Driving LEDs with Xilinx CPLDs

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Summary

Light-Emitting Diodes (LEDs) are commonplace on the modern day Printed Circuit Board (PCB). Whether they are indicating status, activity or some other function, they need to be driven by a device that can provide sufficient current to illuminate them. Traditionally, LED driver devices have been used for this purpose, but this application note aims to demonstrate how that functionality can be incorporated into Xilinx CPLDs to save both cost and valuable board space.

Introduction

Specific driver devices are commonly used to drive common-anode LEDs, including seven segment displays. Figure 1 shows a typical configuration. The output pin of the driver device connects to the cathode of the LED, and the anode is connected to V_{CC}. When a low signal is applied to the output, the driver sinks current and the LED illuminates. Each LED will require a different threshold current to illuminate, but some common examples are found in Table 1 below. As discrete LED Driver ICs integrate more features, their costs rise.

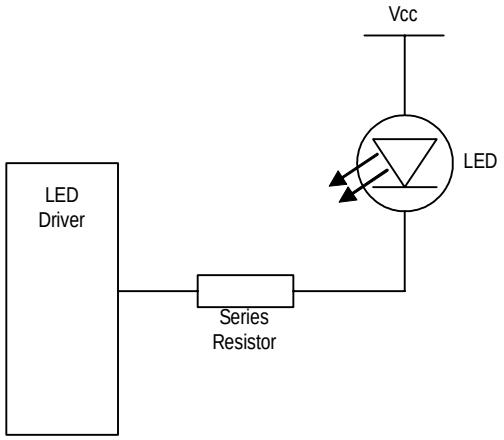

Figure 1: **Traditional LED Driver Setup**

Table 1: **Partial List of Available LED Drivers**

LED Driver Chip	Features
AD8240	Automotive LED Driver with Lamp Failure Detection and PWM Input
ADM8846	LED Driver for White LED LCD Backlights (Cell Phone)
FAN5609	LED Driver with DC/DC Converter
LT1932	Constant Current DC/DC LED Driver
MAX6956	LED Static Display Driver
ICM7218C	8-digit 7-segment Display Driver
TB62701	16-digit LED Driver with SIPO Shifter
TB62705	8-digit LED Driver with SIPO Shifter

Using Xilinx CPLDs to Drive LEDs

Typical Circuit

Xilinx CPLDs can be used instead of traditional LED driver devices to save both cost and board space. Figure 2 shows a typical circuit diagram. A current limiting resistor is typically placed between the output of the CPLD and the cathode of the LED. When the CPLD drives low, the LED illuminates.

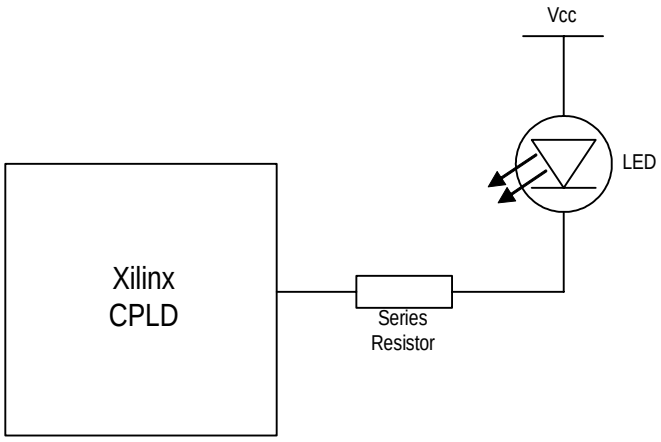

Figure 2: **Xilinx CPLD Driving an LED**

CPLD Output Drive

Table 2 shows the current that can be delivered by a single output of a Xilinx CPLD when driving low. The values are taken from the individual data sheets of each Xilinx CPLD family. You will find the information under the DC Electrical Characteristics sections.

Table 2: **Xilinx CPLD Drive Strengths**

Xilinx CPLD Family	Current Drive Strength
XC9500 (5V)	24 mA
XC9500 (3.3V)	10 mA
XC9500XL	8 mA
XC9500XV	8 mA
CoolRunner™ XPLA3	8 mA
CoolRunner™-II	8 mA

From Table 2, it is clear that Xilinx CPLDs are ideal for driving LEDs that require up to 8-10 mA to illuminate.

Ganged Output Circuits

In cases where 8 mA is insufficient to illuminate an LED, multiple outputs can be tied together to offer double or triple the current sink of a single output. See Figure 3.

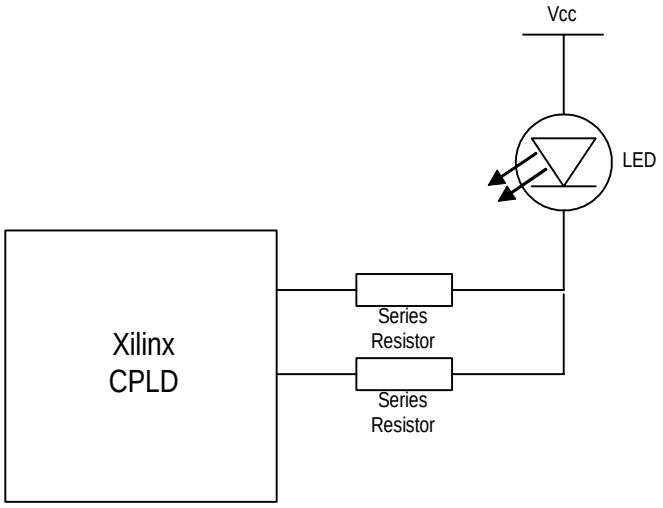

Figure 3: **Gang Multiple Outputs Together for Greater Drive Strength**

Display Drivers

Using the example of an 8-digit 7-segment display driver, we can see a typical circuit design in Figure 4.

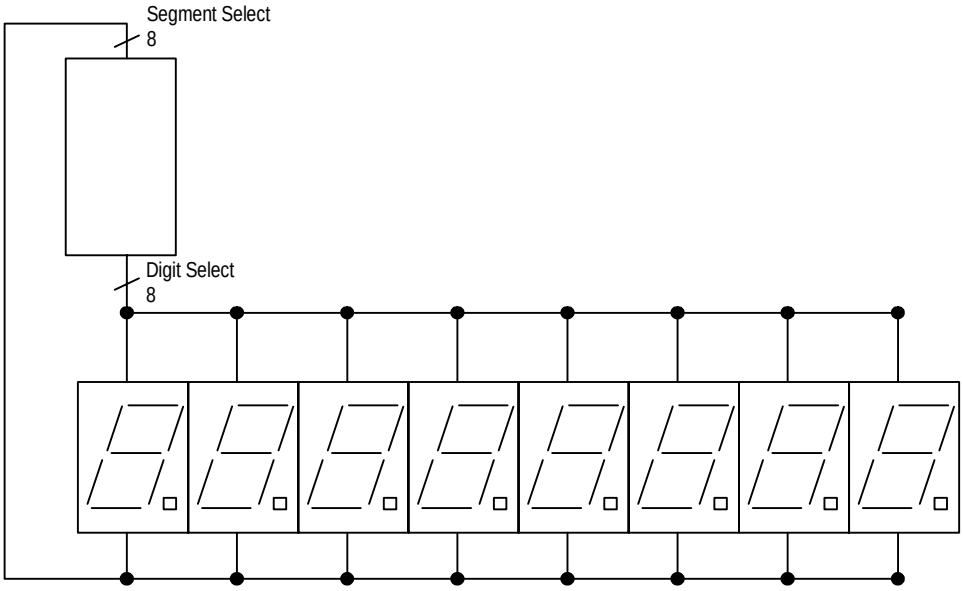

Figure 4: **8-digit 7-segment Display Driver with Data Interface**

Figure 5 shows how a Xilinx CPLD can be used instead of a discrete display driver. It is very likely that a Xilinx CPLD will have spare capacity after implementing an LED display driver; this capacity can be used for other board functions. For example, the functions of other discrete components on the board can be incorporated into the CPLD. The logic that fills the remaining capacity of the CPLD does not have to interface at the same level. Because of the split rail V_{CCIO} available on all CoolRunner-II devices, the CPLD can interface with components of at

least two voltages simultaneously (1.5V, 1.8V, 2.5V or 3.3V). For more information on how to incorporate discrete components, see White Paper 202. For more information on the use of split rail I/O banking, see the **CoolRunner-II Family Data Sheet**.

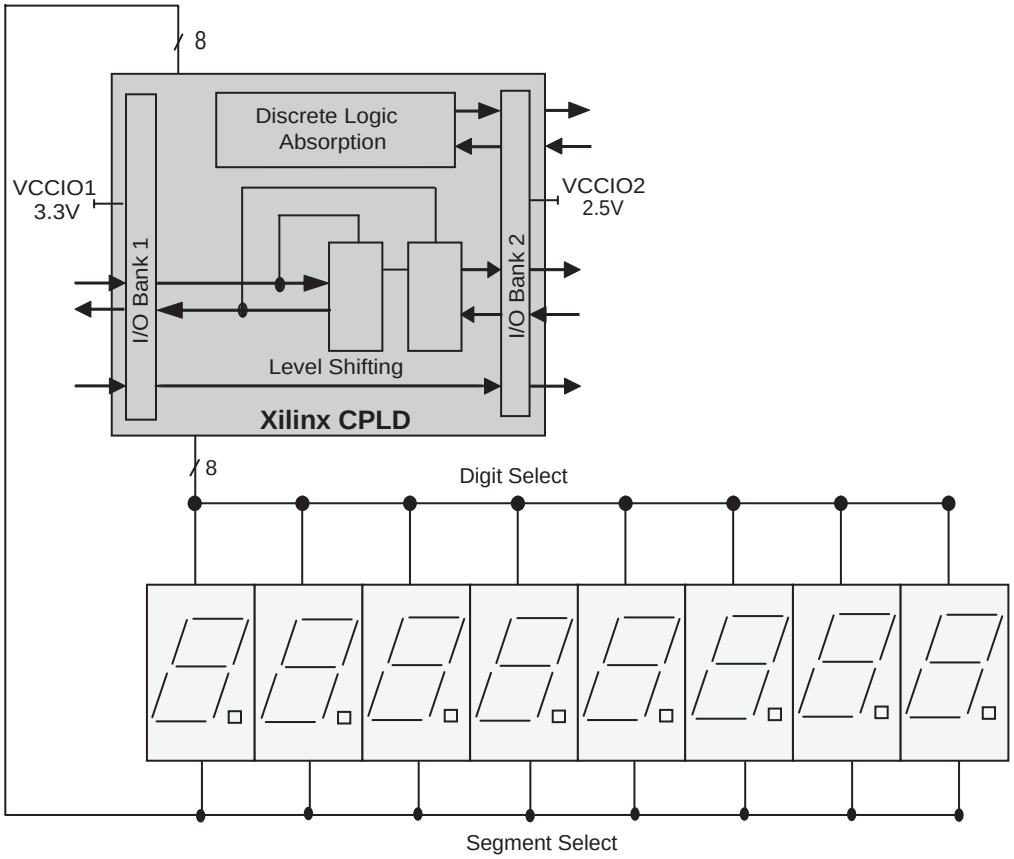

Figure 5: **Xilinx CPLD Used as an 8-digit 7-segment Display Driver with Remaining Capacity Used to Incorporate Discrete Logic and Interface to Different Voltage Levels**

Typical Versus Worst Case Drive Values

The values of V_{OL} for the different Xilinx CPLD devices are mentioned in the data sheets in a format similar to Table 3.

Table 3: **Output Low Voltage for the XC2C64A (LVCMOS 3.3V and LVTTL 3.3V DC Voltage Specifications Shown)**

Symbol	Parameter	Test Conditions	Min.	Max.	Units
V_{OL}	Low Level Output Voltage	I_{OL} = 8 mA, V_{CCIO} = 3V	-	0.4	V
		I_{OL}= 0.1 mA, V_{CCIO} =3V	-	0.2	V

These numbers are taken under worst case conditions and, therefore, we can guarantee that the devices will be able to meet this specification. However, it should also be noted that the output buffers can probably drive significantly more current than worst case conditions.

To find out how much current the output buffers can typically supply, the I/V curves for the devices are needed. They can be found in **XAPP150** for the XC9500/, XC9500XL, XC9500XV

and CoolRunner XPLA3 families. For CoolRunner-II device I/V curves, look in the individual CoolRunner-II datasheets. They appear as shown in Figure 6.

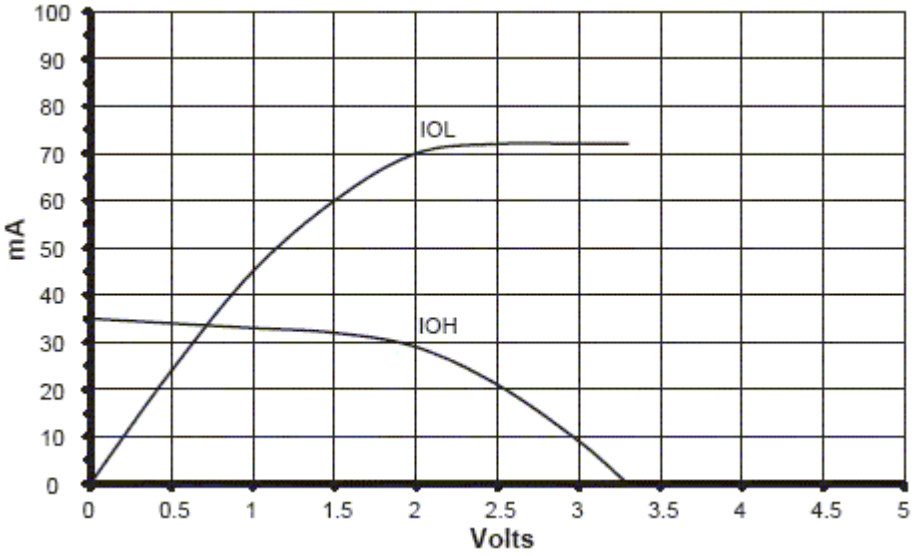

Figure 6: **I/V Curve for the XC9500XL Family**

Under the typical conditions shown above, it is evident that at 0.4V the output low current (I_{OL}) is as high as 20 mA. Of course, these numbers are typical and **cannot be guaranteed under all circumstances**.

Guidelines for Driving Multiple LEDs with the Same CPLD

As mentioned earlier, it is possible to tie two or more outputs together to double or triple (and et cetera) the drive strength for power hungry LEDs.

If multiple LEDs are to be driven by individual pins on the same CPLD, there are a few guidelines that may be helpful. These help to reduce the effect of ground bounce due to multiple outputs switching simultaneously, and hence avoid corrupting the operation of other devices driven by the CPLD.

- Try to stagger the switching of the outputs. LEDs are almost always used for indicating status to a human. Human reactions are sufficiently slow that delaying the output switching by a small amount of time will not be noticable
- Try to skew the switching of the LEDs slightly using the adjustable fast/slow slew rate of the outputs
- If using an XC9500, XC9500XL, or XC9500XV device, try putting some of the macrocells into low power mode, and leave others in high frequency mode. This will have the effect of skewing the switching outputs slightly
- Try to distribute the pins driving LEDs evenly around the device package so as to locate them next to Ground pins. The individual device datasheet has a listing of the pin locations on each package.

Conclusion

Xilinx CPLDs can easily take the place of discrete LED driver devices. They can deliver sufficient current to illuminate most LEDs, but if more current is required, multiple outputs can be tied together. The current drive strength of the different Xilinx CPLDs can be found in the device data sheets available on the Xilinx website. However, under typical conditions, the Xilinx CPLDs can output more current.

Additional Information

[CoolRunner-II Data Sheets, Application Notes, and White Papers]

[Other CPLD Data Sheets, Application Notes and White Papers]

[Device Packages]

Revision History

The following table shows the revision history for this document.

Date	Version	Revision
04/08/05	1.0	Initial Xilinx release.