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Visible Light Communication

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Abstract
This project consisted of the study of theoretical concepts related to a visible light communication (VLC) system. The system transmitter has two simultaneous functions: information transmission and ambient lighting. The system receiver retrieves the transmitted information through variations in light intensity. A simple VLC system was implemented in laboratory and its performance was analyzed.

Keywords — Visible Light, Digital Communication, Ambient Lighting.

Introduction

We consider a VLC system where the information to be transmitted modulates the instantaneous power of a light emitting diode (LED). As the instantaneous power is the intensity of light itself, this kind of modulation is known as Intensity Modulation (IM). In the receiver, a photodiode produces a current proportional to the instantaneous power received, which is converted by a transimpendance amplifier in a measurable voltage. This type of detection is known as Direct Detection (DD) [1]. Even though the received power is null, the LED will respond with a current known as dark current. However, we consider its bandwidth as being infinite.

The channel between the LED and the photodiode is assumed to be a time-invariant linear system whose impulse response is the impulse itself. This is justified by the proximity between the LED and the photodiode, which implies the absence of reflective surfaces. We will also consider the presence of an additive thermal noise of the transimpendance amplifier and that the amplifier bandwidth is finite.

Results and Discussion

Fig. 1 shows the simple circuit mounted in the Telecommunications Laboratory of the Faculty of Technology that implements the system described above. The information is a periodic waveform obtained from a function generator in which the high level pulse corresponds to bit “1” and the low level pulse to bit “0”. This waveform is injected through a resistor in a commercial LED normally used to ambient lighting. The transimpendence amplifier is implemented using a LM741CN circuit with a variable feedback resistor.

Fig. 2 compares the output of the amplifier with the input of the modulator. As the gain of the amplifier is low, it can be observed that the output is very noisy. By using the oscilloscope it was possible to estimate both the rise and fall time of the high-level pulse and consequently estimate the transimpedance amplifier bandwidth through its 3 dB frequency.

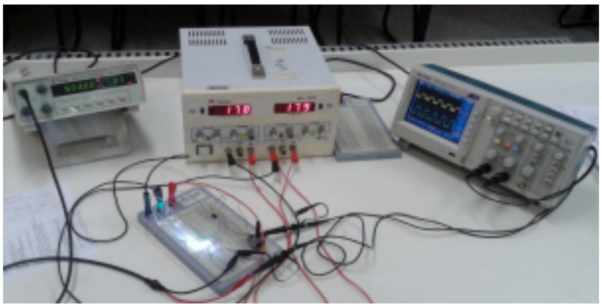

Figure 1. Protoboard–mounted circuit, power supply, function generator and oscilloscope.

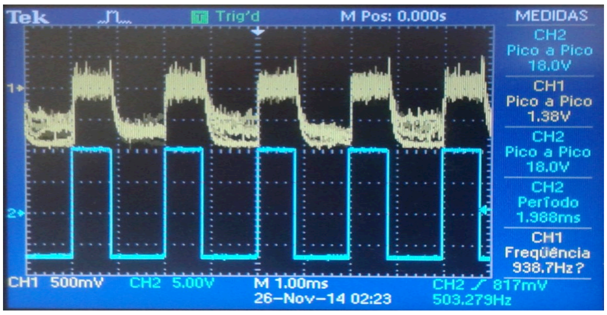

Figure 2. Waveform at the amplifier output compared to the information (blue) transmitted in the modulator.

Conclusions

The distance between the LED and the photodiode was varied and the influence of the detected power on the amplifier output voltage was observed. Moreover, the bit error probability was analyzed.

Acknowledgement

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[1] T. Komine, M. Nakagawa, “Fundamental Analysis for Visible-Light Communication System using LED Lights,” *IEEE Trans. Consumer Electronics*, February 2004, p. 100–107.