UNIVERSITI TEKNOLOGI MALAYSIA

Using BCD-to-Seven-Segment Decoders

Digital Electronics Laboratory Task Force

Abstract
Seven-segment displays are very common output devices. We collect and share some materials from the Internet on using with TTL decoders/drivers.

[1] *Department of Electronic and Computer Engineering, School of Electrical Engineering, Faculty of Engineering*

Seven-Segment Displays

Seven-segment LED (Light Emitting Diode) displays provide a very convenient way of displaying information or digital data in the form of numbers, letters or even alphanumerical characters.

Typically 7-segment displays consist of seven individual coloured LED's (called the segments), within one single display package. In order to produce the required numbers on the display the correct combination of LED segments need to be illuminated.

A standard 7-segment LED display generally has eight (8) input connections, one for each LED segment and one that acts as a common terminal or connection for all the internal display segments. Some single displays have also have an additional input pin to display a decimal point in their lower right or left hand corner.

The 7-segment LED digital displays can be either common cathode or common anode as depicted in Fig. 1. The segments are identified as 'a' to 'g'.

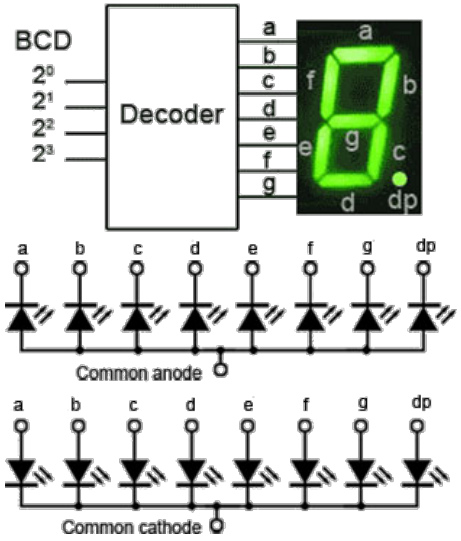

Figure 1. *Common cathode vs common anode.*

The Common Cathode (CC) Display

In the common-cathode display, all the cathode connections of the LED's are joined together to logic "0" or ground. The individual segments are illuminated by application of a "HIGH", logic "1" signal to the individual anode terminals.

Common Common Anode (CA) Display

In the common-anode display, all the anode connections of the LED's are joined together to logic "1" and the individual segments are illuminated by connecting the individual cathode terminals to a "LOW", logic "0" signal.

Decoder/Driver Chips

Three TTL devices specifically designed to be used with 7-segment displays are 74LS47, 74LS48 and 74LS49. Fig. 2 shows the pinouts of these device, while Table 1 compares the important characteristics.

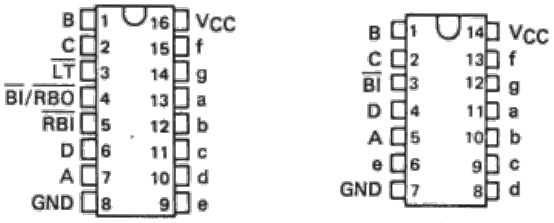

Figure 2. *Pinout of driver chips (a) 74LS47 and 74LS48, (b) 74LS49.*

Table 1. *Differentiating characteristics of BCD-to-7-segment decoders.*

Device	Active Level	Sink Current	Max Voltage	Lamp-Test Input	Ripple Blanking	Blanking Input
74LS47	low	24 mA	15 V	Yes	Yes	No
74LS48	high	6 mA	5.5 V	Yes	Yes	No
74LS49	high	8 mA	5.5 V	No	No	Yes

They are called decoder chips because they decode the BCD inputs and converts the inputs to another form. They are also called driver chips because the have higher current capability than regular TTL chips.

Each of the three chips have its own advantages. The 74LS47 has the highest sink current capability. LEDs connected to it will be the brightest due to more current flowing in each LED. This device also uses negative logic, therefore must be used with common-anode displays. This is the device we will be discussing in further detail.

The 74LS48 and 74LS49 use positive logic, so they are used with common-cathode displays. Their lower current capability means the displays are dimmer. However, high-efficiency LEDs can overcome this disadvantage. The 74LS49 is the simplest to use but lacks the leading/trailing-zero suppression found in 74LS47 and 74LS48.

The 74LS47 Device

Table 2 lists the pin function for the 74LS47 device (as well as 74LS48 and 74LS49).

Table 2. *Pin descriptions for all chips.*

Pin Names	Description
A0-A3	BCD Inputs
$\overline{\text{RBI}}$	Ripple Blanking Input
$\overline{\text{LT}}$	Lamp Test input
$\overline{\text{BI/RBO}}$	Blanking Input or Ripple Blanking Output
$\overline{\text{a}}$-$\overline{\text{g}}$	Segment Outputs

The basic way of using the 74LS47 is by setting inputs RBI, LT and BI/RBO all to high. The BCD data enters through inputs A-D. The outputs a-g then controls the segments. See Fig. 3.

The 74LS47 chip correctly displays BCD digits only, i.e. 0000 through 1001. Values from 1010 to 1110 produce meaningless displays. The value 1111 blanks all segments. This is shown Fig. 4.

IMPORTANT: all segments must connected through a **current limiting resistor**. Otherwise so much current will flow that shall destroy the LED instantly.

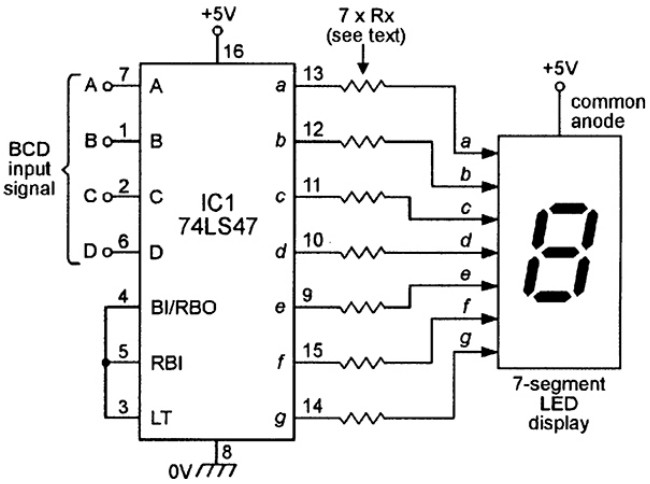

Figure 3. *Connecting a 74LS47 IC to a common-anode LED display.*

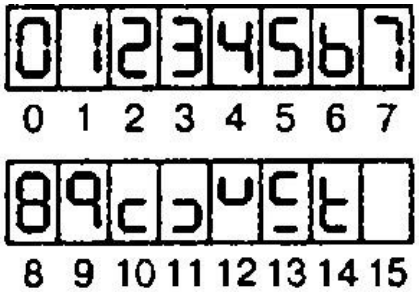

Figure 4. *Numerical designations - resultant displays.*

Calculating Resistor Value

Calculating the value of the current limited resistor requires only basic understanding of Ohm's law as shown in Fig. 5.

An LED has a typical forward voltage drop (V_f) of 2 V to 2.2 V (refer to datasheet for exact value). The current through each LED segment (I_f) is usually around 15 mA - 20 mA. In our example, let $V_f = 2V$ and $I_f = 15mA$. Therefore the value of the current limiting resistor is

$$\begin{aligned} R &= \frac{V_{cc} - V_f}{I_f} \\ &= \frac{5-2}{0.015} \\ &= 200 \end{aligned}$$

Hence, a 200Ω resistor is required, or 220Ω to the nearest higher available value.

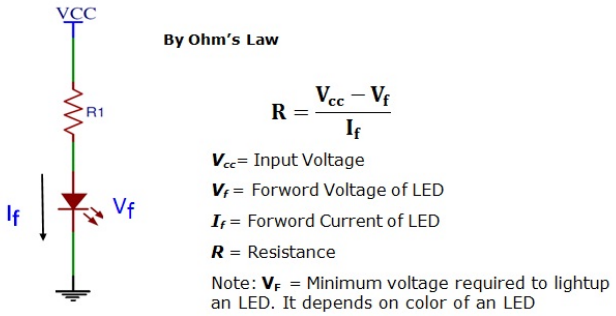

Figure 5. *Calculation of current limiting resistor.*

Zero-Suppression

Zero-suppression means erasing redundant zeroes to increase readability. Instead of displaying 0007 for example, only the the digit 7 is displayed. To do this, the BI/RBO pin of the 74LS47 and 74LS48 is used. Leading-zero suppression cannot be applied on thee 74LS49 due to the missing input.

Fig. 6 shows how to connect the ripple-blanking terminals to give leading zero suppression on the first three digits of a four-digit display. When the BI/RBO terminal on the 74LS47 is pulled low, all outputs are blanked; this pin also functions as a ripple-blanking output terminal.

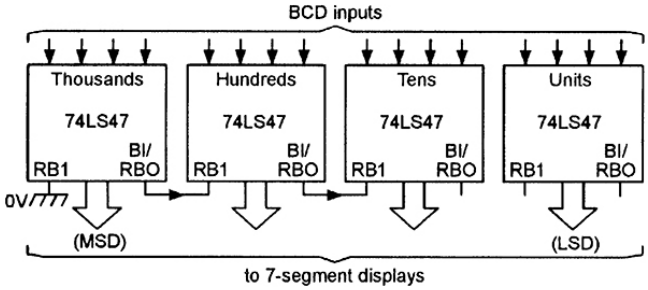

Figure 6. *Method of applying leading-zero suppression to the first three digits of a four-digit display using 74LS47 ICs.*

Acknowledgments

Thanks to the supervisors of digital lab 2018/2019-2 for constructive comments.

References

[1] Munim Zabidi et al. *A Book on Digital Electronics*. Universiti Malaysia Pahang, 2019.

[2] *My First FPGA Design Tutorial*. Altera. July 2008. URL: https://www.intel.com/content/dam/www/programmable/us/en/pdfs/literature/tt/tt_my_first_fpga.pdf.

[3] Ray Marston. "Using Seven-Segment Displays - Part 1". In: *Nuts and Volts* (May 2001). URL: https://www.nutsvolts.com/magazine/article/using-seven-segment-displays-part-1.

[4] Ray Marston. "Using Seven-Segment Displays - Part 2". In: *Nuts and Volts* (June 2001). URL: https://www.nutsvolts.com/magazine/article/using-seven-segment-displays-part-2.