This lab introduces the characterization of a bulb as a transducer between the electrical and thermal domains. Specifically, you will measure the $v_i$ curve of the tungsten filament in an incandescent bulb.

1. The thermal time constant of the filament is on the order of 10 s, which corresponds to a frequency of 0.1 Hz. Build an oscillator to sweep the voltage across the bulb at a frequency about ten times slower to insure the filament reaches steady state. You probably need to make the resistance of the RC network a fixed, large value. Keep the 10 kΩ pot as the divider for the Schmitt trigger. Since you want to sweep the voltage, you don’t want a square wave. Use the capacitor voltage instead. However, you will need an OPA551 buffer to provide the necessary current and avoid loading the oscillator.

2. Connect a resistor in series with the bulb to measure both the voltage across and the current through the bulb. Measure the resistance of the bulb using a multimeter (by itself, before connecting to the circuit). Use this value to choose an appropriate resistance to measure the $v_i$ curve up to 4 V with an appropriate sensitivity. However, note that the resistance will change when the bulb gets hot, so you will need to adjust your resistance accordingly. Check the power dissipated on the resistor!

3. Verify that your $v_i$ curve agrees with the resistance you measured using the multimeter. Where should you look and why?

4. The thermal coefficient $\alpha$ of tungsten is 0.0044. Use your $v_i$ curve to estimate the resistance of the filament at 4 V and the temperature of the filament. Google black body radiation, and verify that your answer is reasonable.

5. Repeat your measurement at a frequency of 0.1 Hz, close to the thermal time constant. Explain concisely your new curve.