UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE
Department of Electrical and Computer Engineering

EXPERIMENT 3 – THE SUMMING AMPLIFIER AND ITS APPLICATIONS

OBJECTIVES

The purpose of this experiment is to introduce the op-amp summing amplifier and two of its applications, D/A conversion and temperature sensing.

INTRODUCTION

The simple summing amplifier (shown in Figure 3-1) is capable of summing as many signals as desired with a proportionality determined by the ratio of feedback resistance to input resistance. The inputs can be any combination of AC and DC signals; however, as with op-amp circuits previously investigated, such limitations as frequency response, slew rate, offset voltage and output voltage range must be considered when predicting the output signal. Clearly, the summing amplifier can be applied in most situations where it is required that the output signal be a weighted sum of multiple inputs.

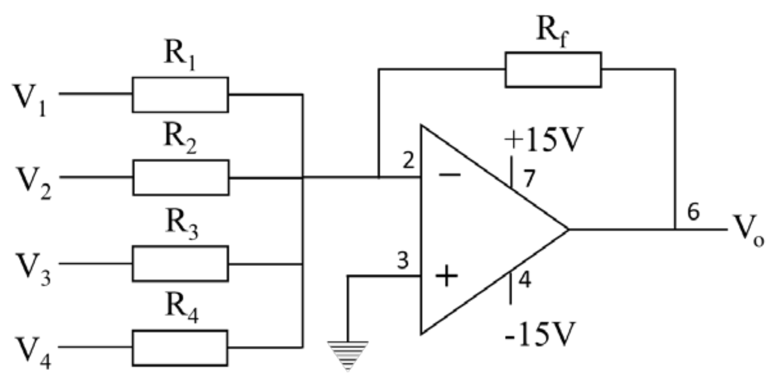

Figure 3-1 Op-amp Summing Amplifier

PRELAB

1. For the summing amplifier circuit in Figure 3-1, what is expression for V_o in terms of R_f, R_1, R_2, R_3, R_4, V_1, V_2, V_3, and V_4.
2. Design a 4 bit D/A converter using an op-amp summing amplifier (see Figure 3-1). Input voltages of 0 V and 5 V will be used to provide logical low and high inputs, respectively. V_1 will be the most significant bit, V_2 the next most significant bit, etc. Select the values of R_f and R_1, R_2 , R_3, and R_4 to provide an output that will vary from 0 V to – 5 V as the digital input varies from 0000 to 1111. Show the schematic diagram for this circuit.
3. Assume that the diode in the circuit of Figure 3-2 is a silicon diode with a knee voltage that varies linearly and inversely with temperature at the rate of 2.5 mV/ ºC, and has a knee voltage of 0.6 V at 20 ºC. Determine values for R_f, R_1, R_2, and V_{ref} that will cause the output voltage to vary linearly from 0 V to 5 V as the temperature varies from 20 ºC to 100 ºC. If needed, V_{ref} can be a negative voltage. Circuits such as this are used in temperature sensing applications; they provide a suitable analog input for A/D converters.

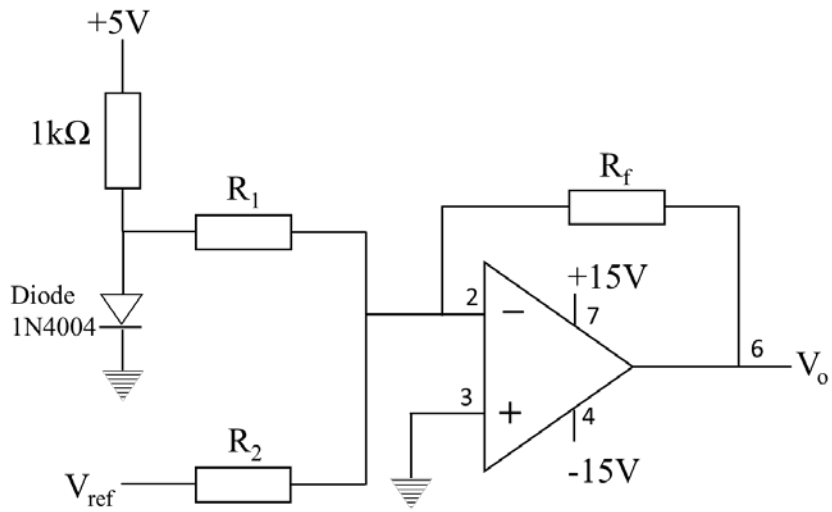

Figure 3-2 Temperature sensing amplifier circuit

PROCEDURE

1. Construct the D/A converter designed in part 2 of the Pre-Lab. Using single-pole single-throw switches, connect the digital inputs so that either 5 V or ground can be applied. Measure and record in a table the output voltages corresponding to each of the digital inputs and also the theoretical output voltages.
2. Construct the circuit of part 3 in the Pre-Lab. Adjust the reference voltage to give an output voltage of zero at room temperature (approximately 20 ºC). If a larger than expected adjustment is needed, there might be a problem with the circuit. When it appears that the circuit is working properly, heat the diode with a heat gun (you can ask the ECE Lab technician for a heat gun if it is not in the room) and observe/record the output voltage as the diode temperature increases. Record the new voltage due to heat changes. **Caution:** Don't place the heat gun close to the circuit or you may melt your board and the circuit components.

POST-LAB

Post-Lab questions must be answered in each experiment's laboratory report.

1. Did the D/A converter functioned as expected? Comment on the error observed between the measured and theoretical outputs, and discuss the possible sources of error. Comment on the voltage difference between successive outputs and the voltage difference between the maximum and minimum outputs.
2. Describe the results obtained with the temperature sensing circuit constructed. This circuit is just the beginning; to complete the design it would be necessary to make some final gain adjustments and develop a calibration curve (i.e., a curve of output voltage vs. temperature).