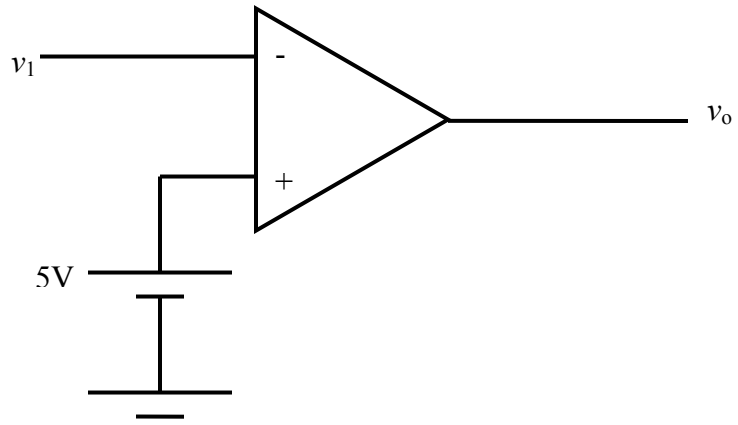
ELG3331: Design Problems for Instrumentations
Assignment Based on DAC, ADC and Comparators
Sections 15.4 and 15.5 of the textbook

Problem 1

Design an alarm system that is to be set off when room temperature exceeds 50°C. Given to you are a temperature-to-voltage- transducer for which 50°C produces a voltage $v_1 = 5$ V. The alarm sounds when -15 V is applied, and it is silent when +15 V is applied.

Solution

We should provide a circuit that monitors the transducer voltage and apply the proper voltage to the alarm. We need a circuit that compares v_1 with a 5-V reference and changes its output suddenly when v_1 exceeds 5 V. Such a circuit is called a **comparator**. When v_1 exceeds 5 V, v_o falls from 15 to -15.

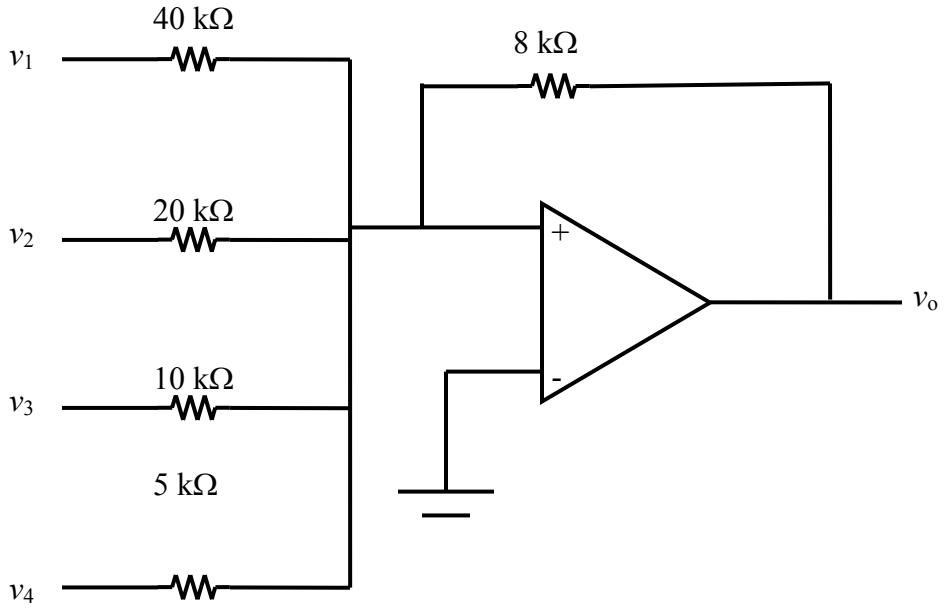


Problem 2

Design a digital-to-analog (DAC) that produces an analog output voltage v_o equal -1 V times the 4-bit number at the input.

Solution

The bits (least significant to most significant) are represented by v_1, v_2, v_3, and v_4. Logic 1 is represented by 5 V and logic 0 by 0 V. One possible design is shown in the following Figure.



v_4	v_3	v_2	v_1	v_o
0	0	0	0	0
0	0	0	5	-1
0	0	5	0	-2
0	0	5	5	-3
0	5	0	0	-4
0	5	0	5	-5
0	5	5	0	-6
0	5	5	5	-7
5	0	0	0	-8
5	0	0	5	-9
5	0	5	0	10
5	0	5	5	-11
5	5	0	0	-12
5	5	0	5	-13
5	5	5	0	-14
5	5	5	5	-15

In summation, each input receives a different gain or weighting

$$v_o = -1.6v_4 - 0.8v_3 - 0.4v_2 - 0.2v_1$$

Problem 3
Draw the circuit diagram for a 4-bit DAC and determine the expression relating v_o to the binary input bits.

Problem 4
Consider the DAC given in Problem 3. What value of RF will give the output range
$-10 \text{ V} \le v_o \le 0 \text{ V}$

Problem 5
Consider the DAC given in Problem 3. What value of RF will give the output range
$-15 \text{ V} \le v_o \le 0 \text{ V}$

Problem 6
Using a DAC model. Design a 4-bit DAC whose output is given by
$$v_O = \frac{1}{10}(8b_3 + 4b_2 + 2b_1 + b_O)\text{ V}$$

Problem 7
A data acquisition uses a DAC with a range of ±10 V. and a resolution of 0.04 V. How many bits must be present in the DAC?

Problem 8
How many comparators are needed in a 4-bit flash ADC?

Problem 9
Consider the ADC (AD574) with the following specifications: $V_{CC} = 15$ V; $0 \le V_{in} \le 15$ V. What is the accuracy (in volts) of the AD574? What is the highest signal that can be converted by this ADC without violating Nyquist criterion if the conversion time is 35 μs?

Problem 10
Sketch the input and output waveforms of a comparator with $V_{ref} = 0.8$ V.

Problem 11
Solve problem 15.71 in the textbook.