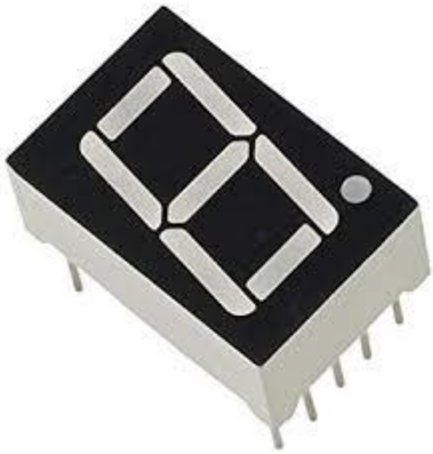
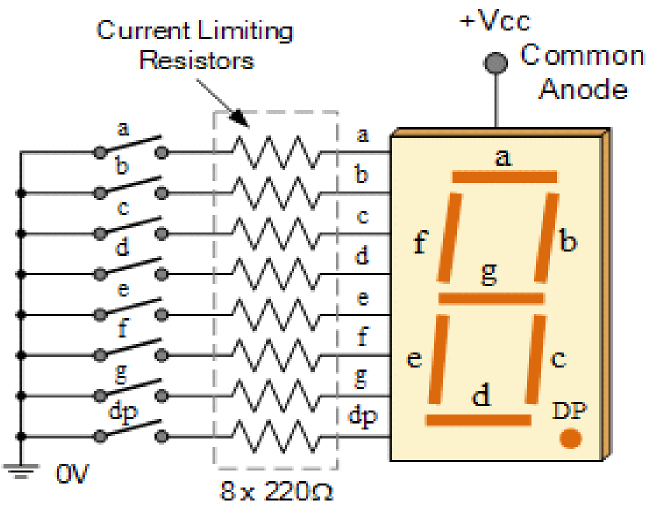
Seven Segment Display

A seven segment display is a form of electronic display device used for displaying decimal numbers and alphabets. They are widely used in digital clocks, electronic meters, basic calculator and other electronic devices that display information. It is very popular device replaced by **"LCD"** (Liquid Crystal Display) because it uses less current.



It has seven LED's in a rectangular pattern. There is an eighth LED to represent decimal point. The entire display has been divided into 7 different segments. Each segment has an LED whose one terminal emerges out of the plastic box of seven segment display and the other terminal is connected to the other segment LED's.

There are 10 pins in which 8 are for LED's and 2 pins are known as common, ground pin and voltage pin.



As shown in this image, all segments have been labeled from A to G.

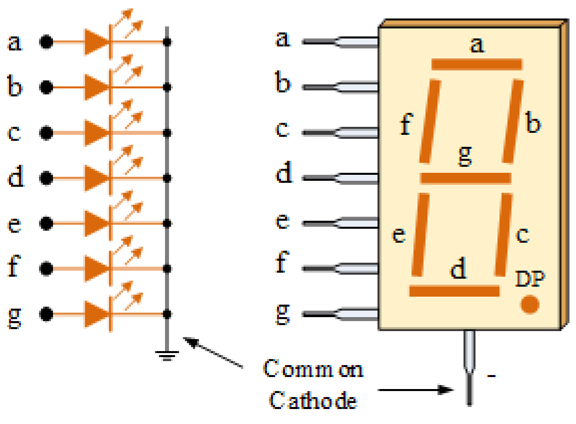
An LED or Light Emitting Diode is a solid state optical PN-junction diode which emits light energy in the form of photons.

Generally, LED consists of 2 pins cathode and anode LED's will glow only if they are in forward bias. These two pins are named as Common Anode and Common Cathode.

There are two types of seven segment display.

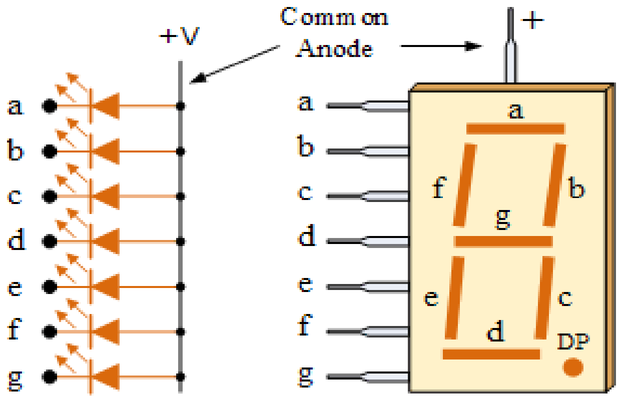
1) Common Cathode

In this one, the cathode of all LED's is attached to the ground commonly and individual segment is lighted with the free terminal attached to logic 1 or High. The individual segments are illuminated by application of logic "1" signal or High signal via a current limiting resistor to anode of the particular segment.



2) Common Anode

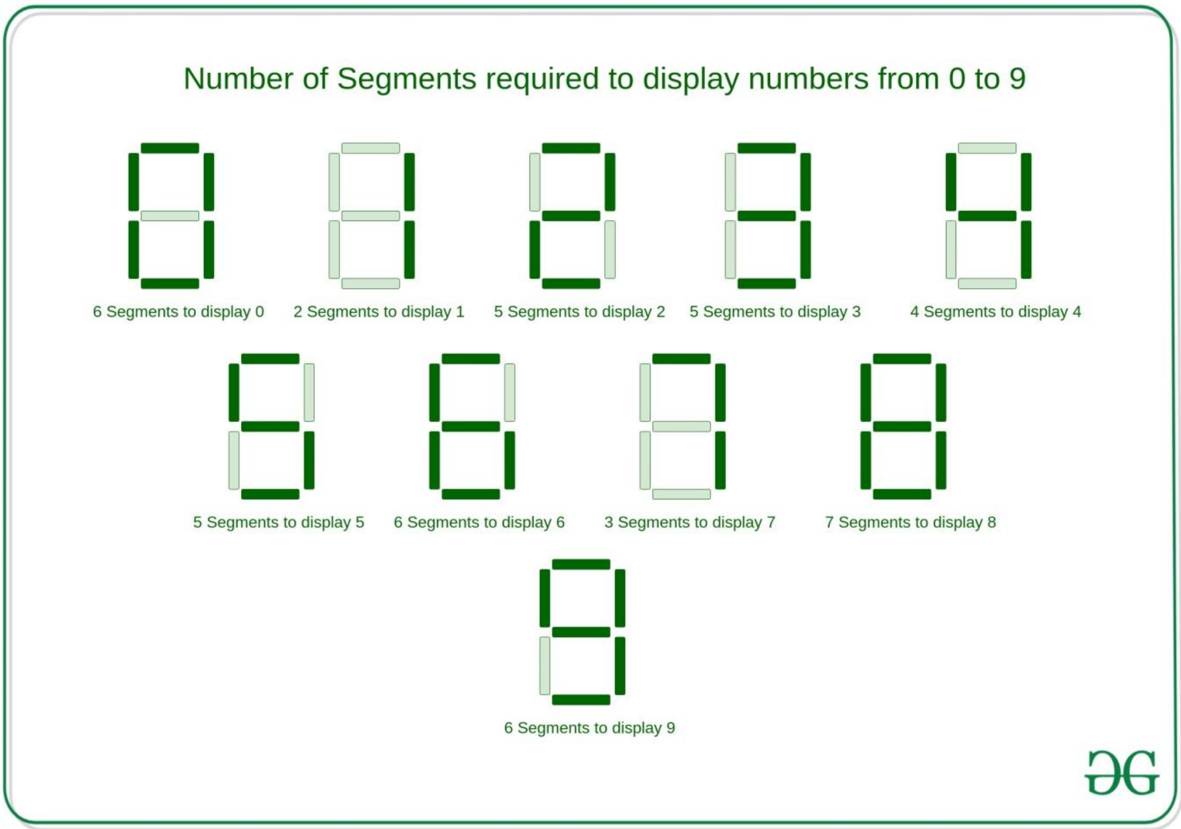
In this one, the anode of all LED's is attached to the logic 1 or High commonly and the other terminal of the individual segment is put at logic 0 or Ground to lit the segment. The individual segments are illuminated by applying ground or logic “0” signal or Low signal via a current limiting resistor to cathode of the particular segment.



TRUTH TABLE

Decimal Number	a	b	c	d	e	f	g
0	1	1	1	1	1	1	0
1	0	1	1	0	0	0	0
2	1	1	0	1	1	0	1
3	1	1	1	1	0	0	1
4	0	1	1	0	0	1	1
5	1	0	1	1	0	1	1
6	1	0	1	1	1	1	1
7	1	1	1	0	0	0	0
8	1	1	1	1	1	1	1
9	1	1	1	1	0	1	1

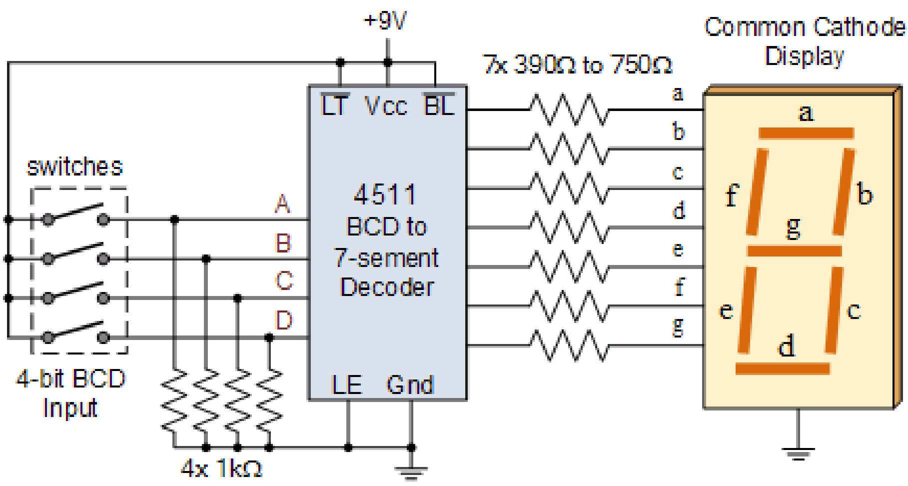
If common anode type, then “1” represents low, otherwise for common cathode it represents high.



This is a reference image which will help you in extracting the truth table of the seven segment display.

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.

Let us make a truth table related to this circuit.

Number	**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

We will make k-maps (kanrnuagh Maps) for deriving logic functions for a, b, c, d, e, f and g in terms of A, B, C and D. For that sake we will assume 10-15 as don’t care.

#This is a reference 4-variable k-map.

	C'D'	C'D	CD	CD'
A'B'	0	1	3	2
A'B	4	5	7	6
AB	12	13	15	14
AB'	8	9	11	10

Here the below images shows the corresponding K-maps.

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

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

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

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

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

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

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

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

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

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

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

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

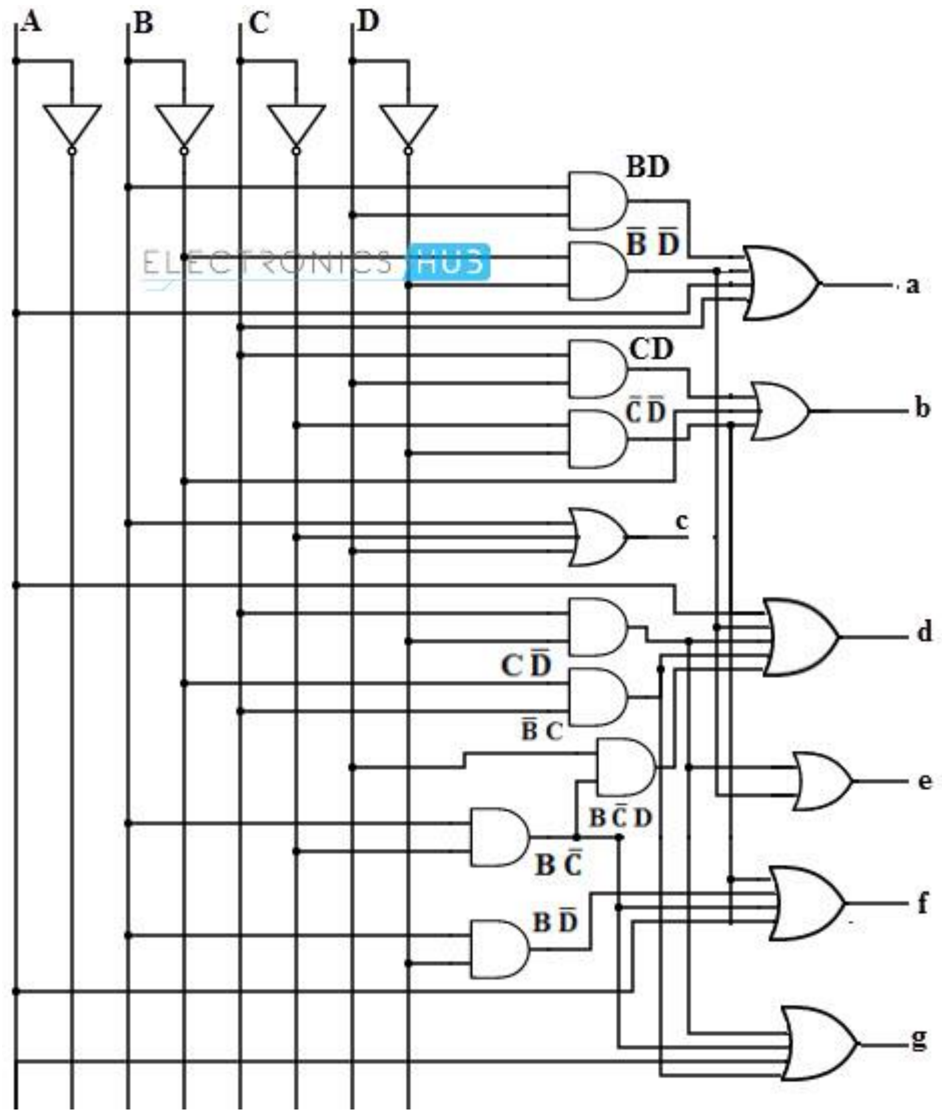
AB \ CD	00	01	11	10
00	0	0	1	1
01	1	1	0	1
11	x	x	x	x
10	1	1	x	x

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

Logic functions:

$$a = \sum m(0,2,3,5,6,7,8,9) = A + C + BD + \bar{B}\bar{D}$$
$$b = \sum m(0,1,2,3,4,7,8,9) = \bar{B} + CD + \bar{C}\bar{D}$$
$$c = \sum m(0,1,3,4,5,6,7,8,9) = B + \bar{C} + D$$
$$d = \sum m(0,2,3,5,6,8,9) = A + B\bar{C}D + \bar{B}C + C\bar{D} + \bar{B}\bar{D}$$
$$e = \sum m(0,2,6,8) = \bar{D}(\bar{B} + C)$$
$$f = \sum m(0,4,5,6,8,9) = A + B\bar{C} + B\bar{D} + \bar{C}\bar{D}$$
$$g = \sum m(2,3,4,5,6,8,9) = A + \bar{B}C + B\bar{C} + C\bar{D}$$

Note: I had tried to simplify the logic functions as possible. Further simplification of logic functions may be possible.



This image is just obtained as a reference.

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.

This is a theoretical circuit and may require few modifications.

References:

1) Electronics hub:

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

2) My senior Devansh Srivastav's Github repository

https://github.com/devansh-srivastav-kashyap/Frequency-Counter/blob/master/7%20Segment%20Display.pdf

A report by ***Jyotsana Sampatharao***