Implementing LED Drivers in MAX and MAX II Devices

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Introduction

Discrete LED driver chips are common on many system boards. Altera® MAX® II, MAX 7000B, MAX 7000A, MAX 3000A, and MAX 7000S devices offer unique capabilities that allow you to integrate single or multiple LED driver chips into a single device. This application note explains how to implement LED drivers in MAX and MAX II devices.

Commercial LED Driver Chips

Many LEDs, such as the seven-segment display, are common-anode LEDs. The LEDs anode connects to V_{CC} and each cathode connects to an output pin of the current-sinking LED driver chip. The driver chip sinks the DC current required to drive the display, and the LED turns on when the driver chip's output pins drive low. Current-regulating circuits are implemented inside the LED driver chips.

Current-sinking LED drivers are more common than current-sourcing drivers are. Table 1 lists some common LED driver chips manufactured by Texas Instruments, National Semiconductor, and Toshiba. The manufacturer data sheets provide additional information about LED driver chips.

Table 1. Current-Sinking LED Driver Chips

LED Driver Chip	Description
Texas Instruments	
TLC5905	LED driver with shift registers, data latch, and constant current circuitry
TLC5910	LED driver with shift registers, data latch, on-chip phase-locked loop (PLL) for gray scale generation and constant current
TLC5911	LED driver with shift registers, data latch, on-chip PLL for gray scale generation and constant current
TLC5921	LED driver with shift register, data latch, and current-sink constant current circuitry
National Semiconductor	
DS8874	9-digit shift input LED driver
DS8863	**MOS**-to-LED 8-digit driver
DS8963	**MOS**-to-LED 8-digit driver
Toshiba	
TB62701AN	16-bit constant current LED driver with shift register and latch functions
TB62705	8-bit constant current LED driver with shift register and latch functions
TB62706	16-bit constant current LED driver with shift register and latch functions
TB62707	8-bit constant current LED driver with latch functions

Implementing LED Drivers in MAX and MAX II Devices

When using a MAX or MAX II device as an LED driver chip, place a current-limiting resistor between the cathode side of the LEDs diode and the MAX or MAX II device I/O. The LEDs anode is tied to V_{CC}, and is turned on when the MAX or MAX II device I/O drive low.

The most important aspect of an LED driver chip is the amount of current it has to sink. Many LED applications call for a current sink specification of 5 to 15 mA. Because MAX II, MAX 7000B, MAX 7000A, MAX 3000A, and MAX 7000S devices can sink up to 50 mA per pin, these MAX and MAX II device families can directly integrate commercial current-sinking LED driver chips.

Table 2 shows the maximum sink current per pin for MAX and MAX II devices.

Table 2. Maximum Sink Current for MAX and MAX II Devices

MAX or MAX II Device	Maximum Sink Current Per Pin	Unit
MAX II	25 *(1)*	mA
MAX 7000S	25	mA
MAX 7000A/AE	25	mA
MAX 7000B	50	mA
MAX 3000A	25	mA

Note to Table 2:

(1) 25mA is the absolute maximum rating for the sink current per pin in the MAX II device. Device operation at the absolute maximum ratings for extended periods of time may have adverse affects on the device. For the absolute maximum ratings of the MAX II device family, refer to the *DC and Switching Characteristics* chapter of the *MAX II Handbook* .

Although a single pin from a MAX 7000B device can sink up to 50 mA of DC current, each GNDIO group can concurrently sink up to 200 mA of current due to the support of advanced I/O standards.

Table 3 shows the maximum source current for a set of I/O pins between any two VCCIO pads or maximum sink current between any two GNDIO pads (regardless of the I/O bank) in MAX and MAX II devices.

Table 3. Maximum Source Current for Each VCCIO Group and Maximum Sink Current for Each GNDIO Group in MAX and MAX II Devices

MAX or MAX II Device	Maximum Source Current Per VCCIO Group	Maximum Sink Current Per GNDIO Group	Unit	MAX or MAX II Device
MAX II	170	130	mA	MAX II
MAX 7000S	244	160	mA	MAX 7000S
MAX 7000A/AE	224	167	mA	MAX 7000A/AE
MAX 7000B	380	200	mA	MAX 7000B
MAX 3000A	224	167	mA	MAX 3000A

For example, the EPM240 device has six GNDIO pads, which provide six I/O regions that can sink up to 130 mA. If you need to sink 15 mA for the outputs, you can have eight outputs per region. With the six regions of I/O between GNDIO pads, there are 48 possible outputs, each sinking 15 mA.

For more information about GNDIO grouping, refer to the *MAX II Device Pin-Out Files*, and the *MAX 7000B Device Pin-Out Files*. These files are on the *Pin-Outs* page of the *Literature* section of the Altera website (**www.altera.com**).

Implementing LED Driver Chips

Figure 1 shows an example of an application circuit with the Toshiba TB62701AN LED, its 16-bit constant current LED driver with shift registers and latch functions. The 16 outputs of the circuit sink current for two seven-segment displays. You can implement the LED driver chip in the circuitry using only one MAX or MAX II device, provided the device has enough register and pin capabilities to replace the functionality of the entire LED driver chip.

Figure 1. Application Circuit Example Using the Toshiba TB62701AN LED Driver Chip

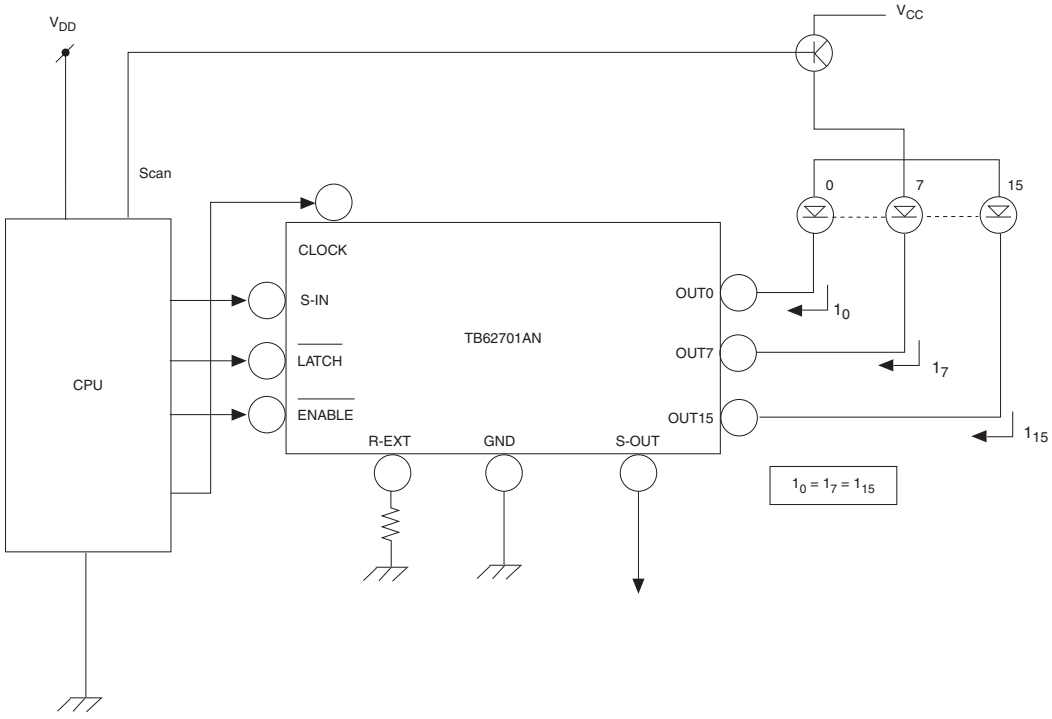
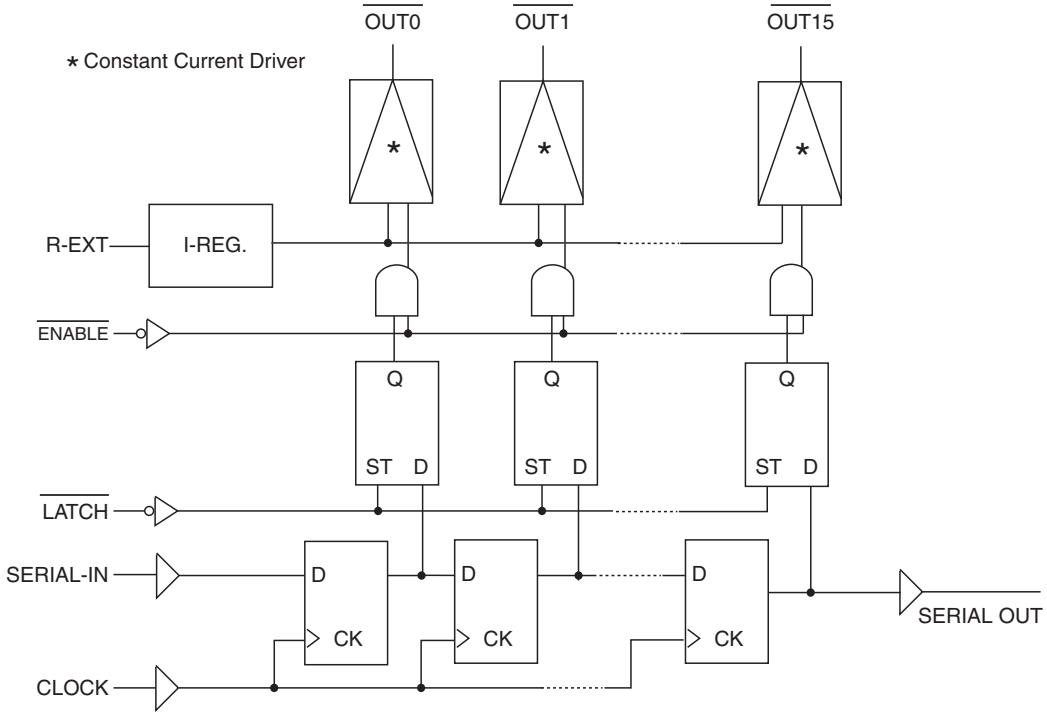


Figure 2 shows a block diagram of the Toshiba TB62701AN LED driver chip. The Altera LED driver reference design has the same architecture as the TB62701AN. It consists of three main categories:

- 16-bit serial shift registers
- 16-bit latches
- An array of AND gates

The data from serial-in that determines which LED to be driven is shifted serially into the 16-bit shift registers for every low-to-high transition on the clock signal. With a high-to-low transition on the latch signal, the 16-bit data, which stores the 16-bit shift registers, is latched into 16-bit latches to drive the LED when the enable signals drive low.

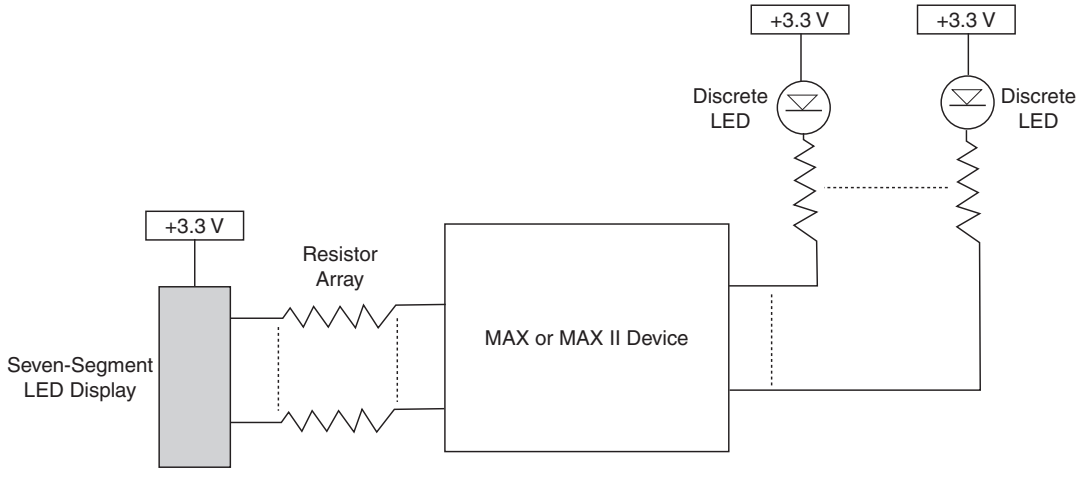
Figure 2. Block Diagram of the Toshiba TB62701AN LED Driver Chip



The Altera LED driver reference design only emulates the functioning of the Toshiba TB62701AN. To implement the external resistor (R-EXT) and the current-regulating circuit, place an individual current-limiting resistor between the cathode side of the LEDs diodes and the I/O pins of the MAX or MAX II device.

Figure 3 shows the implementation of the LED driver using a MAX or MAX II device.

Figure 3. Implementing the LED Driver Using a MAX or MAX II Device



The right hand side of Figure 3 shows the connection between discrete LEDs and the I/O pins of a MAX or MAX II device, while the left hand side shows the connection between a seven-segment LED and the MAX or MAX II device. The output pins of the MAX or MAX II device connected to the LEDs are driven low to turn on the LEDs.

To download the LED drivers reference design, refer to the design files listed with *AN 286: Implementing LED Drivers in MAX and MAX II Devices*, on the *Literature* section of the Altera web site (**www.altera.com**).

Design Implementation

You can target the LED drivers reference design in MAX II (EPM240T100C3) or MAX 3000A (EPM3064ATC44) devices using the Quartus® II software. The design utilization in MAX II and MAX 3000A devices is shown in Table 4 and Table 5.

Table 4. EPM240 LED Drivers Design Utilization

Resource	Available	Used	Utilization (%)
Logic Cells	240	33	1
Flips Flops	240	17	1
I/O pins	65	21	32

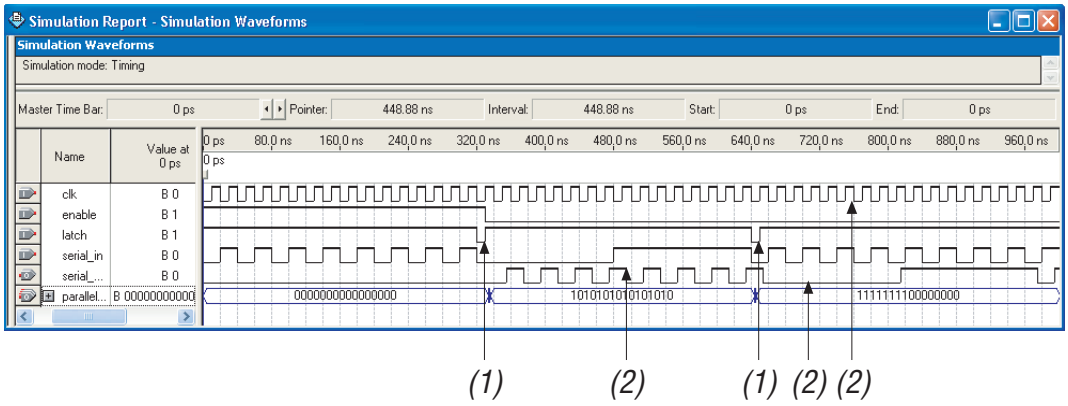
Table 5. EPM3064A LED Drivers Design Utilization

Resource	Available	Used	Utilization (%)
Macrocells	64	49	76
Flips Flops	64	17	26
I/O pins	34	21	61

Design Verification

You can achieve design verification for the LED driver by using the Quartus II software. MAX II and MAX 3000A design verification occurs in both functional and timing simulations. Figure 4 shows the timing simulation of the LED drivers.

Figure 4. LED Driver Timing Simulation in the Quartus II Software



Notes to Figure 4:

(1) The high-to-low transition of the latch signal latches the serially-shifted input to drive the LED.

(2) The low signal enables output to drive the LED.

As shown in Figure 4, the LED driver is first configured so that the `parallel_out` drives an output value of `1010101010101010`. In the final configuration, the `parallel_out` output value is `1111111100000000`.

Advantages

The major advantage of implementing LED drivers with MAX or MAX II devices is that MAX or MAX II devices can also integrate other user logic using their programmable logic. If you have to implement user logic on the same board as the LED driver, additional devices are required if you use a commercial LED driver chip. However, if a MAX or MAX II device is used, additional chips would not be required, saving valuable board space and reducing the overall system cost.

Conclusion

Altera's MAX and MAX II devices not only provide solutions to the communications and industrial fields, but also offer simple solutions to integrate commodity products such as LED drivers. MAX and MAX II devices can integrate LED drivers and provide user logic, which saves on board space and reduces overall system cost.

Referenced Document

This application note references the following documents:

- *DC and Switching Characteristics* chapter of the *MAX II Handbook*
- *MAX II Device Pin-Out Files* on the *Pin-Outs* page of the *Literature* section of the Altera website (**www.altera.com**)
- *MAX 7000B Device Pin-Out Files* on the *Pin-Outs* page of the *Literature* section of the Altera website (**www.altera.com**).

Revision History

Table 6 shows the revision history for this FrameMaker template.

Table 6. Template Revision History

Date and Revision	Changes Made	Summary of Changes
October 2008 version 2.3	■ Added"Note to Table 2:" on page 2.	—

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