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Abstract

A Low-Cost Visible Light Communications System Based on Organic Photodetection for Transmitting Images †

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Abstract: In Visible Light Communication (VLC) Systems, data are transmitted by modulating light from an illumination source, that could be an ordinary lamp or light-emitting diodes (LEDs). Photovoltaic cells based on massive heterojunctions of semiconductor polymers have focused the attention of researchers due to several potential advantages over their inorganic counterparts, such as simplicity, low cost and the ability to process large area devices even on flexible substrates. In this paper, we use commercial LEDs in transmission and organic photodetectors (OPD) based on poly(3-hexylthiophene) (P3HT) and a phenyl-C61-butyric acid methyl ester (PCBM) blend used as active layer in reception. We have fabricated and characterized the I-V curve and the Bit Error Rate (BER) response of the OPD using low cost processing techniques and we have used an Atmel 8-bit microcontroller in order to control the electronics to transmit and modulate the signal. Finally, in this work, we have developed and characterized organic photodetectors in a low cost visible light communications system capable of transmitting an image file in real-time, as a proof of concept that is cost effective, since the whole system was implemented using low cost components. You can find more information in the supplementary materials.

Keywords: visible light communications; organic photodetector; P3HT:PCBM; IEEE 802.15.7

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- Abstract
- Introduction
- Materials and methods
  - Description of the system
  - Polymer devices fabrication method
- Results
- Conclusions

Abstract

Visible light communications (VLC) is an interesting technology for future communication systems (accepted to 5G) in the visible range of the electromagnetic spectrum using light-emitting diodes (LEDs) and can be considered an alternative to traditional communication systems to be included in the Internet of Things (IoT).

However, a drawback of these systems remains at the receiver side, due to the lack of photovoltaic devices for this specific use.

Organic photodetectors have great potential to be applied in VLC systems because of the simplicity and low cost of these devices.

Introduction

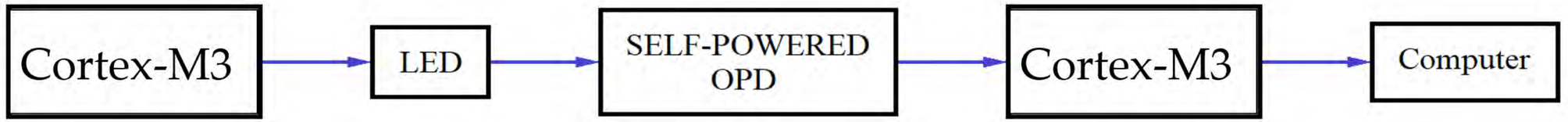
In this article, we used commercial light-emitting diodes (LEDs) in transmission and two different kinds of organic photodetectors based on poly(3-hexylthiophene) (P3HT) and a phenyl-C61-butyric acid methyl ester (PCBM) blend as active layer in reception.

Compared to the article: "**A Low-Cost IEEE 802.15.7 Communication System Based on Organic Photodetection for Device-to-Device Connections" (**https://**doi**.org/10.3390/s20030714), the authors have improved some parts of the previous paper in order to transmit images:

- Using another microcontroller with a greater clock frequency and CRC.
- Utilization of instructions of assembly code in order to optimize the source code.
- Increasing the concentration of P3HTdissolved in chlorobenzene.

Materials and methods: Description of the system

We have changed from an ATMega328 microcontroller (with a clock frequency of 16 MHz) to a Cortex-M3 (with a clock frequency of 84 MHz).



We have maintained the same electronic prototyping platform (Arduino), only modifying the version (from Arduino UNO to Due).

Finally, we have programmed the software using instructions of assembly code in order to optimize the source code.

Materials and methods: Polymer devices fabrication method

In our system, photodetectors were based on organic electronics, also known as organic photodetectors (OPD). The OPD manufacturing technique used was spin-coating.

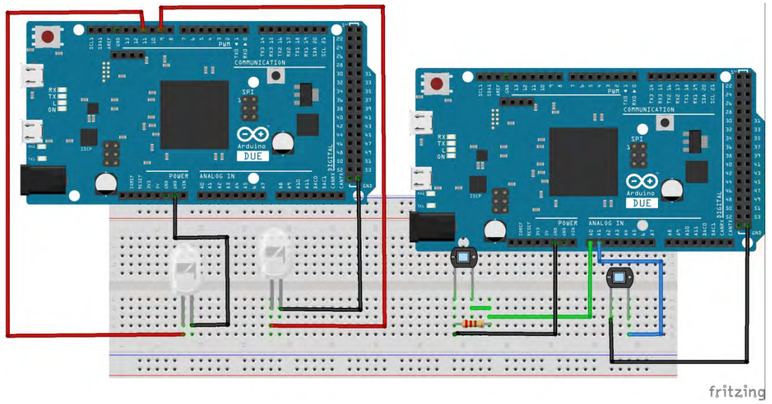
For the active layer manufacture, a [P3HT:PCBM] solution with a weight ratio of [1:1] was prepared. In this solution, polymers were well dissolved in chlorobenzene at 20 mg/ml.

The active layer was deposited at 800 rpm for two minutes and annealed at 80 °C for 1 hour. Finally, using a vacuum chamber and the Joule effect, the last layer of aluminum was deposited.

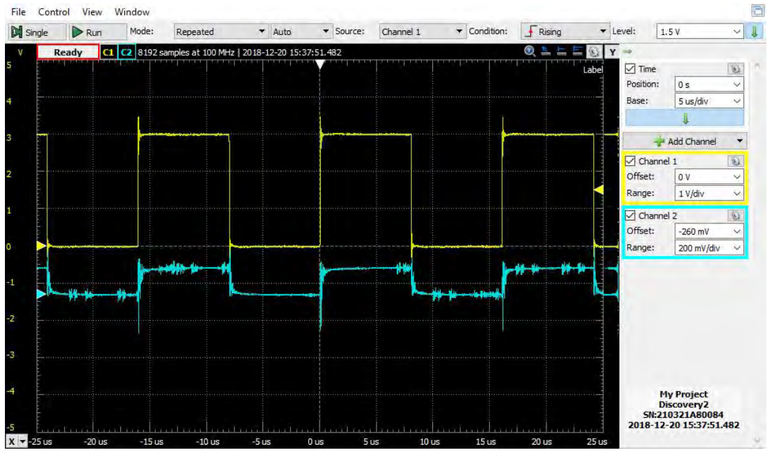
Materials and methods: Polymer devices fabrication method

Results

Connections of transmitter and receiver with Arduino DUE

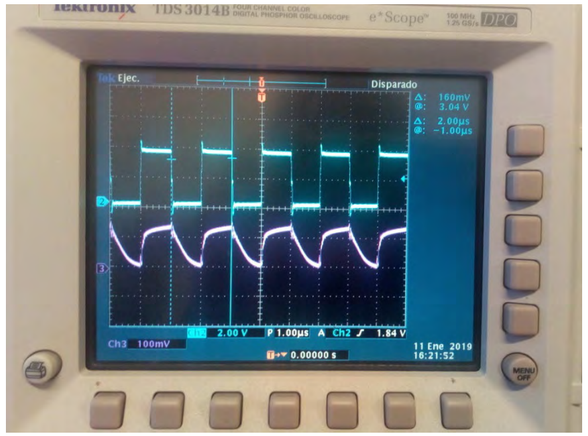


Results obtained at 125 kHz without CRC code

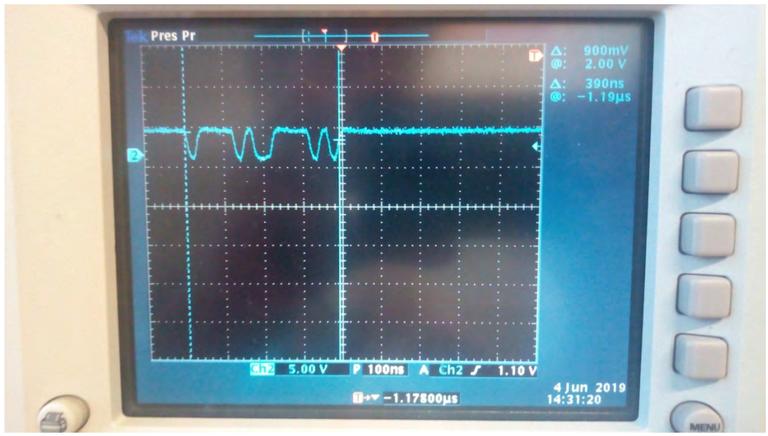


Results

Results obtained at 500 kHz with CRC code



Results obtained at 3,33 MHz adding port register



Conclusions

This paper shows the feasibility of a low-cost visible light communication system based on self-powered organic photodetectors in order to transmit images.

The article has improved previous systems using another microcontroller with a greater clock frequency and CRC, with the utilization of instructions of assembly code in order to optimize the source code and increasing the concentration of P3HTdissolved in chlorobenzene.

Additionally, properties of organic photodetectors could be improved by developing new materials with high charge mobility and through enhancements in manufacturing. Consequently, the response speed of organic devices may be increased.

UNIVERSITAS

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