Transceiver Modules for General Illumination and Free-Space Optical Communications

Jimmy Chau <jchau@bu.edu>, **Thomas Little** <tdcl@bu.edu>
Multimedia Communications Laboratory, Electrical and Computer Engineering, Boston University, Boston, MA

T1.2.3

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:

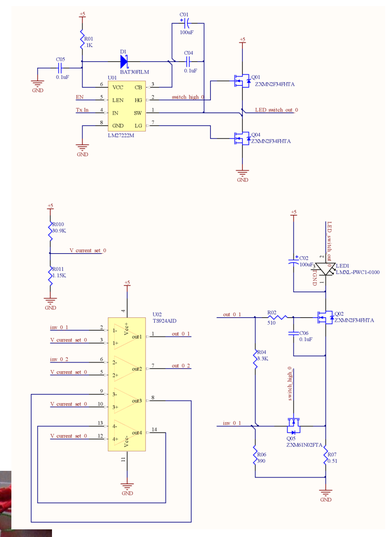
- higher luminous efficacy
- longer life
- less radio-frequency interference
- ability to direct and spatially restrict the signal

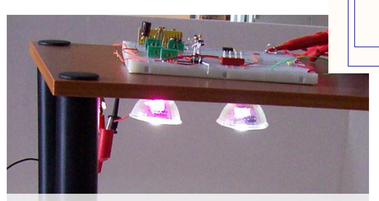
This project overcame the following challenges to use LEDs to simultaneously provide general lighting and high-speed data transmission:

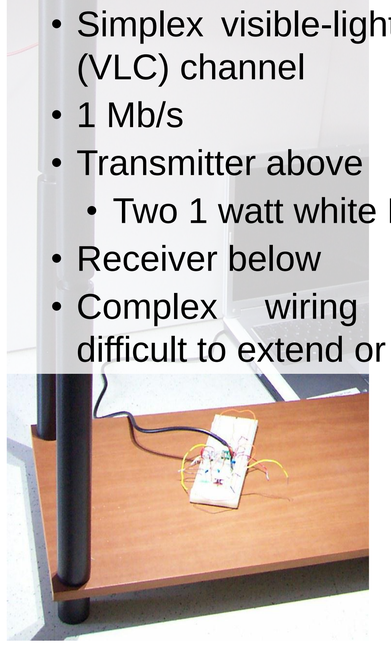
- high-brightness LEDs require large currents,
- the current must be regulated for reliable operation, and
- the large, regulated current needs to switch quickly for high-speeds.

Previous Prototype

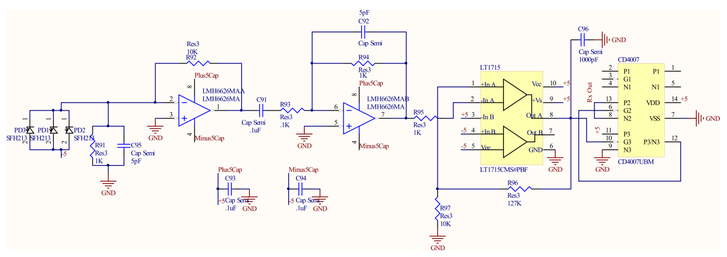
- Transmitter
  - Feedback loop using an operational amplifier
  - MOSFET driver input





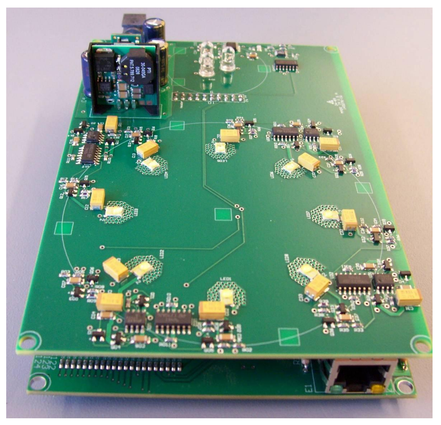


- Simplex visible-light communication (VLC) channel
- 1 Mb/s
- Transmitter above
  - Two 1 watt white LEDs
- Receiver below
- Complex wiring made system difficult to extend or reproduce

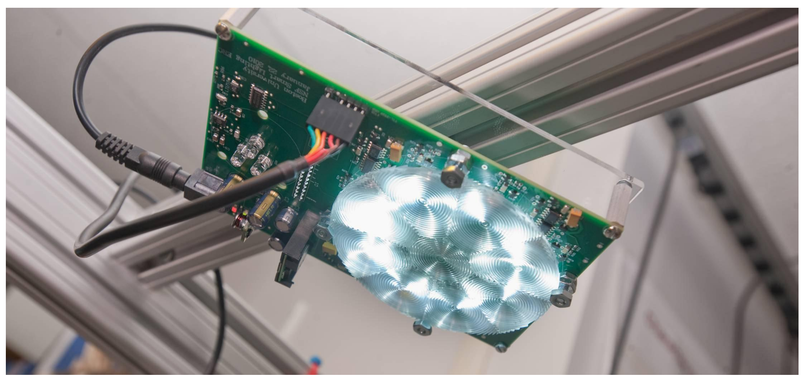


Revised as Printed Circuit Boards

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.

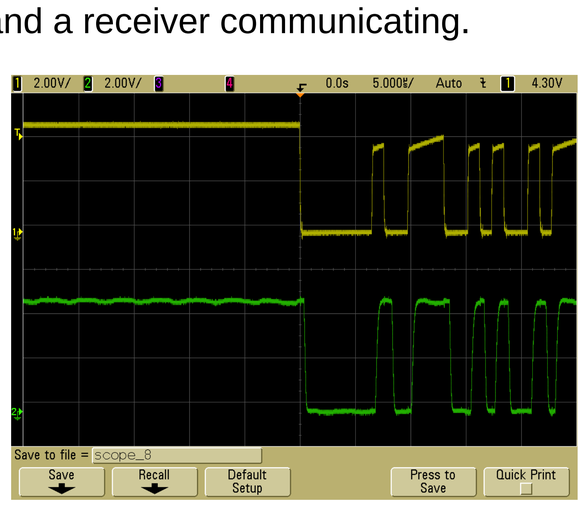


Shown above is the latest version of this transceiver in operation. It produces approximately 400 lumens.

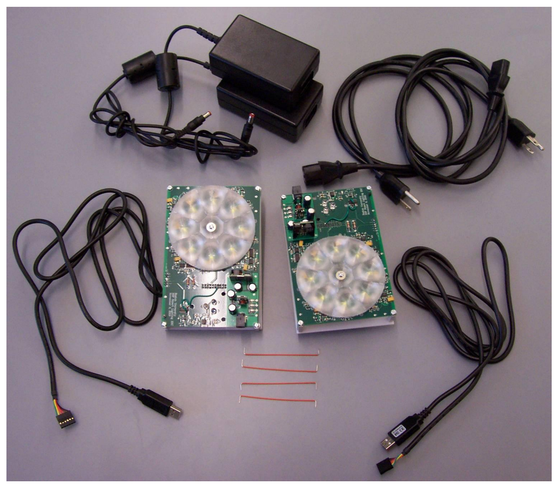
Shown below are the oscilloscope traces of a transmitter and a receiver communicating.

Transmitter input:

Receiver output:



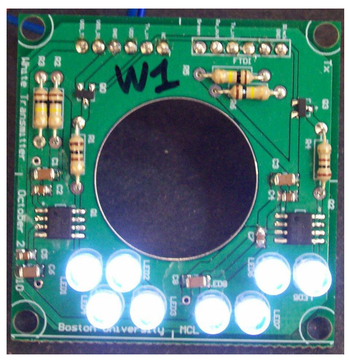
Several demonstration kits including these transceivers have been assembled and distributed. Kits include the following:

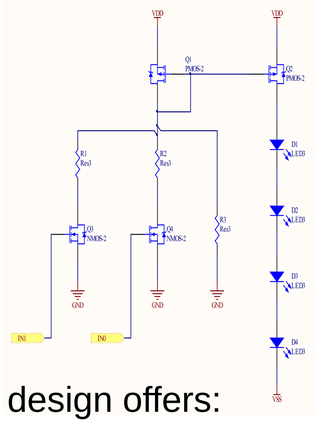


- Power supplies and cables
- USB-to-serial data cables
- A pair of fully-assembled transceivers
- Jumper wires
- Demonstration software
- User manual

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.

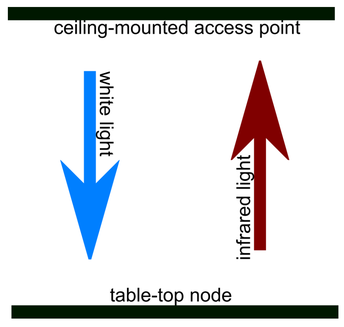
Current-Mirror Transmitter & Hybrid VLC-IR Transceiver

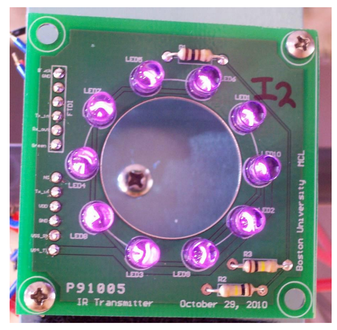




This new current-mirror design offers:

- •support for multi-level signaling (PAM)
- •pre-biased LEDs for faster switching
- •simpler design
  - •facilitates analysis
  - •Improved reliability
  - •less than $30 each
- •LEDs can remain on without signal



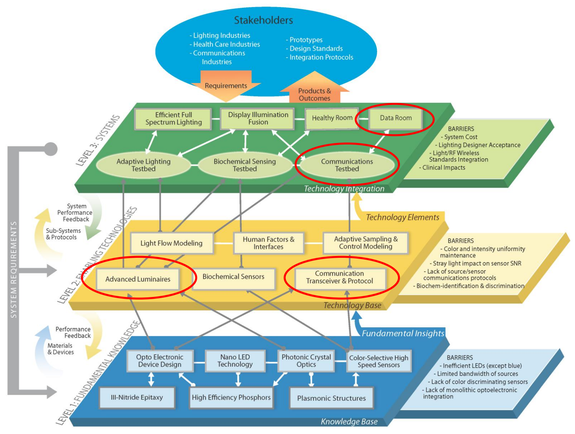


The VLC-infrared (VLC-IR) transceiver:

- •eliminates optical crosstalk between uplink and downlink
- •eliminates discomfort to eyes

Smart Lighting Strategic Plan

- Develops designs for transceivers and advanced luminares
- Provides prototypes the communications testbed and the data room
- Supports testing of new VLC protocols
- Generates requirements for optoelectronic and other components



Acknowledgements

Thanks to the following people for their contributions to and help with the presented work:

Aaron Ganick, Daniel Ryan, Geoff Brown, Kandarp Shah, Travis Rich, and Michelle Nadeau.

This work is supported by the NSF under cooperative agreement EEC-0812056 and by New York State under NYSTAR contract C090145. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

- Jimmy Chau, Thomas Little. “Transceiver Modules for General Illumination and Free-Space Optical Communications.” Smart Lighting Engineering Research Center Site Visit. Troy, NY. Jun 2011.