ECE 214 - Lab #5 — Oscillator Design

21 February 2017

Introduction: Two TL082 Operational Amplifiers (OpAmps) are used to produce an oscillator. The oscillator is formed by connecting the output of a Schmitt trigger to the input of an inverting integrator, and connecting the output of the inverting integrator back to the input of the Schmitt trigger. A block diagram is shown in Figure 1 and the oscillator circuit is shown in Figure 2.

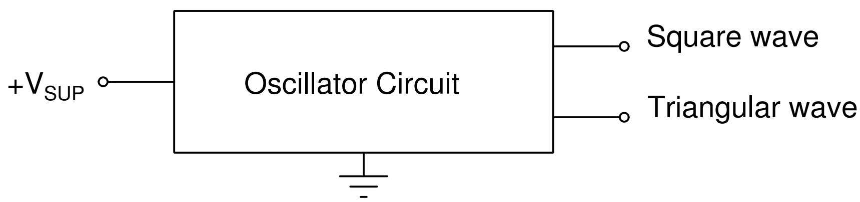

Figure 1: Block diagram of the oscillator circuit.

Specification:

1. Input: $+V_{SUP} = 10$ V DC
2. Outputs:
   (a) Square wave and triangular wave
   (b) Frequency $= 4.0 \pm 0.3$ kHz
   (c) Duty cycle $= 50 \pm 3\%$

Pre Lab:

1. Explain how the circuit in Figure 2 functions and sketch the shape of the expected output signals V_{OUT_1} and V_{OUT_2} as a function of time.

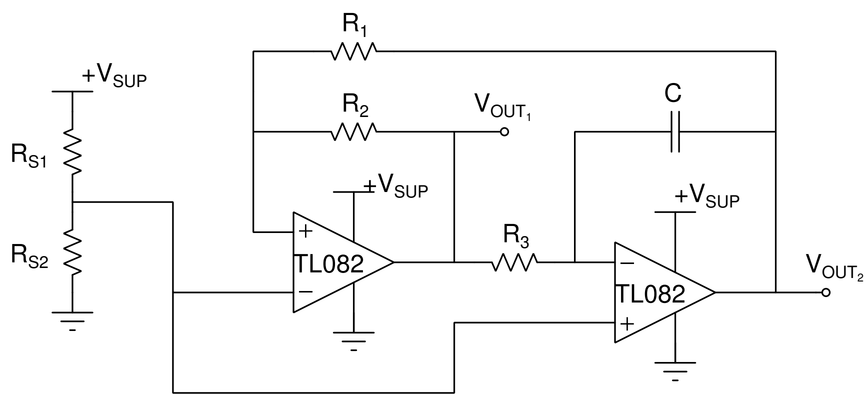

Figure 2: Oscillator circuit using a Schmitt trigger and an inverting integrator.

2. Assume the OpAmps are ideal. Derive the formula that relates the oscillation frequency to the values of the components R_1, R_2, R_3, and C. Make sure the formula and derivation are recorded in your notebook and there is an entry in the table of contents indicating the page where the derivation and formula are located.

3. Let $C = 0.1\,\mu F$, $+V_{SUP} = 10$ V, and $R_{S1} = R_{S2} = 10$ kΩ. Use the formula from step 2 and the value R_1 and R_2 determined in Lab #4, Lab Procedure Step 19(d), to determine the value of R_3 needed to produce an oscillation frequency of 4 kHz.

4. Use NGspice to simulate the circuit of Figure 2 with the TL082 OpAmp. What is the simulated value of the oscillation frequency? What is the duty cycle?

5. Since the TL082 OpAmp is not ideal, the value of R_3 you calculated will be slightly off. Adjust the value of R_3, if needed, to produce an oscillation frequency of 4 kHz.

6. Since the saturation voltages of the TL082 are not 0 V and 10 V, the duty cycle of the waveform will not be 50%. Adjust the ratio of R_{S1} to R_{S2} to produce a $50 \pm 3\%$ duty cycle. You may have to adjust the value of R_3 to keep the frequency in the range of 4 ± 0.3 kHz.

Lab Procedure:

Build the oscillator circuit in Figure 3 using the component values you determined in the Pre Lab. Set the potentiometer (variable resistor) near the mid-point resistance so that $R_{S1} = R_{S2}$.

1. Measure V_{OUT_1} and V_{OUT_2} on the scope. Are the frequency and duty cycle what you expected? Include a sketch or photograph of V_{OUT_1} and V_{OUT_2} in your notebook.

2. Use the FFT function of the scope to examine the output signal in the frequency domain. Include a sketch or photograph of the frequency response of V_{OUT_1} and V_{OUT_2} in your notebook.

3. Do you observe both even and odd harmonics in the frequency spectrum? If so, your duty cycle $\neq 50\%$. The duty cycle can be adjusted by changing the DC reference voltage at the non-inverting terminal of the inverting integrator using the variable resistor. Adjust the DC reference voltage while observing the FFT signal on the scope. Determine the values of R_{S1} and R_{S2} that minimize the even harmonics. Compare the ratio of R_{S1} and R_{S2} to the simulated value from step 6 of the Pre Lab.

4. This oscillator circuit should generate a 4 ± 0.3 kHz output signal. Redesign the circuit if necessary to meet this specification. What was the final value of resistor R_3?

5. Record your final output spectrum in your notebook.

6. Measure the magnitude of the first five harmonics for both the triangular– and square–wave outputs and compare these results to the theoretical values based on the coefficients of the Fourier series. Record the results in a table in your notebook. Reference this table in your table of contents.

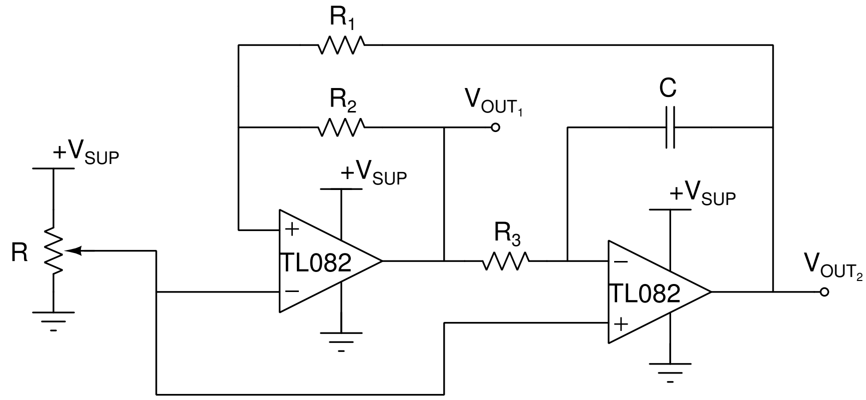

Figure 3: Oscillator with variable resistor to adjust the duty cycle.

Post Lab:

Summarize your simulation and experimental results. Compare the performance of the simulated design with the actual design. How did the final component values of the actual design compare with the simulated design. Did the simulation provide you with a good prediction of the actual circuit performance?