Lab # 6: Oscillators

Background preparation

- Wien bridge oscillator: AOE, 7.1.5 B
- Phase-shift oscillator: AOE, 7.1.5 C

Note: remember that the solderless breadboards can have ~ nF capacitances between neighbouring sockets. You are welcome to implement your circuits on a solderable breadboard if you prefer.

Wien bridge oscillator

a) Construct just the Wien bridge shown in Figure 1. In Figure 1, the input of the bridge is the node shown connected to the opamp’s output terminal, and the output of the bridge is the node connected to the non-inverting terminal of the opamp. Measure the frequency $f_0$ at which the phase shift through the Wien bridge is zero. To do this, you may find it useful to display both the input and output sinusoidal waveforms on the scope simultaneously, and adjust the frequency until the zero crossings line up exactly on both the waveforms. Measure the attenuation, $\beta(f) = \left| \frac{V_{\text{out}}(f)}{V_{\text{in}}(f)} \right|$, at the frequency $f_0$.

b) Construct the oscillator as shown in Figure 1. You may need to solder some wires onto the lamp. The bridge is on the positive feedback path, and it feeds a non-inverting amplifier. Adjust the value of the feedback resistance until you obtain a stable sinusoidal signal. Measure the oscillation frequency $f_W$, and estimate the gain of the non-inverting amplifier at the point where stable oscillations are obtained. Comment on whether these measurements are consistent with the loop gain required for an oscillator.

c) Calculate the power spectrum of the output of the oscillator, using the scope and the power spectrum code from the course webpage. Observe all the frequency components contained in the power spectrum, and comment on whether the output is a “clean” sine wave. You may need to increase the sample length of the data trace acquired from the scope, in order to obtain good frequency resolution.

d) Replace the lamp with a fixed resistor, whose value is equal to the disconnected lamp’s resistance. What happens to the oscillations? Comment on the purpose of the lamp.

(60 mins)
Phase-shift oscillator

a) Construct the cascaded high-pass filter shown in Figure 2. Measure the frequency \( f_\pi \) at which the phase shift through the filter is 180°. Measure the attenuation through the filter, \( \beta(f) = \left| \frac{V_{out}(f)}{V_{in}(f)} \right| \), at the frequency \( f_\pi \).

b) Construct the oscillator as shown in Figure 2. The filter is on the negative feedback path, and it feeds into an inverting amplifier. Build the inverting amplifier with a potentiometer on the feedback path. Adjust the potentiometer until you observe a steady oscillation. Measure the oscillation frequency \( f_P \), and comment on whether it makes sense.

c) Calculate the power spectrum of the output of the oscillator, and again comment on whether the output frequency is sharply defined. How does this oscillator compare to the Wien bridge oscillator?

Remember: The frequency resolution of the calculated power spectrum depends on the length of the trace that you use to calculate it. Make sure that you have a sufficiently long trace to be able to study the spectrum of the oscillator in sufficient detail.

(60 mins)

Design problem

a) You are given a series LCR filter with \( L = 1 \, \mu\text{H}, C = 1 \, \mu\text{F}, R = 100 \, \Omega \). Design an oscillator using this filter and an opamp, and calculate the resonance frequency. Test if your design works in Qucs.
Figure 2: The cascaded high-pass filters are highlighted in the circuit. Try using $R \sim 1 \text{k}\Omega$, $C \sim 100 \text{nF}$, $R_1 \sim 1 \text{k}\Omega$. Pick a value for the potentiometer $R_{fb}$ in the feedback path based on the attenuation $\beta$ that you measured for the filter.

(40 mins)