Transceiver Modules for General Illumination and Free-Space Optical Communication

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Introduction

Light-emitting diodes (LEDs) can be used to both provide general illumination and transmit high-speed data. LEDs can have several advantages over alternatives in these two applications:

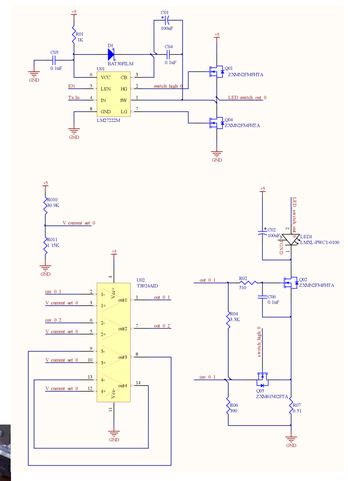
- higher luminous efficacy
- longer life
- less radio-frequency interference
- ability to direct and spatially restrict the signal

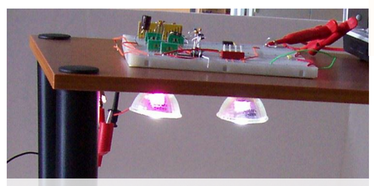
This project overcame the following challenges to use LEDs to simultaneously provide general lighting and high-speed data transmission:

- high-brightness LEDs require large currents,
- the current must be regulated for reliable operation, and
- the large, regulated current needs to switch quickly for high-speeds.

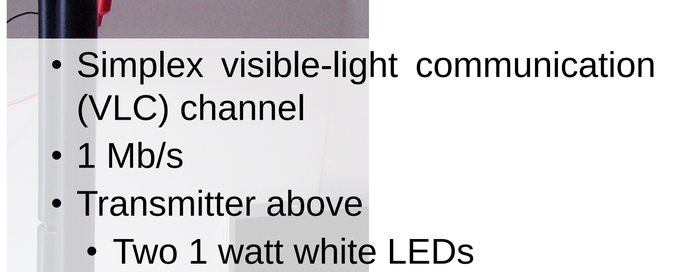
Previous Prototype

- Transmitter
  - Feedback loop using an operational amplifier
  - MOSFET driver input



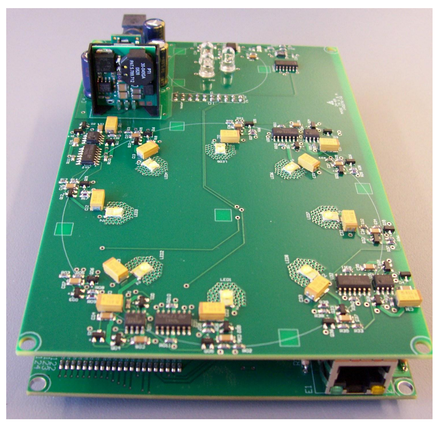


- Simplex visible-light communication (VLC) channel
- 1 Mb/s
- Transmitter above
  - Two 1 watt white LEDs
- Receiver below
- Complex wiring made system difficult to extend or reproduce

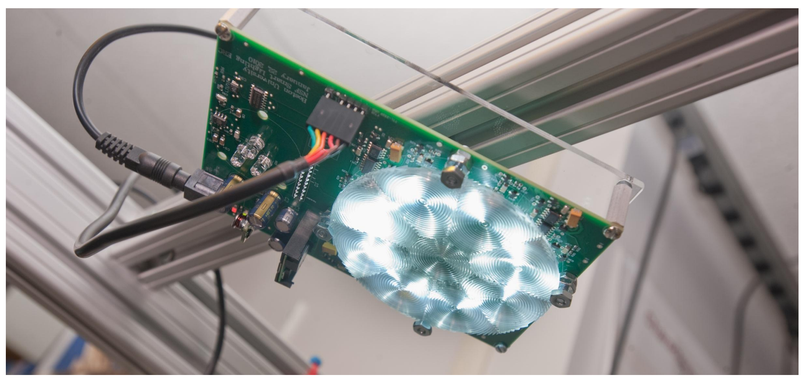


Revised as Printed Circuit Boards

In order to improve the ease of expanding and replicating the system, the transceiver was re-created on printed circuit boards (PCBs). Shown To the right is the transceiver, which drives eight high-power LEDs.



Each transceiver has both the transmitter and receiver on the same board, allowing for two-way communications.

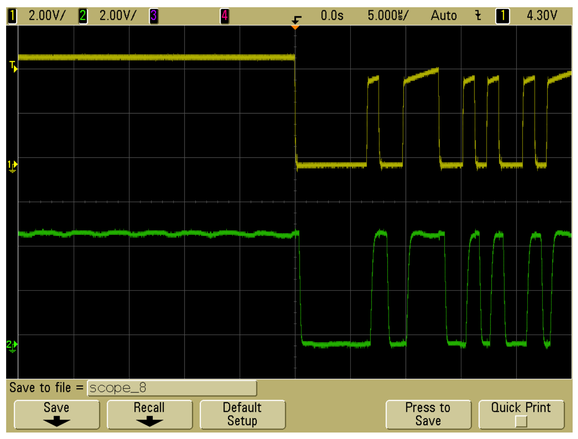


Shown above is the latest version of this transceiver in operation. It produces approximately 400 lumens.

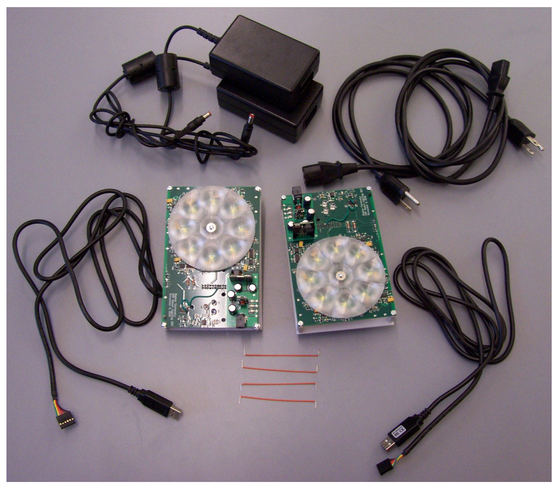
Shown below are the oscilloscope traces of a transmitter and a receiver communicating.

Transmitter input:

Receiver output:



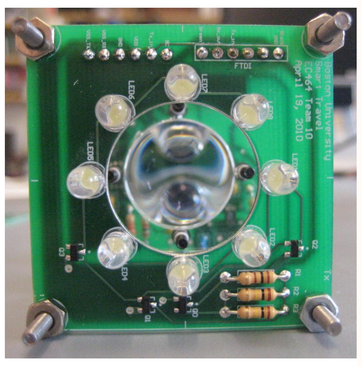
Several demonstration kits including these transceivers have been assembled and distributed. Kits include the following:

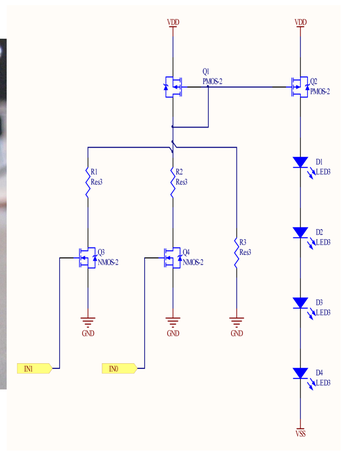


- Power supplies and cables
- USB-to-serial data cables
- A pair of fully-assembled transceivers
- Jumper wires
- Demonstration software
- User manual

In the process of developing this series of transceivers, many potential improvements have been identified. These include methods to greatly reduce costs, add versatility, and improve performance. Many of these improvements have already been built into newer designs.

Current-Mirror Transmitter



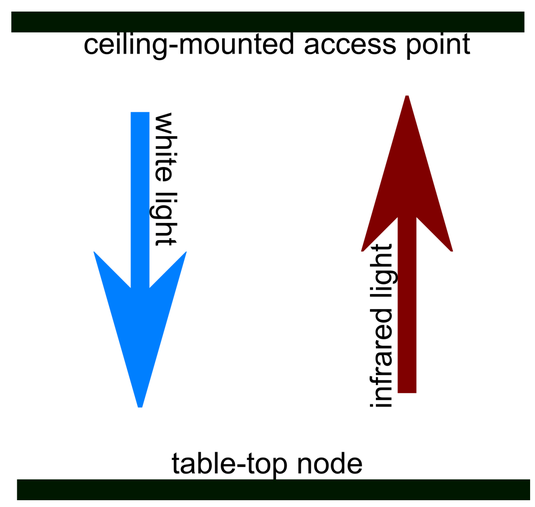


Although the transceiver shown above uses lower-power LEDs, its transmitter's design was originally for an improved general illumination transceiver; adjusting the resistors' resistances will enable support for high-power LEDs.

This new current-mirror based design offers many advantages:

- support for multi-level signaling
- pre-biased LEDs for faster switching
- simpler design
  - eliminating many problematic parts
  - easier analysis for troubleshooting
  - much less expensive
- LEDs can remain on without signal

Hybrid VLC-IR Transceiver



The new VLC-infrared (VLC-IR) transceiver will remedy these problems:

- the transmitter interferes with the receiver on the same transceiver and
- the bright table-top transmitter may cause discomfort to the user's eyes.

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