Department of Electrical Engineering

UET, Lahore

Digital Systems Laboratory

Lab # 8

Introduction to 7-Segment Display Unit, BCD to 7-Segment Decoder IC And Multiplexers: Construction, Operation and Application

Objective:

In this lab you will learn

- To use a 7 segment display unit and BCD to 7 segment display decoder IC.
- To use 4x1 multiplexer IC, constructing larger multiplexers out of smaller units and implementing a Boolean function with the help of multiplexers.

Apparatus:

- A common anode 7 segment display unit.
- 74LS247 BCD to 7 segment decoder IC
- 74LS153 Dual 4x1 multiplexer IC
- 74LS04 NOT gate IC

Lab Part (a): Introduction to the 7-Segment display and BCD to 7-Segment decoder IC.

Theoretical Background:

An LED or Light Emitting Diode, is a solid state optical PN-junction diode which emits light energy in the form of "photons" when it is forward biased by a voltage allowing current to flow across its junction, and in Electronics we call this process electroluminescence.

Light Emitting Diodes have many advantages over traditional bulbs and lamps, with the main ones being their small size, long life, various colors, cheapness and are readily available, as well as being easy to interface with various other electronic components and digital circuits.

But the main advantage of light emitting diodes is that because of their small die size, several of them can be connected together within one small and compact package producing what is generally called a 7-segment Display.

The 7-segment display, also written as “seven segment display”, consists of seven LEDs (hence its name) arranged in a rectangular fashion as shown. Each of the seven LEDs is called a segment because when illuminated the segment forms part of a numerical digit (both Decimal and Hex) to be displayed. An additional 8th LED is sometimes used within the same package thus allowing the indication of a decimal point, (DP) when two or more 7-segment displays are connected together to display numbers greater than ten.

Each one of the seven LEDs in the display is given a positional segment with one of its connection pins being brought straight out of the rectangular plastic package. These individually LED pins are labelled from a through to g representing each individual LED. The other LED pins are connected together and wired to form a common pin.

So by forward biasing the appropriate pins of the LED segments in a particular order, some segments will be light and others will be dark allowing the desired character pattern of the number to be generated on the display. This then allows us to display each of the ten decimal digits 0 through to 9 on the same 7-segment display.

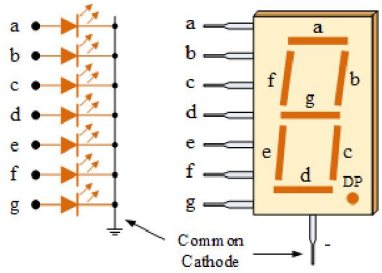
The displays common pin is generally used to identify which type of 7-segment display it is. As each LED has two connecting pins, one called the “Anode” and the other called the “Cathode”, there are therefore two types of LED 7-segment display called: **Common Cathode** (CC) and **Common Anode** (CA).

The difference between the two displays, as their name suggests, is that the common cathode has all the cathodes of the 7-segments connected directly together and the common anode has all the anodes of the 7-segments connected together and is illuminated as follows.

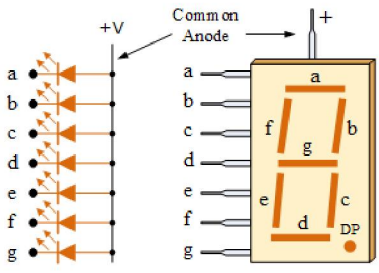
1. The Common Cathode (CC) – In the common cathode display, all the cathode connections of the LED segments are joined together to logic “0” or ground. The individual segments are illuminated by application of a “HIGH”, or logic “1” signal via a current limiting resistor to forward bias the individual Anode terminals (a-g).

2. The Common Anode (CA) – In the common anode display, all the anode connections of the LED segments are joined together to logic “1”. The individual segments are illuminated by applying a ground, logic “0” or “LOW” signal via a suitable current limiting resistor to the Cathode of the particular segment (a-g)

Common Cathode 7-segment Display



Common Anode 7-segment Display



Depending upon the decimal digit to be displayed, the particular set of LEDs is forward biased. For instance, to display the numerical digit 0, we will need to light up six of the LED segments corresponding to a, b, c, d, e and f. Then the various digits from 0 through 9 can be displayed using a 7-segment display as shown.

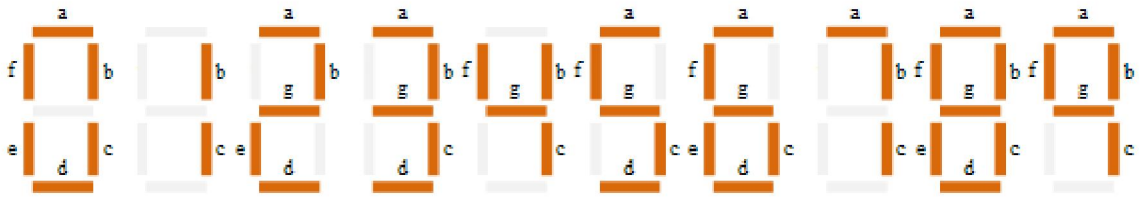


Figure: 7-Segment Display Segments for all Numbers

Then for a 7-segment display, we can produce a truth table giving the individual segments that need to be illuminated in order to produce the required decimal digit from 0 through 9 as shown on right.

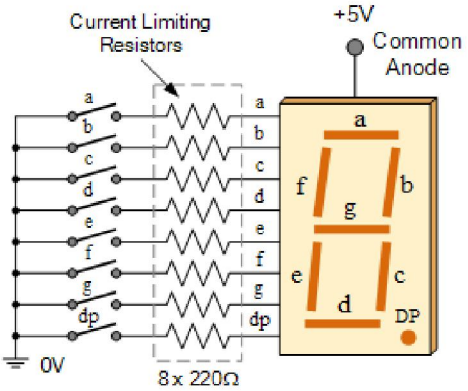
7-segment Display Truth Table

Decimal Digit	Individual Segments Illuminated						
	a	b	c	d	e	f	g
0	×	×	×	×	×	×	
1		×	×				
2	×	×		×	×		×
3	×	×	×	×			×
4		×	×			×	×
5	×		×	×		×	×
6	×		×	×	×	×	×
7	×	×	×				
8	×	×	×	×	×	×	×
9	×	×	×			×	×

Driving a 7-segment Display:

Although a 7-segment display can be thought of as a single display, it is still seven individual LEDs within a single package and as such these LEDs need protection from over current. LEDs produce light only when it is forward biased with the amount of light emitted being proportional to the forward current.

Driving a 7-segment Display



The forward voltage drop across a red LED segment is very low at about 2-to-2.2 volts, (blue and white LEDs can be as high as 3.6 volts) so to illuminate correctly, the LED segments should be connected to a voltage source in excess of this forward voltage value with a series resistance used to limit the forward current to a desirable value.

Typically for a standard red colored 7-segment display, each LED segment can draw about 15 mA to illuminated correctly, so on a 5 volt digital logic circuit, the value of the

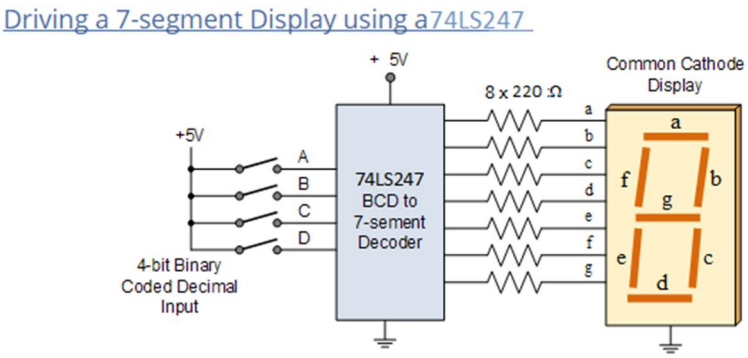
current limiting resistor would be about 200Ω (5v – 2v)/15mA, or 220Ω to the nearest higher preferred value.

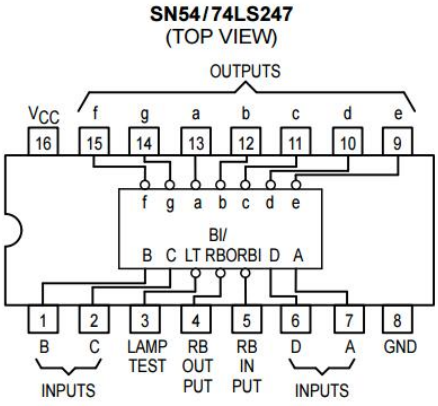
So to understand how the segments of the display are connected to a 220Ω current limiting resistor consider the circuit below.

7-segment Displays are usually driven by a special type of integrated circuit (IC) commonly known as a 7-segment decoder/driver, such as the TTL 74LS247. This 7-segment display driver which is known as a Binary Coded Decimal or BCD to 7-segment display decoder and driver, is able to illuminate a common anode display.

This BCD-to-7 segment decoder/driver takes a four-bit BCD input labelled A, B, C and D for the digits of the binary weighting of 1, 2, 4and 8 respectively, has seven outputs that will pass current through the appropriate segments to display the decimal digit of the numeric LED display.

Connection diagram and pin configuration of 74LS247





Lab Task (a): Connect 74LS247 with a 7 segment display and show its working to the lab instructor.

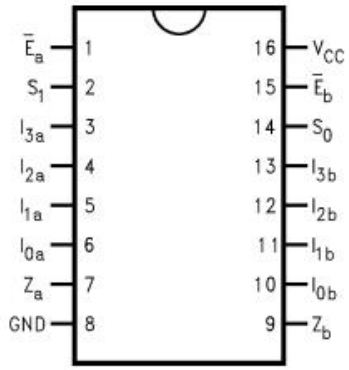
Lab Part (b): Multiplexers: Construction, Operation and Applications

Theoretical Background:

A multiplexer is a combinational circuit that selects binary information from one of many input lines and directs it to a single output line. The selection of a particular input line is controlled by a set of selection lines. Normally, there are 2^n input lines and n selection lines whose bit combinations determine which input is selected. For details refer to article 4.11 of the text book: Digital Design, 5^{th} ed. by M Morris Mano.

In this laboratory you will use Dual 4 to 1 multiplexer IC: 74LS153. This IC has two 4 to 1 multiplexers units with common selection switches with separate enabling for both multiplexers. The pin configuration and pin description of this IC is shown below:

Connection Diagram



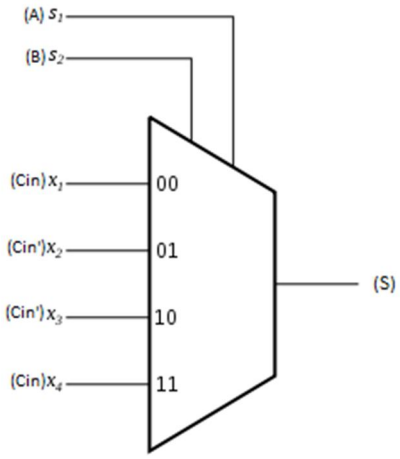
Pin Description

Pin Names	Description
I_{0a}–I_{3a}	Side A Data Inputs
I_{0b}–I_{3b}	Side B Data Inputs
S_0, S_1	Common Select Inputs
$\overline{E}_a$	Side A Enable Input
$\overline{E}_b$	Side B Enable Input
Z_a	Side A Output
Z_b	Side B Output

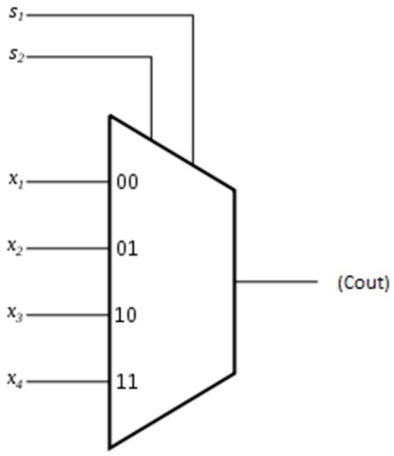
Lab Task (b): Show the operation of 4 to 1 multiplexer to your lab instructor.

Lab Task (c): Implement a full adder using multiplexers. And show its output on 7 segment display units.

A	B	Cin	S	
0	0	0	0	S = Cin
0	0	1	1	
0	1	0	1	S = Cin’
0	1	1	0	
1	0	0	1	S = Cin’
1	0	1	0	
1	1	0	0	S = Con
1	1	1	1	



A	B	Cin	Cout	
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		



Lab Task (d): Implement an 8 to 1 multiplexer using two 4 to 1 multiplexers.

Comments:

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Lab Instructor: _____

Dated: _____