



## BRAC UNIVERSITY

CSE 350: Digital Electronics and Pulse techniques

Exp-05: Flash Analog to Digital converter (ADC)

Name: <u>Ayubek Roy Sparho</u>	Section: <u>06</u>
ID: <u>20301262</u>	Group: <u>04</u>

### Objectives

1. To analyze a 2-bit flash analog to digital converter.

### Equipment and component list

#### *Equipment*

1. Multimeter
2. Trainer board

#### *Component*

- Single Supply Quad Operational Amplifier - LM324 - x1 piece
- 8-to-3 Line Priority Encoder - IC74148 - x1 piece
- Resistors -
  - ◆ 10 K $\Omega$  - x7 pieces
  - ◆ 1 K $\Omega$  - x2 piece

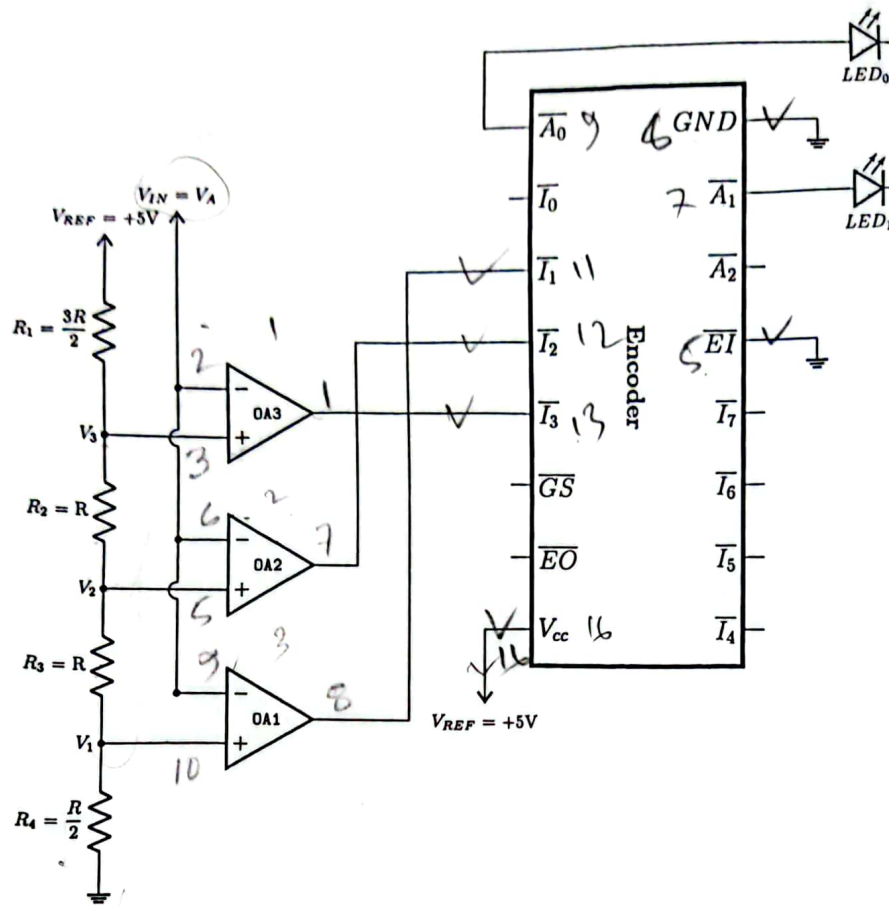


Figure 1: Flash Analog to Digital Converter (ADC)

## Task-01: Flash ADC

### THEORY

Flash ADC is the fastest analog-to-digital converter. You can see the circuit diagram of a 2-bit flash ADC in figure 1. All the op-amps operate as comparator in this circuit. The analog input ( $V_A$ ) is applied to the 'non-inverting' input of the three op-amps.

There is a resistive ladder-network with a reference voltage  $V_{REF} = 5\text{ V}$  at the top of the network. We will obtain some fixed voltages at each node of these network. These nodes are denoted as  $V_1$ ,  $V_2$  and  $V_3$ . Then, we have connected the  $V_1$  node to op-amp 1 (OA1). Similarly, the other two nodes are connected to the corresponding op-amps.

Now, let us calculate the node voltages  $V_i$ 's of the ladder network. For this, keep in mind that the current towards op-amp's input terminals are negligible. First, the total resistance of the ladder network is

$$R_{total} = \sum R_i = R_1 + R_2 + R_3 + R_4 = 4R. \quad (1)$$

So, using Ohm's law, the current through the ladder network will be (same current flows through all the  $R_i$ 's)

$$I_{ladder} = \frac{V_{REF} - 0}{R_{total}} = \frac{V_{REF}}{4R}. \quad (2)$$

It is now trivial to calculate all the node voltages. The equations for all the node voltages are given below for your convenience.

$$V_1 = IR_4 = \frac{V_{REF}}{4R} \times \frac{R}{2} = \frac{V_{REF}}{8} \quad (3)$$

$$V_2 = I(R_3 + R_4) = \frac{V_{REF}}{4R} \times \frac{3R}{2} = 3 \times \frac{V_{REF}}{8} \quad (4)$$

$$V_3 = I(R_2 + R_3 + R_4) = \frac{V_{REF}}{4R} \times \frac{5R}{2} = 5 \times \frac{V_{REF}}{8} \quad (5)$$

Now, closely analyze the operation of all the op-amps. OA1 has input voltage  $V_A$  at its '+' input (non-inverting input) and  $V_1$  at '-' input (inverting input). If  $V_A > V_1$ , OA1 will give a HIGH output. Similarly, OA2 will give HIGH output if  $V_A > V_2$  and OA3 if  $V_A > V_3$ .

Next, we send the outputs of all the op-amps to a priority encoder. We will then get our desired 2-bit digital signal at the output of this encoder which corresponds to the original analog input signal.

For this flash ADC design, we will need  $2^n - 1$  op-amps for implementing an n-bit ADC. This presents a huge disadvantage in terms of practical implementation in laboratory.

## Procedure:

1. Construct the circuit as shown in figure 1. Consider,  $R = 10 \text{ K}\Omega$ .
2. We will not use any external LEDs. Connect the outputs of the encoder to the LEDs of the Trainer Board.
3. Vary the analog input voltage,  $V_{IN}$  or,  $V_A$  from 0V to 5V.
4. Observe when the two LEDs switches ON or OFF and measure the input voltage which causes the transitions. Fill up data table 1 using these data.

Note: The encoder is "Active LOW". This means that whenever the output ( $A_0, A_1$ ) is supposed to be "Logical 1", they are at a LOW voltage. Hence, the corresponding LED will turn OFF!

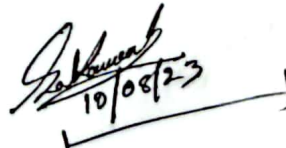
## Data Tables

Fill up the table for the Flash AD Converter.

Input Voltage $V_{IN} = V_A$	State of LED1	State of LED0	Digital Binary Output
$0 \rightarrow 1.16$	ON	ON	00
$1.17 \rightarrow 2.48$	ON	OFF	01
$2.49 \rightarrow 3.81$	OFF	ON	10
$3.82 \rightarrow <$	OFF	OFF	11

Table 1: Data Table for Flash AD Converter

  
Signature 19/08/23

  
10/08/23



## Report

Please answer the following questions briefly in the given space.

1. Use your "group number" as input voltage  $V_A$  and observe the output. If group number is greater than 5, divide by 2 and use the resultant value as input. Explain the reason for obtaining the output.

Ans.

$$V_A = 4V \quad | \quad V_1 = 1.16, \quad V_2 = 2.48, \quad V_3 = 3.81$$

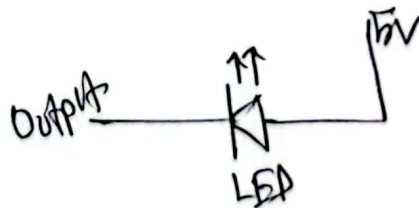
Here,  $V_A > V_1, V_2, V_3$ , So,  $OA_1, OA_2, OA_3$  will produce high outputs. Then we send the output (111) to the priority encoder. Then priority will give output in 2-bit according to the priority. Here, highest priority is 11. That's why we get output as 11.

2. Adjust the input voltage such that we get Binary output 00 and 01. For each case, measure the output voltages of the encoder. Explain why the LEDs turn on or off. (Note: disconnect the LEDs when measuring the output voltages)

Ans.

For output 00  $\Rightarrow V = 2.526V$

For output 01  $\Rightarrow V = 126mV$



When, output voltage is low, current flow through LED and it turns ON. When, output voltage is high, there is no flow of current and LED remains OFF.

3. Write down an advantage and disadvantage of Flash AD converter.

Ans.

Advantage:

- 1) It is fastest type of ADC because the conversion is performed simultaneously through a set of comparators.
- 2) The construction is simple and easy to design.

Disadvantage:

- 1) The circuit complexity increases with the increase in the use of comparators in Flash ADC.
- 2) It is very expensive.

3) It converting non-periodic signal using pipeline ADCs can be difficult as it typically runs at a periodic rate.

4. Measure the voltages of points  $V_3$ ,  $V_2$  and  $V_1$ . Do the values match with the theory?

Ans.

Here,  $I = \frac{V_{ref} - 0}{R_1 + R_2 + R_3 + R_4} = \frac{5}{40} = 0.125 \text{ mA}$

So  $V_1 = 0.125 \times 5 = 0.625 \text{ V}$

$V_2 = V_1 + 0.125 \times 10 = 1.875 \text{ V}$

$V_3 = V_2 + 0.125 \times 10 = 3.125 \text{ V}$

From Experiment

$V_1 = 1.6$

$V_2 = 2.48$

$V_3 = 3.81$

So, the values are quite similar.

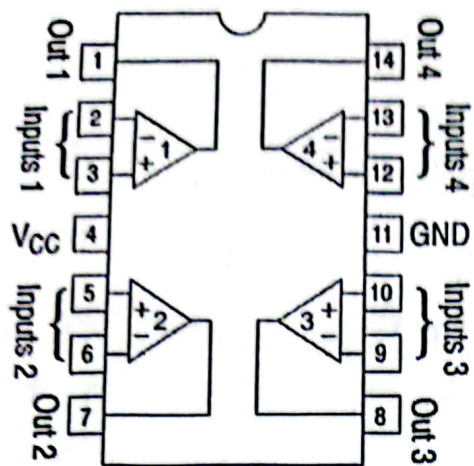
5. If we wanted to build a 3-bit Flash AD converter, how many resistors and comparators (op-amps) would we need?

Ans.

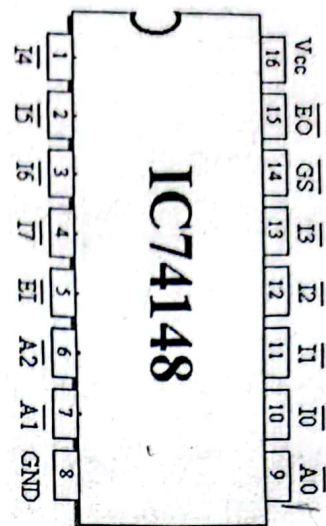
For build a 3 bit Flash AD converter

We need  $2^n = 2^3 = 8$  resistors and

$2^n - 1 = 2^3 - 1 = 7$  comparators (op-amps)



LM324 IC (Quad Op-Amp) pin diagram



74148 IC (Encoder) pin diagram

	INPUTS								OUTPUTS		
EI	0	1	2	3	4	5	6	7	A2	A1	A0
H	X	X	X	X	X	X	X	X	H	H	H
L	H	H	H	H	H	H	H	H	H	H	H
L	X	X	X	X	X	X	X	L	L	L	L
L	X	X	X	X	X	X	L	H	L	L	H
L	X	X	X	X	X	L	H	H	L	H	L
L	X	X	X	X	L	H	H	H	L	H	H
L	X	X	X	L	H	H	H	H	H	L	L
L	X	X	L	H	H	H	H	H	H	L	H
L	X	L	H	H	H	H	H	H	H	H	L
L	L	H	H	H	H	H	H	H	H	H	H

74148 IC (Encoder) Truth Table