# Homework #4 Solution (Temperature Controller)

You're given the same oven from the previous homework. The heater is controlled by a solid state relay (SSR). The relay is designed to turn on with 5V and draw about 10mA. You are given a **5V power supply** that can provide up to 100mA. A **LM35 temperature sensor** is mounted in the oven and when powered provides a **10mV/C output** (i.e. the output is 100mV@10C, 200mV@20C, etc).

Complete the design to keep the oven at 50C. Since this is above room temperature you want to turn on the heater when the oven is below 50C.

Hint: Remember that **the LM311 has an open collector output**. Look at the example in the datasheet of the LM311 connected to a relay. Once you have the circuit figured out on scratch paper print this page and complete the circuit. **List all resistor values** (and don't forget the power supply decoupling caps). **Show all power and ground connections**. Lastly add a sentence or two explaining how the circuit works.
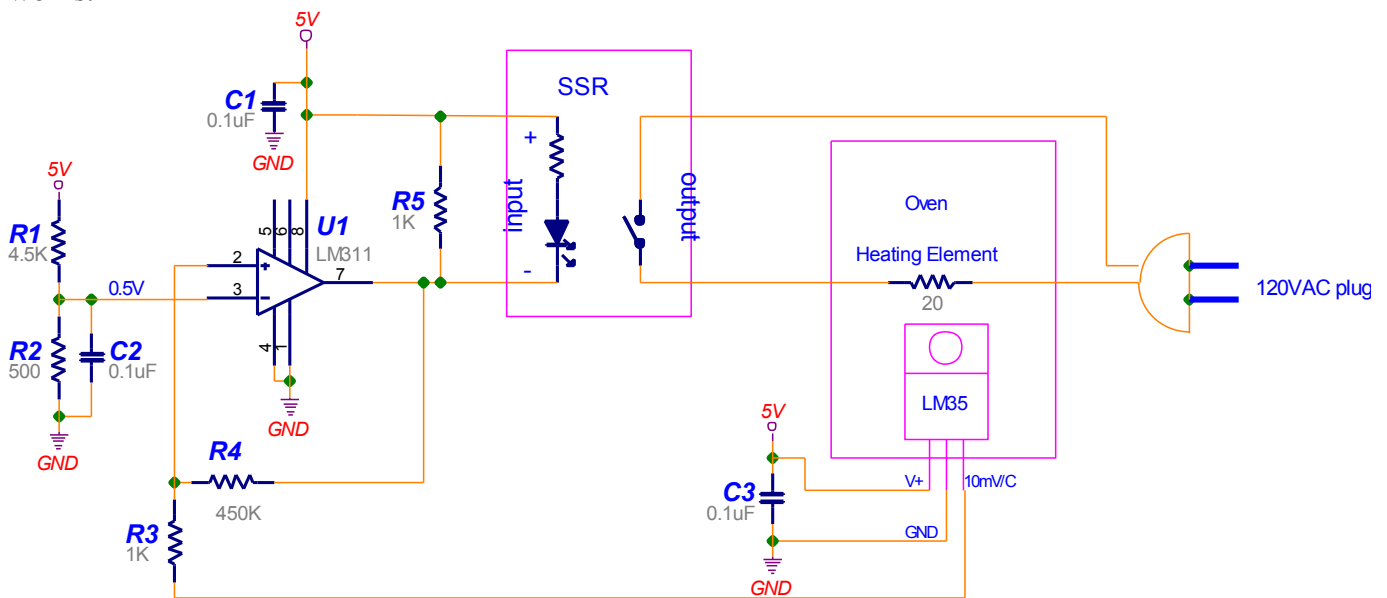
When the oven is <50C the output of the LM35 is <0.5V thus the comparator + input is less than the - input and its output is low. When the comparator goes low the SSR turns on (5V at the SSR + input and about 0V at the SSR – input). This turns on the heater and increases the temperature. Once the oven goes above 50C the LM35 output will be >0.5V and the comparator output will go high (i.e. no current flows through the SSR).

Note: R4 & R5 could be removed and R3 shorted if hysteresis isn't desired. 1/450th of the difference between the output and input is feed back [(5V-0.5V)/450 = 10mV = (1 degree C)]. Note: an SSR won't be damaged by turning on and off continuously as a mechanical relay would be (but if the SSR isn't a zero crossing relay than unnecessary harmonics would be generated if the output oscillates).

Note: It would be better to use a stable voltage reference to provide the 0.5V (50C) to the comparator rather than using the 5V supply. The 5V output may drift with temperature, load, etc.