LED Driver Design for an Optical Transmitter and Illuminator

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Introduction

Light-emitting diodes (LEDs), as a more energy-efficient light source, may soon replace fluorescent and incandescent lighting. Unlike fluorescent and incandescent lighting, LEDs can also be used to transmit data at high speeds by modulating light. By leveraging this transition and this ability, this project aims to enable network connectivity wherever electrical lighting exists.

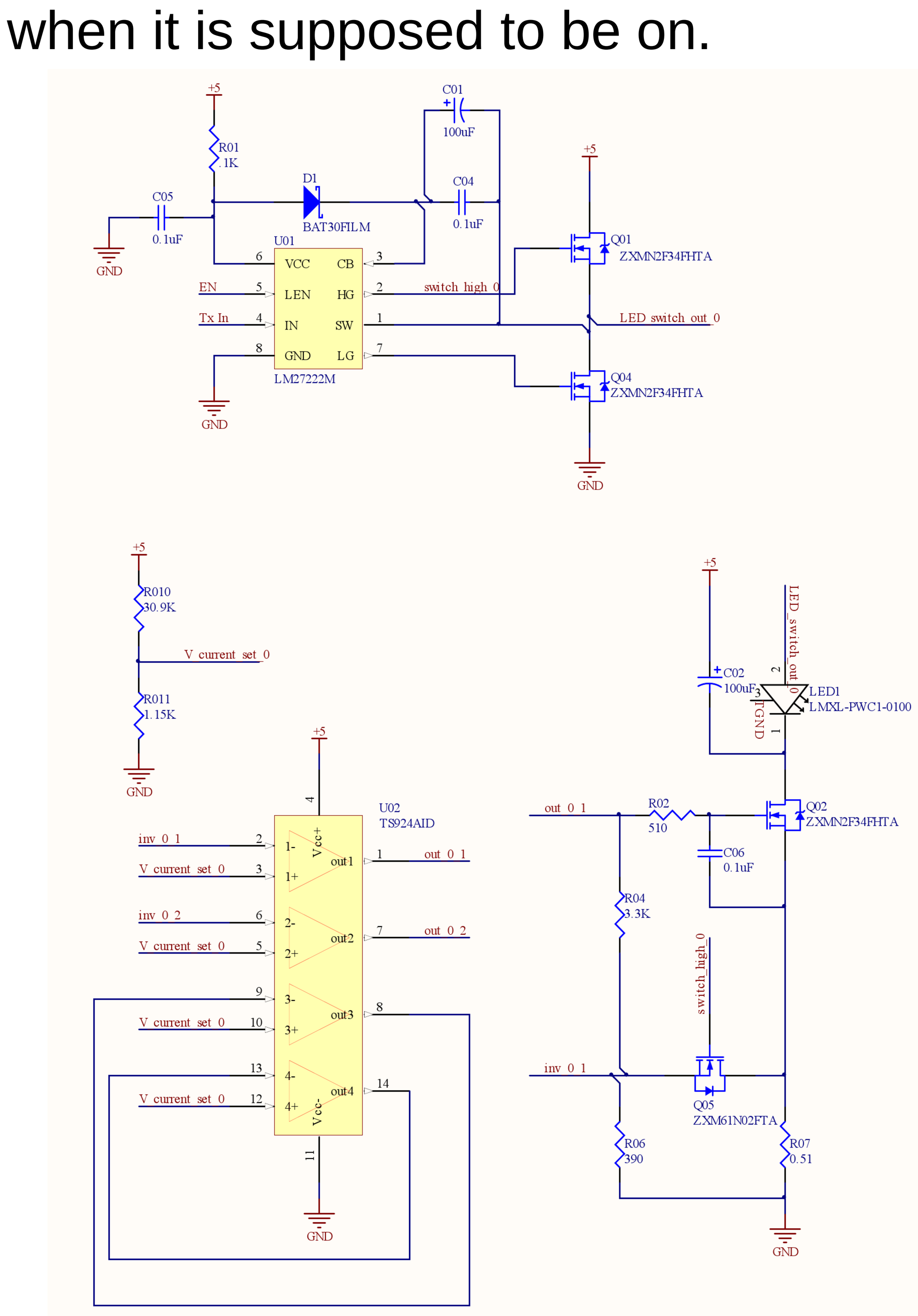
To do so, the LEDs must be driven with a large current to be sufficiently bright; this current must also be regulated to prevent damage to the LEDs and be switched quickly to enable high data rates.

Unfortunately, no off-the-shelf LED drivers were found to meet these requirements.

Approach Taken

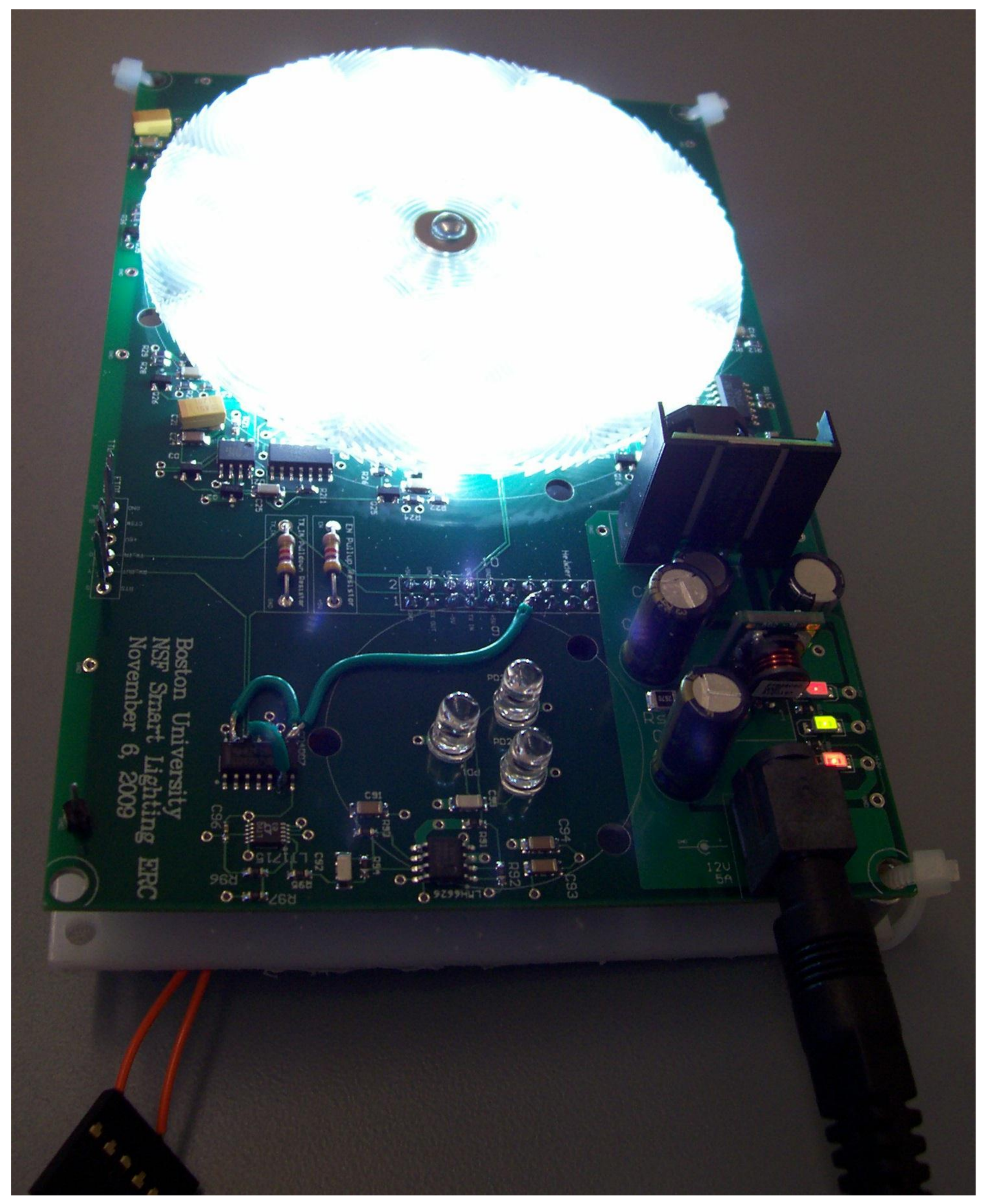
To fit this need, a custom LED driver was designed.

This design consists of two parts (as shown in the schematic below). The top third was designed to switch current toward and away from the LED; when the LED should be off, current is switched away from it to discharge any capacitance across the LED. The bottom part was designed to maintain the desired current through the LED when it is supposed to be on.

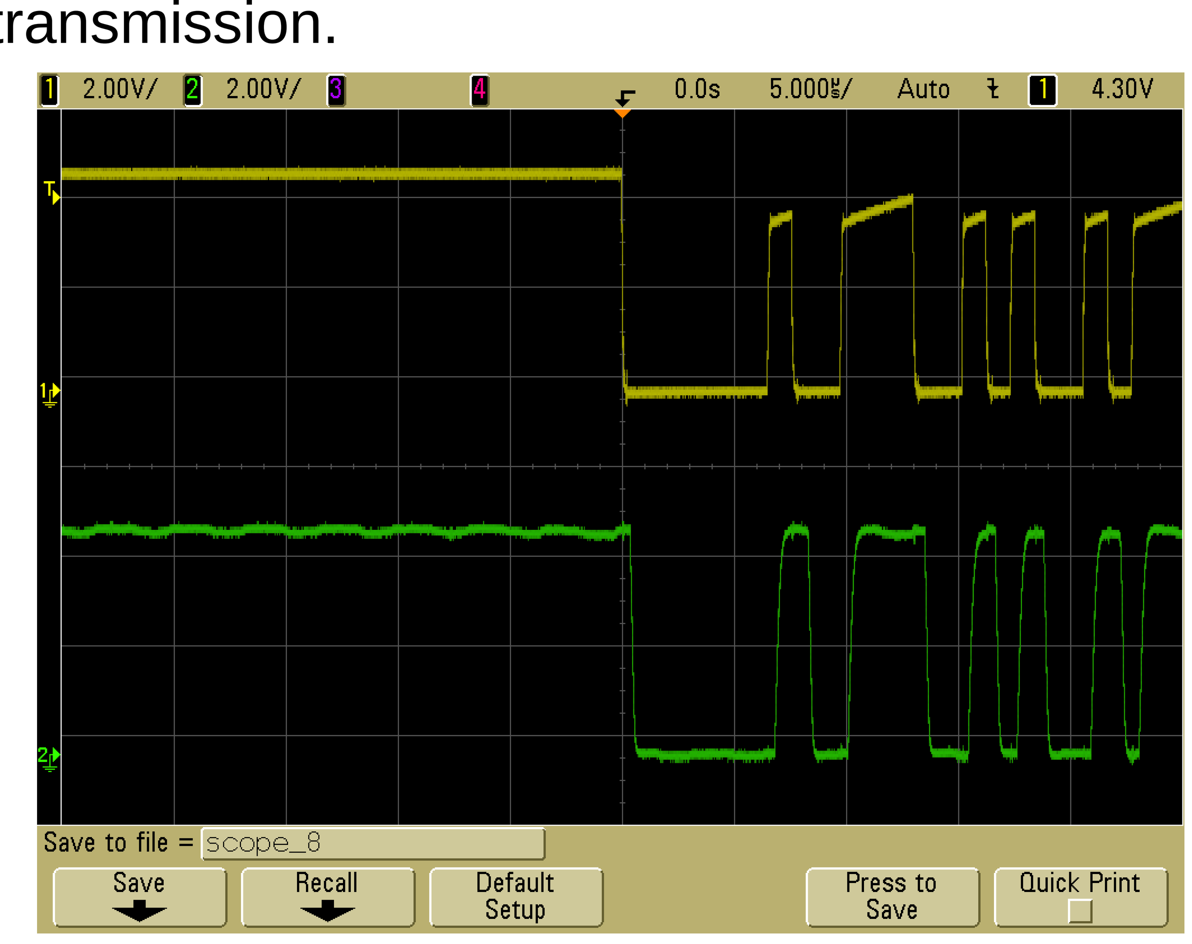


Results and Analyses

Shown in the photograph below is the transceiver transmitting data. The LED driver is in the top half of the photograph, lighting the white LEDs under a lens.



The typical performance of the transceiver at 1Mbps is shown below, with the transmitter input as the yellow signal and the receiver output as the green signal. The left half shows the operation when the transceiver is idle with the LEDs on and the right half shows data transmission.



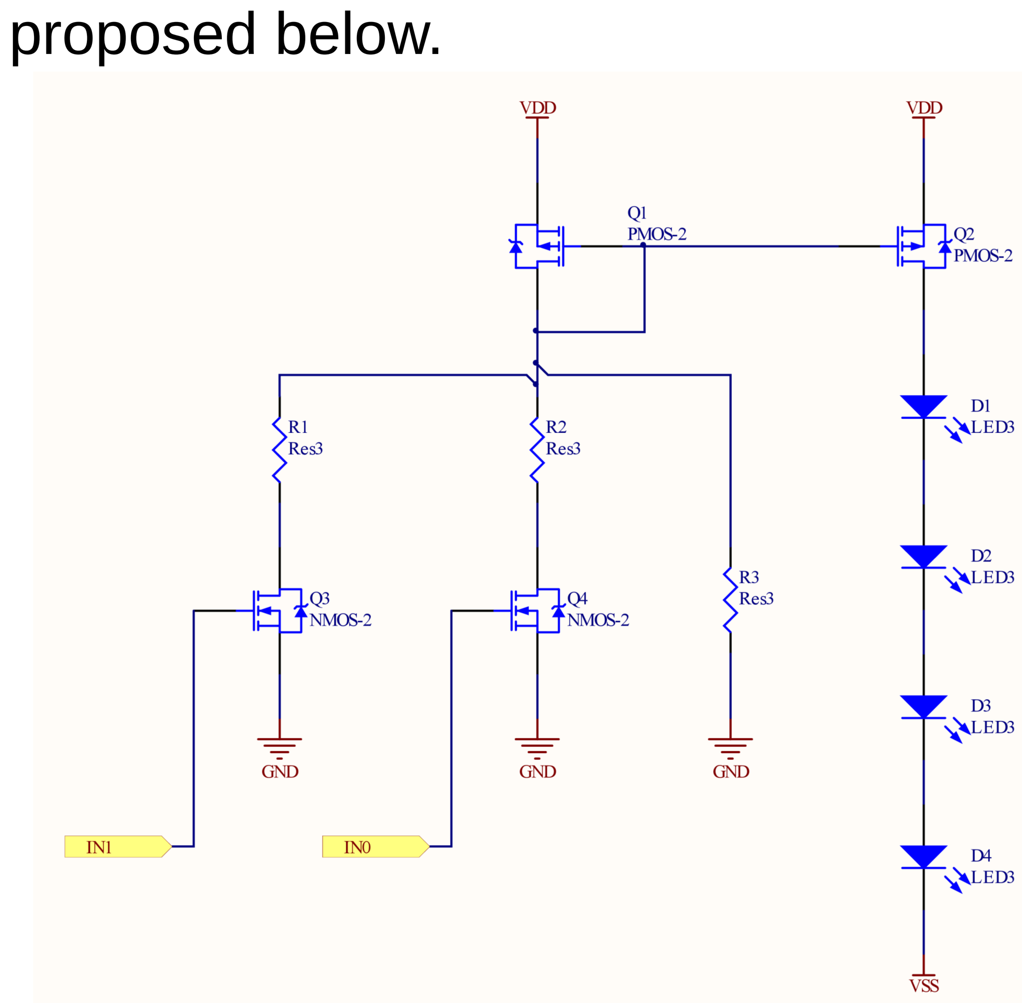
These waveforms hint at two areas of improvement. The first hint is that the input signal is not able to reach the upper rail when switching; this suggests that the LM27222 chip, to which the input goes, draws too much current.

The second hint is that a high signal is used to represent that no data is being sent; this behavior is standard for computer serial ports. Unfortunately, this behavior is also incompatible with the way the LM27222 operates: it must occasionally turn off to recharge.

Suggested Improvements

From the analyses, eliminating or replacing the LM27222 will improve the performance and reliability of the LED driver. The LM27222 was originally needed to prevent shoot-through across transistors Q01 and Q04, which would result in a short between the +5V rail and ground.

However, a different configuration of transistors can also be used to eliminate this risk. Such a design is proposed below.



This new design offers many benefits over the existing one:

- it supports multi-level signaling, allowing more data to be sent per cycle;
- it can pre-bias the LEDs, allowing them to switch on faster;
- each driver can support more LEDs, reducing the overall costs;
- its design is simpler, which reduces costs, improves reliability, and facilitates modeling.

The new design utilizes a current-mirror to regulate the current through the LEDs: the resistors and transistors Q3 & Q4 set the current through the left branch of the current mirror while Q1 and Q2 ensure that an equal current flows through the LEDs in the right.

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