

# Seven-Segment LED Displays

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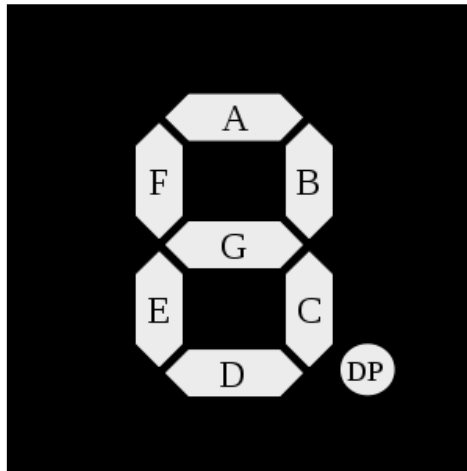
## **Abstract**

Seven-segment displays are electronic display devices used as an easy way to display decimal numerals and an alternative to the more complex dot-matrix displays. The LDS-C303RI, a common seven-segment display, will be examined. Common anode vs. common cathode will be outlined. LED drivers such as the CD74HC4511E will also be discussed. Design applications such as digital clocks and electronic meters will be covered briefly.

**Keywords:** Seven-Segment, LED Display, Common Anode/Cathode, Drivers, LDS-C303RI, CD74HC4511E

## Introduction

Seven-segment displays first became widely used as a popular way of displaying numbers. Today they are used as displays in home appliances, cars, and various digital devices. The LDS-C303RI is commonly used in many designs, it includes seven LED bars aligned in a figure eight pattern as seen in Figure 1. It is capable of displaying the numbers 0-9 and the letters A-F by lighting the appropriate segments. This is typically controlled by a driver like the CD74HC4511E.



**Figure 1: Seven-Segment Layout**

## Objective

The following will detail the necessary requirements to implement a display into a circuit. This application note will also provide the basic functionality of a seven-segment display. In terms of hardware, the implementation of the display into a counter using a CD74HC4511E driver will be discussed. Schematics are included in order to explicitly show the correct implementation of the display into a simple binary counter.

## Methods

### Seven-Segment Display

When dealing with seven-segment displays, there are two types. Common anode and common cathode; in common anode all the anodes on the display are tied to a common pin, typically the power source, and the LED are controlled via the cathodes with ground being on and power being off. In common cathode all the cathodes are tied to a common pin, in this case generally ground, and the LED are driven by the state of the anodes where ground is off and power is on.

Hence a seven-segment plus decimal point package will only require nine pins, though commercial products typically contain more pins in order to match industry standard pinouts. See Figure 2 and 3 for reference.

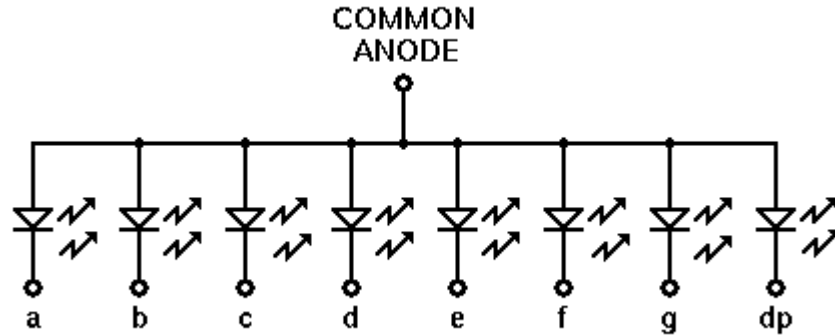


Figure 2: Common Anode

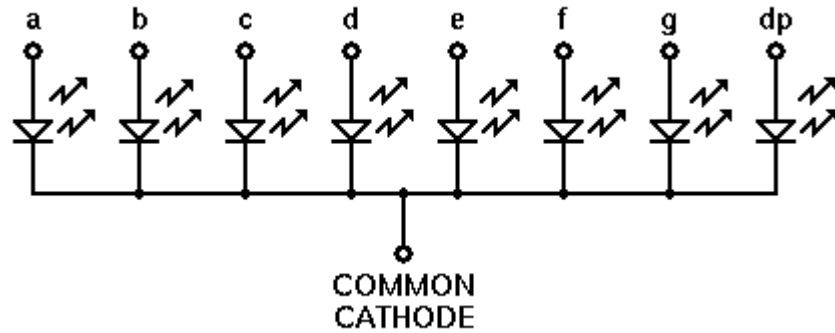


Figure 3: Common Cathode

A simple truth table can be used to show how to display each number and letter. This can be seen in Table 1. For example, it can be seen that if a 0 is wanted to be displayed the a-f LED segments need to be turned on while the g segment is off. Note that B and D are displayed as b and d; this is done to obtain a unique, unambiguous shape for each letter. Otherwise, a capital D would look identical to a 0 and a capital B would look identical to an 8.

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

9	On	On	Off	Off	On	On	On
A	On	On	On	Off	On	On	On
B	Off	Off	On	On	On	On	On
C	On	Off	Off	On	On	On	Off
D	Off	On	On	On	On	Off	On
E	On	Off	Off	On	On	On	On
F	On	Off	Off	Off	On	On	On

Table 1: Seven-Segment Truth Table

### Display Driver

Controlling a seven-segment display will require eight pins for most displays and nine pins if it has a decimal point. This adds a lot of wiring to the circuit; however the use of a display driver can simplify this by reducing the number of pins required to four. A display driver is a simple logic based device that is passed a 4-bit binary input which is decoded and translated into the correct pin values for the display, see Appendix for chip schematic. So if we wanted the display to show a C representing the number 12 we would pass it the 4-bit representation 1100. It must be kept in mind however that not all drivers are capable of displaying the letters A-F. Shown below in Figure 4 is the complete function table for the CD74HC4511E, a display driver made by Texas Instruments. Here D<sub>0</sub>-D<sub>3</sub> are the 4-bit inputs and a-g are the outputs controlling the display. LE, BL, and LT are all unique to the chip and used to perform various tests, they are of no concern for this example.

FUNCTION TABLE														
INPUTS								OUTPUTS						
LE	BL	LT	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	a	b	c	d	e	f	g	DISPLAY
X	X	L	X	X	X	X	H	H	H	H	H	H	H	8
X	L	H	X	X	X	X	L	L	L	L	L	L	L	Blank
L	H	H	L	L	L	L	H	H	H	H	H	H	L	0
L	H	H	L	L	L	H	L	H	H	L	L	L	L	1
L	H	H	L	L	H	L	H	H	L	H	H	L	H	2
L	H	H	L	L	H	H	H	H	H	L	L	H	H	3
L	H	H	L	H	L	L	L	H	H	L	L	H	H	4
L	H	H	L	H	L	H	H	L	H	H	L	H	H	5
L	H	H	L	H	H	L	L	L	H	H	H	H	H	6
L	H	H	L	H	H	H	H	H	H	L	L	L	L	7
L	H	H	H	L	L	L	H	H	H	H	H	H	H	8
L	H	H	H	L	L	H	H	H	H	L	L	H	H	9
L	H	H	H	L	H	L	L	L	L	L	L	L	L	Blank
L	H	H	H	L	H	H	L	L	L	L	L	L	L	Blank
L	H	H	H	H	L	L	L	L	L	L	L	L	L	Blank
L	H	H	H	H	L	H	L	L	L	L	L	L	L	Blank
L	H	H	H	H	H	L	L	L	L	L	L	L	L	Blank
L	H	H	H	H	H	H	L	L	L	L	L	L	L	Blank
H	H	H	X	X	X	X	†	†	†	†	†	†	†	†

X = Don't care  
† Depends on BCD code previously applied when LE = L  
NOTE: Display is blank for all illegal input codes (BCD > HLLH).

Figure 4: Display Driver Function Table

Seen below in Figure 5 is an example of a wiring diagram for a seven-segment display using a LDS-C303RI and the CD74HC4511E. This circuit could be connected to a simple switch based input that would control the count manually, or it could be appended to the end of a clocked counter circuit using JK Flip-Flops for the input. Additionally, for a more complex counting scheme the circuit could be hooked up to a microcontroller and be customized to specifications via programming.

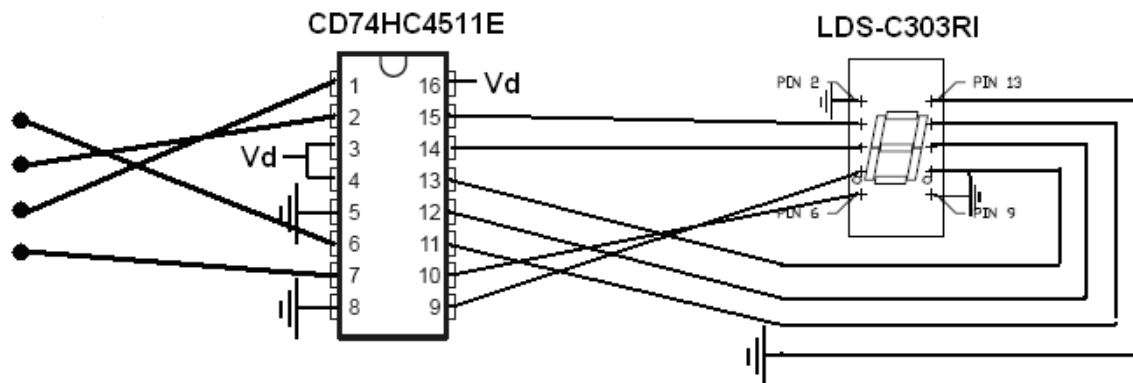


Figure 5: Schematic

## Discussion

Seven-segment displays are very convenient to use and simple to design. The specific application of using a seven-segment display as a method of showing a numerical output for a binary counter was discussed here. However, the basic framework provided here should yield other applications as well. The displays are highly versatile and with proper input can display a variety of numbers, letters, and figures. If the case occurs where multiple digits are needed to be displayed, then by expanding on the applications provided serial inputs should be found that allow control of a set of digits from only a few inputs.

## References

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# Appendix

