Digital to Analog Converter (DAC) and Analog to Digital Converter (ADC)

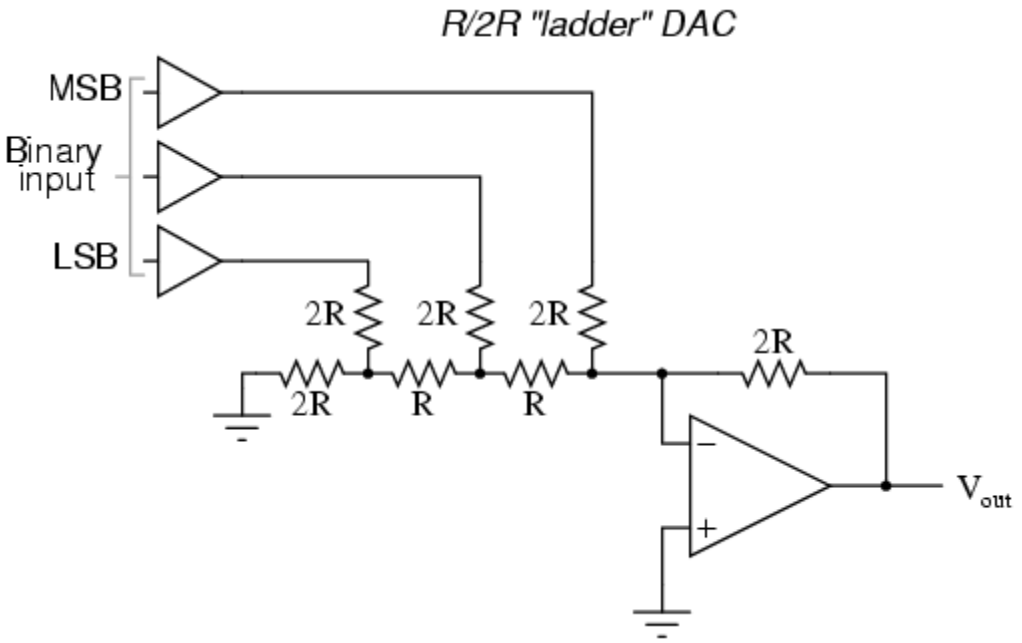
Objective: Construct and study DAC and ADC using OPAMPS and resistors.

Background: Digital-to-Analog converters (DACs) and Analog-to-Digital converters (ADC) are important building blocks which interface sensors (e.g. temperature, pressure, light, sound, cruising speed of a car) to digital systems such as microcontrollers or PCs. An ADC takes an analog signal and converts it into a binary one, while a DAC converts a binary signal into an analog value.

Digital to Analog Converter: Addition of digital inputs(0 or 1, where say 1 corresponds to 5 volt) give rise to analog output, which can be added with different weights considering their place in binary number. But this type of circuit has a disadvantage of requirement of large number accurate resistors for high number of bits. For example, 8 bit converter requires eight resistors ranging from some value *R* to 128*R*. Following R/2R ladder DAC circuit eliminates this problem.

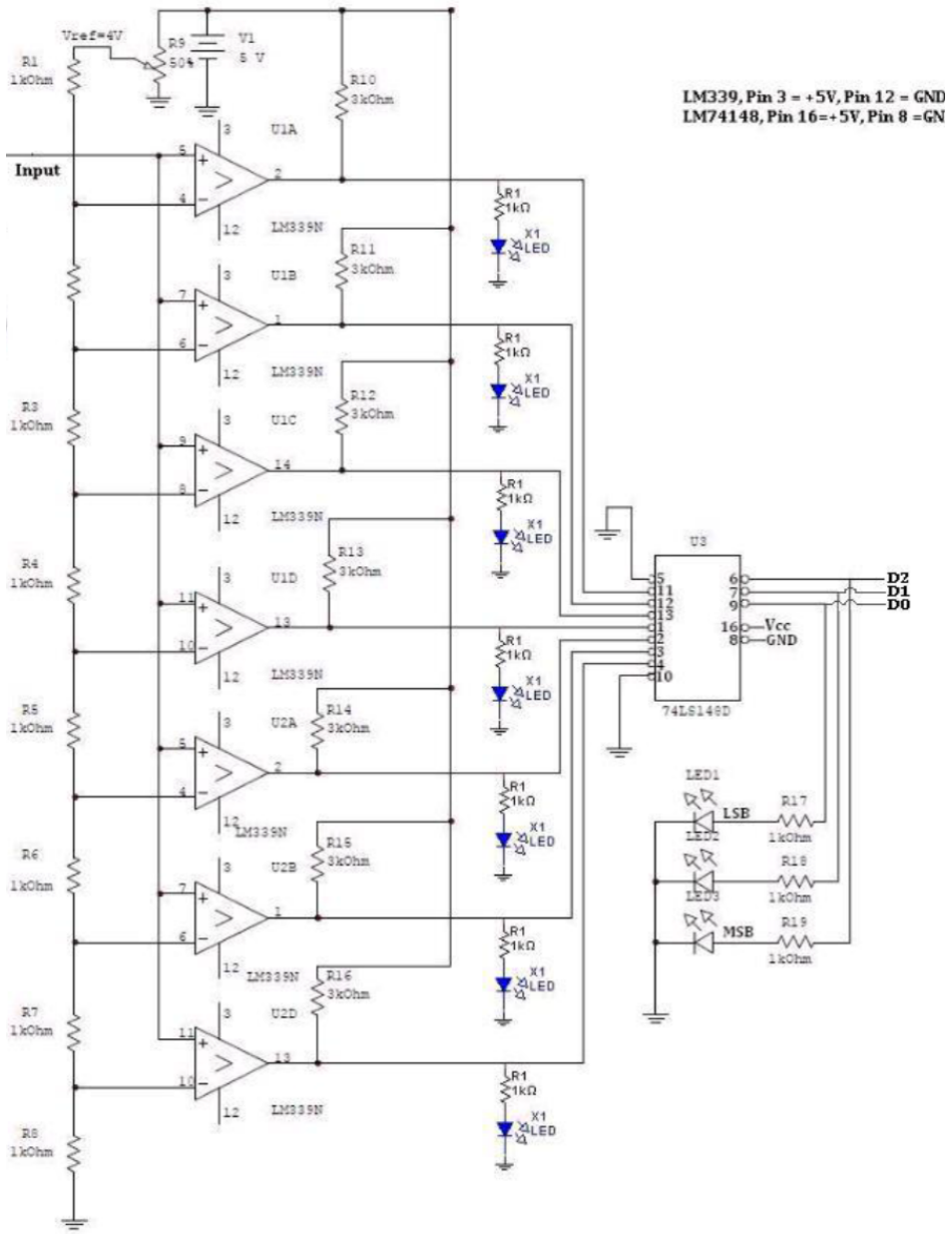
Design a 4 bit R/2R ladder DAC using 741 opamp by choosing components appropriately.

Performance of DAC is characterized by Resolution, Accuracy, Linear errors, Monotonicity and settling time. What are they?



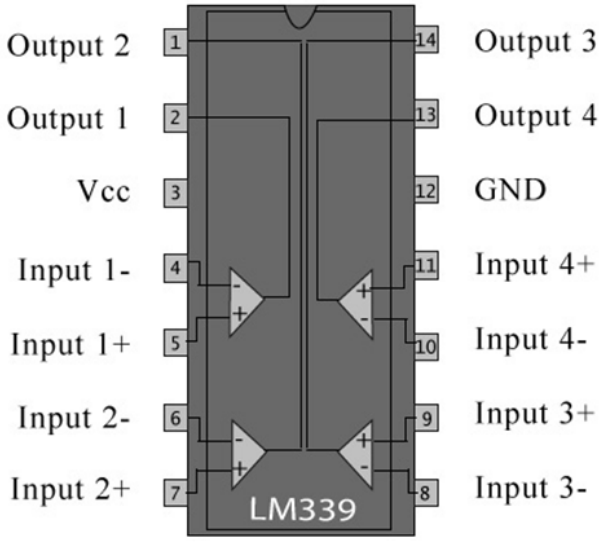
Analog to Digital Converter: In this Analog input from the DC power supply is converted to Binary output using LM339 comparator chip and 74LS147 priority encoder chip. Binary output further can be converted to BCD (Binary coded decimal) format using 7447 chip, which can displayed on common cathode 7-sement BCD display as decimal digit.

Circuit diagram to convert Analog to Binary format digital output with flash conversion method using 8 to 3 priority encoder (74LS148) is given below. Construct a circuit with 10 to 4 priority encoder (74LS147), which is available in the lab.



Note that LM339 is a quad comparator chip. It requires pull up resistors at the outputs. Always use 1 kΩ resistors in series with the LEDs while using LM339 chip. Supply voltage to LM339 can be up to 15 V. Set the reference voltage appropriately. Before connecting ADC circuit, understand the operation of LM339 by connecting one of the comparator. Pin diagram of LM339 is given below.

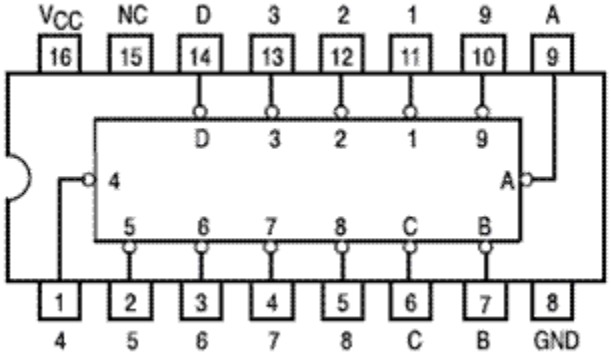
74LS147 is 8 to 4 priority encoder. Pin diagram is given below.



Pin Description:

Pin No	Function	Name
1	Output of 2nd comparator	Output 2
2	Output of 1st comparator	Output 1
3	Supply voltage; 5V (+36 or ±18V)	Vcc
4	Inverting input of 1st comparator	Input 1-
5	Non-inverting input of 1st comparator	Input 1+
6	Inverting input of 1st comparator	Input 2-
7	Non-inverting input of 2nd comparator	Input 2+
8	Inverting input of 3rd comparator	Input 3-

9	Non-inverting input of 3rd comparator	Input 3+
10	Inverting input of 4th comparator	Input 4-
11	Non-inverting input of 4th comparator	Input 4+
12	Ground (0V)	Ground
13	Output of 4th comparator	Output 4
14	Output of 3rd comparator	Output 3

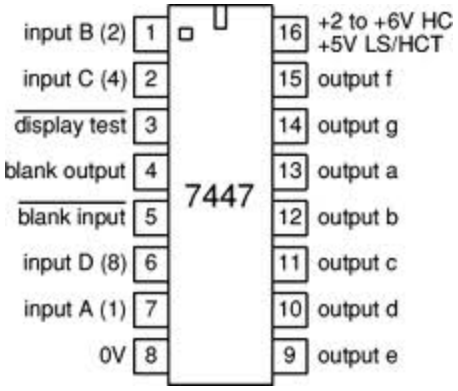


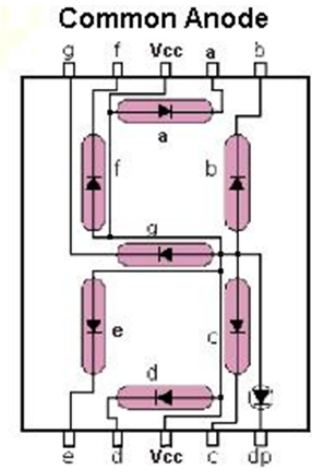
Pin diagram of 74LS147

Conversion of binary output to decimal output

After converting analog input to binary output, it can be converted to binary coded decimal and can be displayed on BCD display. Pin diagram for 7447 (binary to BCD decoder) and common anode BCD display are given below.

What are the advantages and disadvantages of this flash conversion method for ADC? Try reconstructing Digital input by combining both ADC and DAC


input B (2) 1
input C (4) 2
display test 3
blank output 4
blank input 5
input D (8) 6
input A (1) 7
0V 8
7447
16 +2 to +6V HC
+5V LS/HCT
15 output f
14 output g
13 output a
12 output b
11 output c
10 output d
9 output e


Common Anode
g f Vcc a b
a
f
b
g
e
c
d
e d Vcc c dp