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@10°C, 200mV@20°C, etc).

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

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 <50°C 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 50°C 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 (50°C) to the comparator rather than using the 5V supply. The 5V output may drift with temperature, load, etc.