\mathrm{V}_{\mathrm{DC}}$ output voltage from the boost–converter.
7. Record the final capacitance values and a photograph of the output waveform from the oscilloscope in your lab notebook.
8. Do not disassemble the astable multivibrator circuit. You can use the oscillator again as part of Lab #9.

**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. Determine 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.