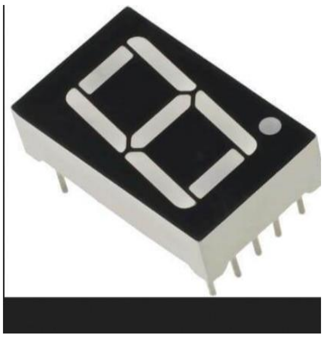
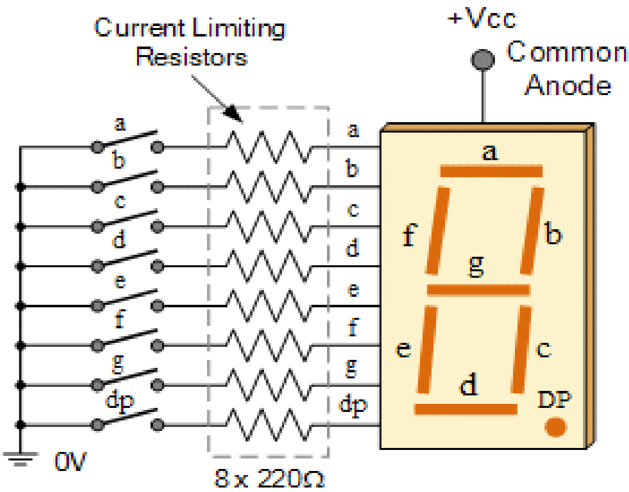
SEVEN SEGMENT DISPLAY

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

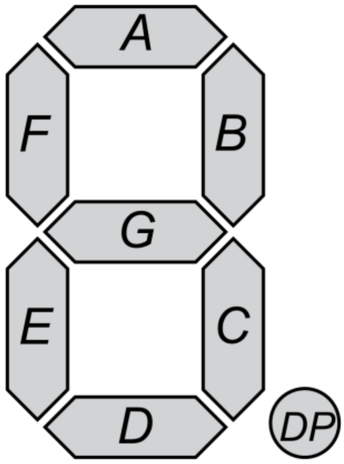
But the main advantage of light emitting diodes is that because of their small die size, several of them can be connected together within one small and compact package producing what is generally called a **7-segment Display**.



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.

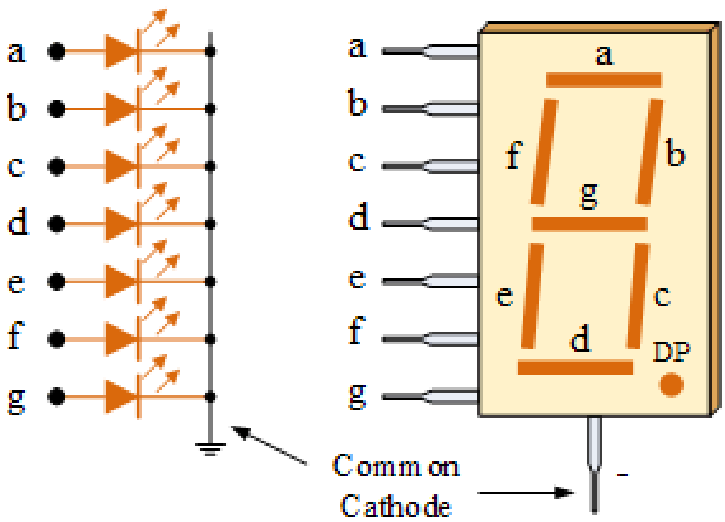


An additional 8th LED is sometimes used within the same package thus allowing the indication of a decimal point, (DP) when two or more 7-segment displays are connected together to display numbers greater than ten.

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).

1. The Common Cathode (CC) :

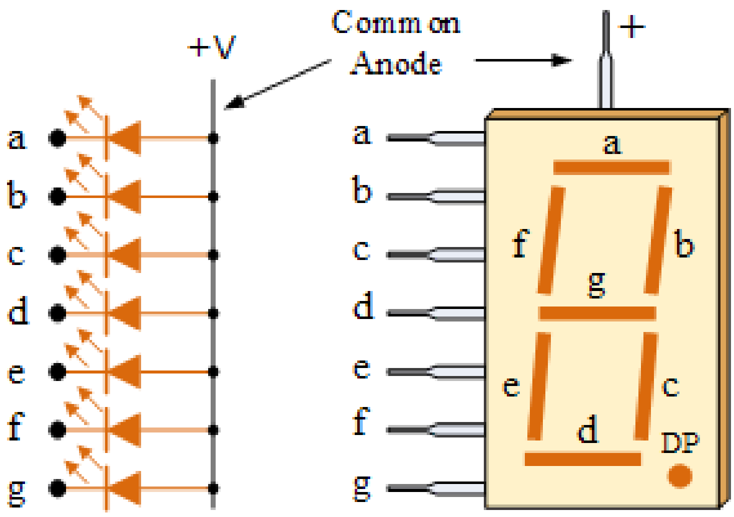
In the common cathode display, all the cathode connections of the LED segments are joined together to logic “0” or ground. The individual segments are illuminated by application of a “HIGH”, or logic “1” signal via a current limiting resistor to forward bias the individual Anode terminals (a-g).



Common Cathode 7-segment Display

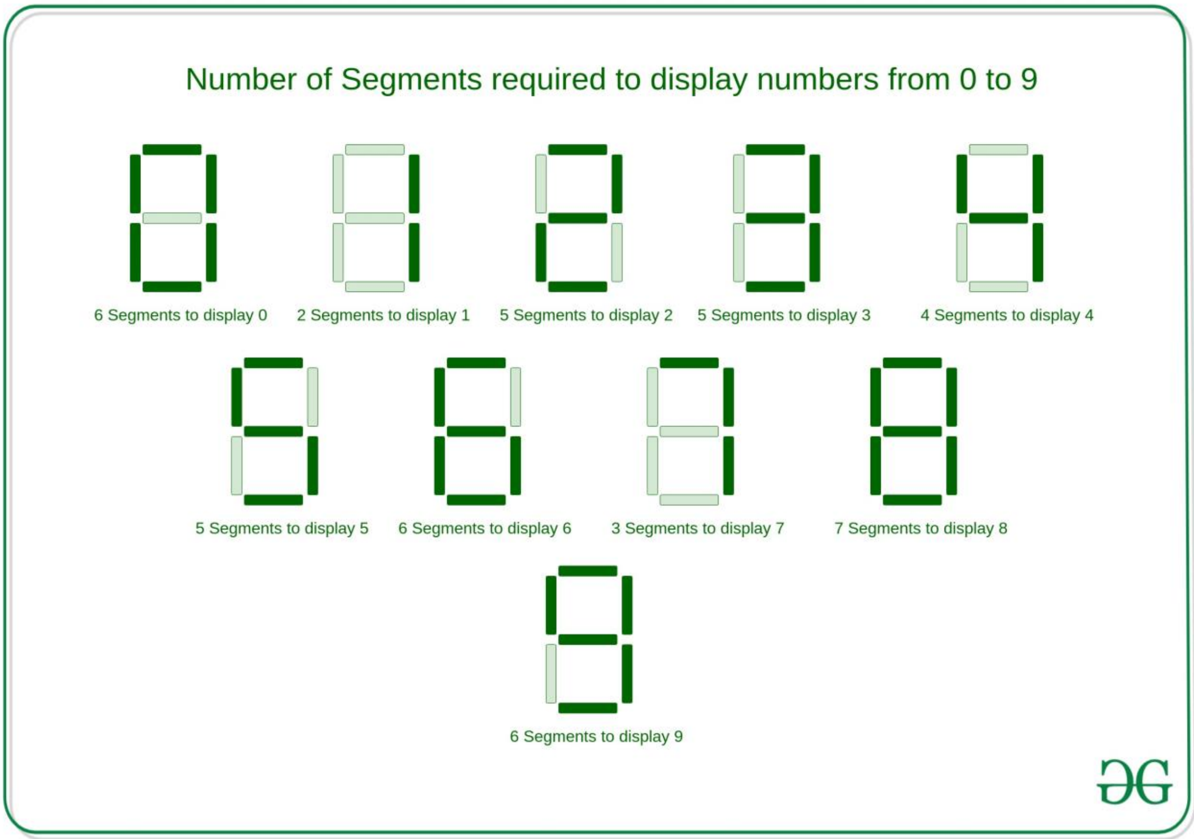
2. The Common Anode (CA) :

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 Anode 7-segment Display

The below reference image will help to understand the working of the segments and the truth table for each segment.

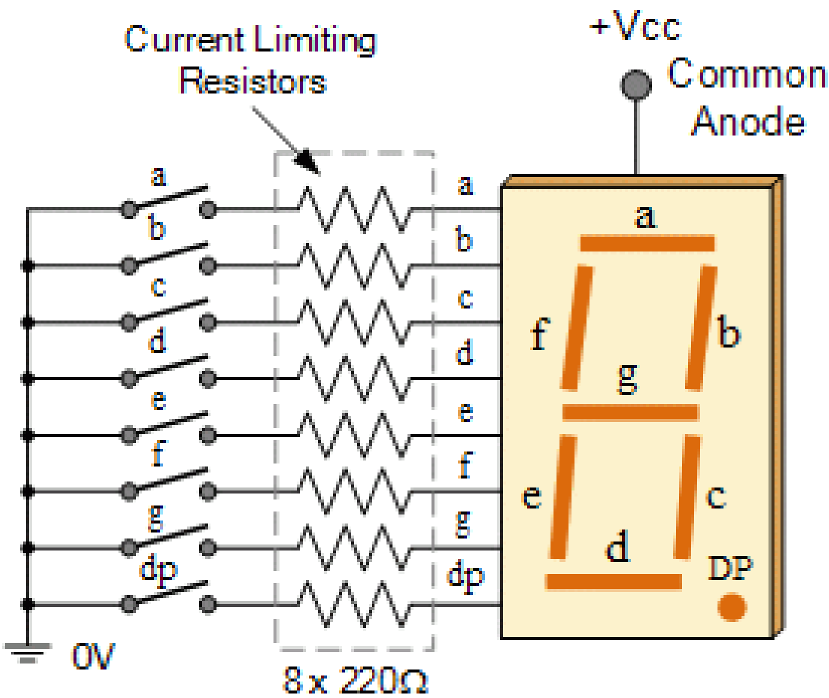


TRUTH TABLE

Segments Inputs							7 Segment Display Output
a	b	c	d	e	f	g	
0	0	0	0	0	0	1	0
1	0	0	1	1	1	1	1
0	0	1	0	0	1	0	2
0	0	0	0	1	1	0	3
1	0	0	1	1	0	0	4
0	1	0	0	1	0	0	5
0	1	0	0	0	0	0	6
0	0	0	1	1	1	1	7
0	0	0	0	0	0	0	8
0	0	0	0	1	1	0	9

It is difficult to operate 7-segment display manually as it demands the frequent ON and OFF of LED's.

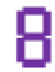
So we use any consistent encoded system. So let us see an example Binary Coded Decimal encoded system.



Here we are connecting an IC (Integrated Circuit) which takes 4 bit data input and sends corresponding signals to the Display.

Let us design a combinational Circuit which performs this logic operation using Logic gates only.

Truth Table for this is as follows :

Decimal Digit	Input lines				Output lines							Display pattern
	A	B	C	D	a	b	c	d	e	f	g	
0	0	0	0	0	1	1	1	1	1	1	0	
1	0	0	0	1	0	1	1	0	0	0	0	
2	0	0	1	0	1	1	0	1	1	0	1	
3	0	0	1	1	1	1	1	1	0	0	1	
4	0	1	0	0	0	1	1	0	0	1	1	
5	0	1	0	1	1	0	1	1	0	1	1	
6	0	1	1	0	1	0	1	1	1	1	1	
7	0	1	1	1	1	1	1	0	0	0	0	
8	1	0	0	0	1	1	1	1	1	1	1	
9	1	0	0	1	1	1	1	1	0	1	1	

Now for each of the segment (a, b, c, d, e, f, g) we make a K Map to derive the logic functions for each in terms of A, B, C and D.

As we have to find functions from 0 to 9, so we take the 10 to 15 as don't care case (X).

AB \ CD	00	01	11	10
00	1	0	1	1
01	0	1	1	1
11	×	×	×	×
10	1	1	×	×

$$a = A + C + BD + \overline{B}\,\overline{D}$$

AB \ CD	00	01	11	10
00	1	0	1	1
01	1	0	1	0
11	×	×	×	×
10	1	1	×	×

$$b = \overline{B} + \overline{C}\,\overline{D} + CD$$

AB \ CD	00	01	11	10
00	1	1	1	0
01	1	1	1	1
11	×	×	×	×
10	1	1	×	×

$$c = B + \overline{C} + D$$

AB \ CD	00	01	11	10
00	1	0	1	1
01	0	1	0	1
11	×	×	×	×
10	1	1	×	×

$$d = \overline{B}\,\overline{D} + C\,\overline{D} + B\,\overline{C}\,D + \overline{B}\,C + A$$

AB \ CD	00	01	11	10
00	1	0	0	1
01	0	0	0	1
11	×	×	×	×
10	1	0	×	×

$$e = \overline{B}\,\overline{D} + C\,\overline{D}$$

AB \ CD	00	01	11	10
00	1	0	0	0
01	1	1	0	1
11	×	×	×	×
10	1	1	×	×

$$f = A + \overline{C}\,\overline{D} + B\,\overline{C} + B\,\overline{D}$$

AB \ CD	00	01	11	10
00	0	0	1	1
01	1	1	0	1
11	×	×	×	×
10	1	1	×	×

$$g = \overline{B}\,C + C\,\overline{D} + B\,\overline{C} + B\,\overline{C} + A$$

Logic Functions :

a = F1 (A, B, C, D) = ∑m (0, 2, 3, 5, 7, 8, 9)

b = F2 (A, B, C, D) = ∑m (0, 1, 2, 3, 4, 7, 8, 9)

c = F3 (A, B, C, D) = ∑m (0, 1, 3, 4, 5, 6, 7, 8, 9)

d = F4 (A, B, C, D) = ∑m (0, 2, 3, 5, 6, 8)

e = F5 (A, B, C, D) = ∑m (0, 2, 6, 8)

f = F6 (A, B, C, D) = ∑m (0, 4, 5, 6, 8, 9)

g = F7 (A, B, C, D) = ∑m (2, 3, 4, 5, 6, 8, 9)

$$a = A + C + BD + \overline{B}\,\overline{D}$$

$$b = \overline{B} + \overline{C}\,\overline{D} + CD$$

$$c = B + \overline{C} + D$$

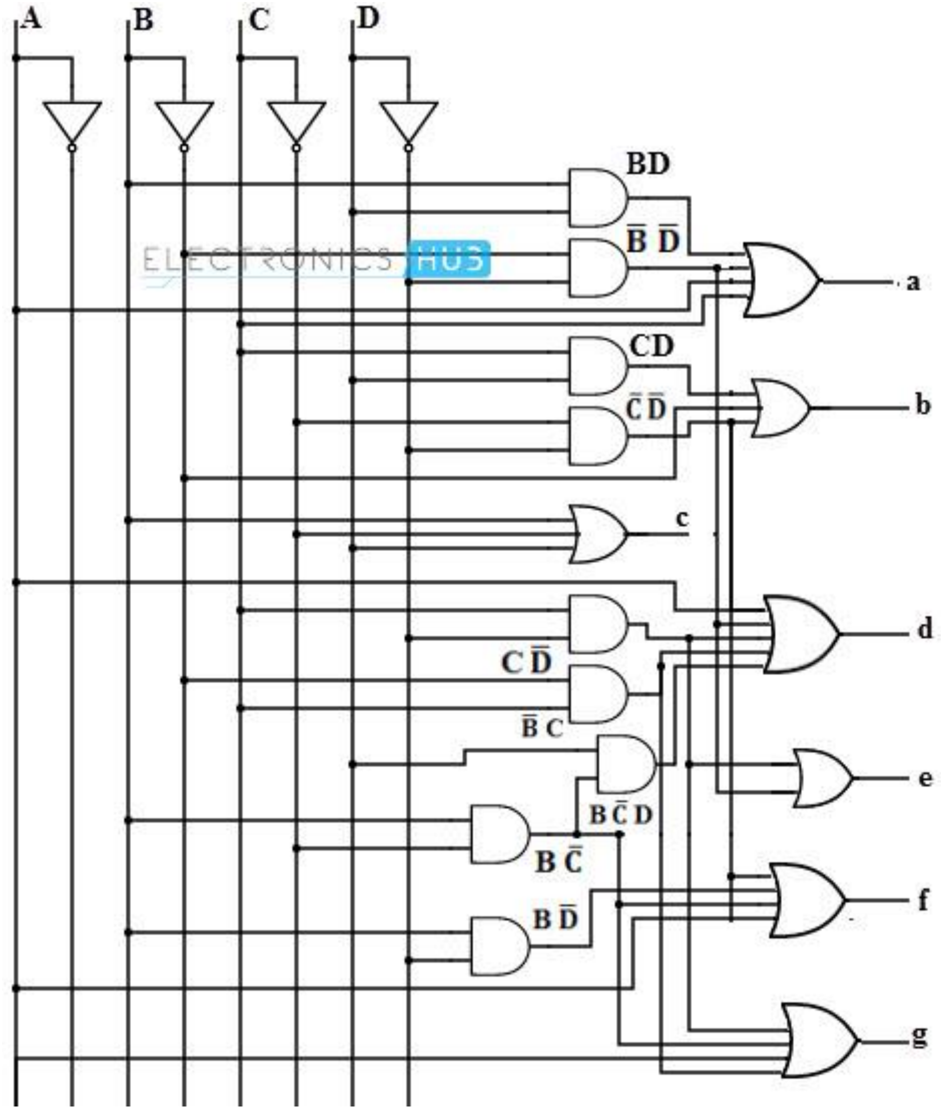
$$d = \overline{B}\,\overline{D} + C\,\overline{D} + B\,\overline{C}\,D + \overline{B}\,C + A$$

$$e = \overline{B}\,\overline{D} + C\,\overline{D}$$

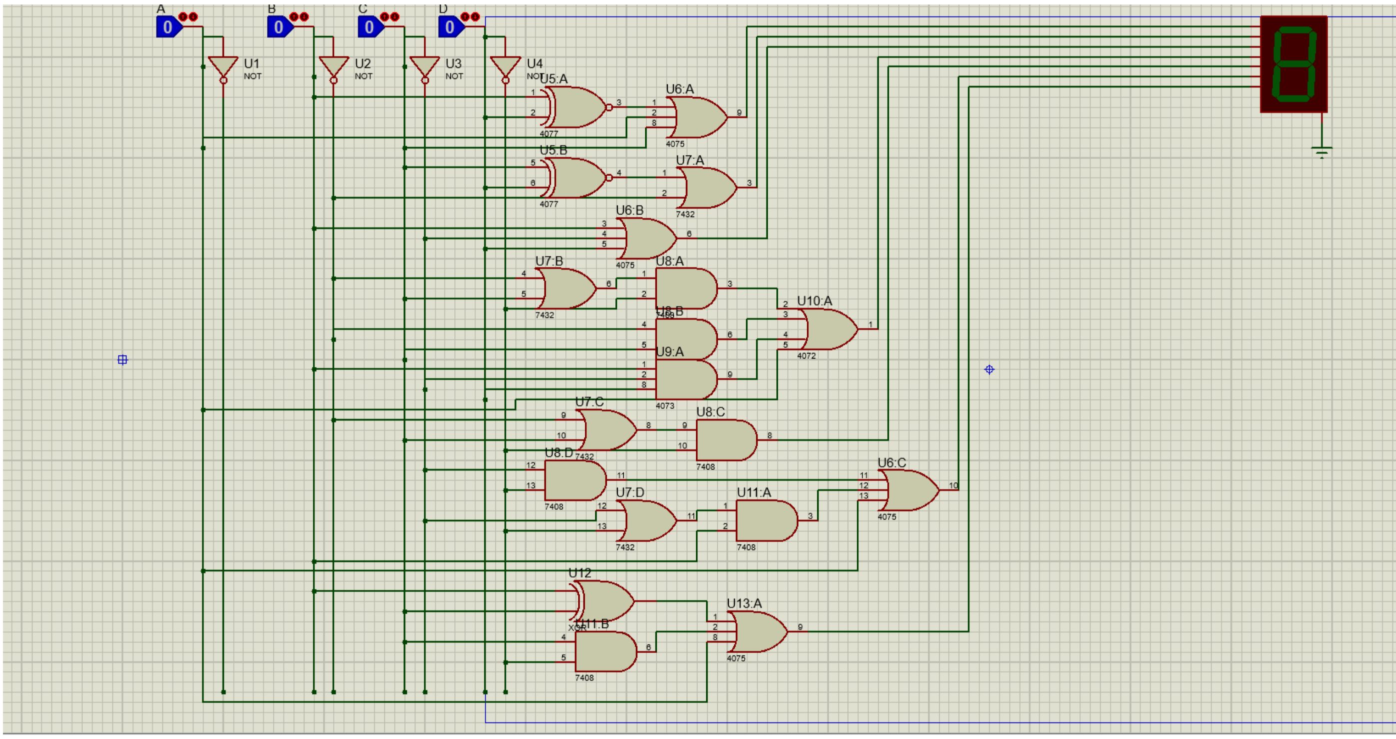
$$f = A + \overline{C}\,\overline{D} + B\,\overline{C} + B\,\overline{D}$$

$$g = A + B\,\overline{C} + \overline{B}\,C + C\,\overline{D}$$

Note : It can further be simplified as another function.



Note : We can use other logic functions to implement the circuit in another way. It is just a reference.



Circuit simulated on PROTEUS.

Application of 7 segment display :

Common applications of seven segment displays are in:

1. Digital clocks
2. Clock radios
3. Calculators
4. Wristwatchers
5. Speedometers
6. Motor-vehicle odometers
7. Radio frequency indicators

Limitations:

• This circuit is very complex and involves many logic gates and occupies a lot of space.

• Timing delay by each logic gate is a matter of concern and this circuit might not produce accurate results when used to display count of pulses.

References :

https://www.geeksforgeeks.org/seven-segment-displays/

https://www.electronicshub.org/bcd-7-segment-led-display-decoder-circuit/

My senior Devansh Srivastav's GitHub repository :

Frequency-Counter/7 Segment Display.pdf at master · devansh-srivastav-kashyap/Frequency-Counter · GitHub

Report by ***SATYAM KUMAR***