Reception of audio signals received from different LEDs used in the low cost LI-FI systems

Tsvetan Valkovski[1], Kalin Dimitrov [2]

Abstract – **In this article we will discuss the possibilities of using different LEDs in low cost LI-FI systems. The results of the studied LEDs, their advantages and disadvantages will be analysed.**

The presented LI-FI systems are designed in order to use a minimum number of electrical elements in order to design and build such systems by students during laboratory exercises as a practical exercise. The main goal is to acquaint students with the advantages of LI-FI systems.

Keywords – **Acoustic, Optical, Audio, Li Fi, Optoacoustic.**

I. Introduction

More and more people are interested in high-speed signal transmission, and in recent years optical methods of information transmission have been found in all areas of telecommunications and audio and video transmission.

In this article, the transmission of audio signals by optical methods or the so-called "Li-Fi" is of interest.

There are various methods for building systems for transmitting audio signals through optical methods, and here we will focus on the consideration of the various light signal sources, namely LEDs.

Different LEDs of the visible and infrared spectra will be considered, and experimental studies will be performed to show the performance of each LED under the same conditions.

II. Theory

The idea of systems for transmitting audio signals through optical methods is to use changes in the magnitude - the modulation of light for data transmission. This means that when the LED is on, it emits radiation that can be considered level 1, and when it is off it does not emit radiation that can be considered level 0. The frequency when switching between these two levels changes so quickly that it remains invisible to the human eye, continuing to receive continuous radiation. In our previous articles we have considered the model of Low Cost Laboratory Environment for the Use of Optical Methods for Transmission of Audio Signals, with the principle scheme shown in Fig.1. [1-2]

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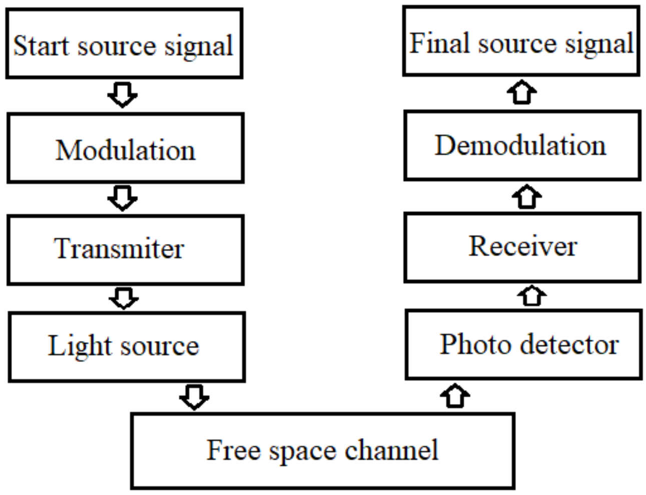

Fig. 1. Principle scheme of basic Li-Fi system

Fig. 1 shows an easy-to-build model diagram of a system for transmitting audio signals by optical methods using LEDs. The figure shows that the data from the source is modulated to a carrier signal and is sent by a modulated light signal from the LED to the light receiver. On the receiving side we have a photodetector, which could be a photodiote, a solar panel or something else. This is not currently considered in the article, as in our previous works we have considered the possibilities for the receiving side of the signal.[2]

The main features that distinguish Li-Fi technology are efficiency, safety, security and large capacity for the ability to transmit information. These systems provide a large bandwidth, easy to use and last but not least free. Another important thing is that Li-Fi technology provides higher data density than standard wireless Wi-Fi technology, and the channel charge can be up to 1000 times higher than other technologies.

As mentioned above, apart from the fact that the data density is much higher compared to other technologies and the minimum number of elements used, another advantage of systems for transmitting audio signals by optical methods is that by using different frequencies of the light spectrum , different signals can be transmitted. This could be easily designed, and in the receiving part by signal filtering the different signals could be separated without the presence of interference between the different signal transmission channels.[3]

In this regard, different LEDs will be considered and a comparison will be made between them to see experimentally under identical conditions, what signal level they could emit and whether it is possible to transmit signals with different frequencies and a very close signal level.

The wiring diagram of the experimental system consists of a minimum number of electrical elements, including audio interfaces, LED, power supply, LED, resistor and photodetector. An exemplary such circuit diagram is shown in Fig. 2. [4-5]

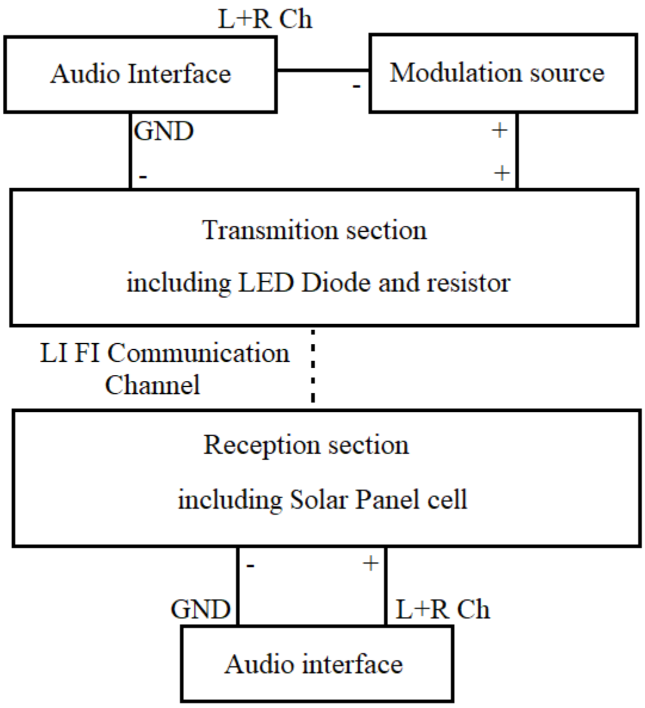

Fig. 2. Wiring diagram of "Modulation circle LED" [2]

In the shown wiring diagram in the experimental environment, the LEDs and resistors will be changed. The receiving part will be made through a solar panel, and there will be no changes.

III. Comparison of Different LEDs Used in the Low Cost Li-Fi Systems

To conduct the experiments, we created a Li-Fi system, described in our previous publications.

The source of the audio input signal in this case will be a smartphone that will transmit the signal through an audio jack.

The audio jack is connected to a diode, which must be powered by the amplitude modulated audio signal.

For this purpose we will use a 9 volt battery to which we will connect a resistor (Rled) with a value: 270 ohm, 360 ohm or 390 ohm in accordance with the respective LED, which we will test to get the necessary resistance selected from theoretical sources needed to implement the shown above circuit with which to power the diode optimally without the danger of it burning. [6-7]

We will connect the battery and the audio jack to close the circuit and with that our transmission part is ready.

As a signal receiver we will use a solar panel connected to an audio jack, which will be connected to an active speaker through which to output the audio signal. The level of the electrical signal generated by the solar panel will be sufficient for the input line signal of an active speaker, so we have a direct conversion from light to electrical signal, without additional signal conversions.

The circuit works as the diode receives an electrically amplitude modulated signal, which converts it into light by very fast pulsations that are not visible to the human eye. The diode is directed to the solar panel placed at a distance from it, which converts these pulsations again into an electrical signal, and as a result of the amplitude modulation, the carrier signal is the light signal and the modulated signal is the useful audio signal. The solar panel receives this signal, leaving the electrical signal with only the useful audio signal and sending it through the audio jack to the active speaker, which reproduces the received analog audio signal. We implemented the scheme shown above in Fig. 3. [8]

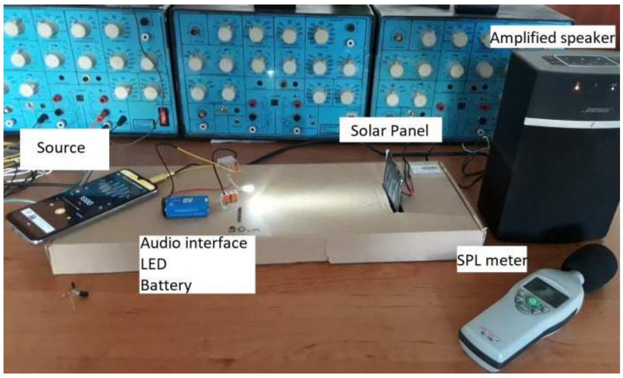

Fig. 3. Illustration of the Laboratory environment for measurement of the signal level at 20 cm

For the experimental solution of the set task we used a sinusoidal signal with a frequency (f) of 1000 Hz and we placed the LED and the solar panel at a distance (Z) of 20 cm. We used a noise meter to measure the level of the output signal. We tested 5 different LEDs: infrared, green, red, blue and white as the red LED simulates a laser. The situation remains the same, only the diodes and resistors are changed, as each LED is tested on 10 different days in the manner shown in Fig.5-9.

Fig. 4. Conducting an experiment using a white LED as a source of optical radiation

Fig. 5. Conducting an experiment using a blue LED as a source of optical radiation

Fig. 6. Conducting an experiment using a green LED as a source of optical radiation

Fig. 7. Conducting an experiment using a infrared LED as a source of optical radiation

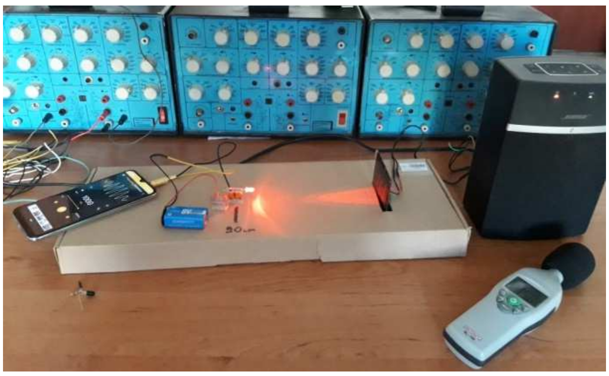

Fig. 8. Conducting an experiment using a red LED as a source of optical radiation

Table 1 shows the results of the experiments performed on each tested LED from the 10 tests at a sinusoidal signal with frequency f = 1000Hz and distance between transmitter and receiver Z = 20 cm. [9]

The results shown were taken for 10 days under identical conditions in the laboratory.

TABLE I

THE SIGNAL LEVEL WHEN CHANGES THE LED DIODES AT 20 CM DISTANCE.

Diode	Infrared	Green	Red	Blue	White
SPL, dB	85,5	79,9	77,2	73,4	77,2
SPL, dB	86,5	80,5	75,4	74,4	76,3
SPL, dB	85,9	81,8	76,9	74,1	77,3
SPL, dB	86,3	79,8	75,8	75,2	76,8
SPL, dB	87,2	79,9	76,2	73,4	77,6
SPL, dB	86,1	81,4	76,8	74,3	76,8
SPL, dB	85,4	80,7	75,4	75,1	77,6
SPL, dB	86,3	81,3	75,9	74,4	76,7
SPL, dB	85,4	80,7	75,9	75,2	78,1
SPL, dB	86,5	80,8	77,3	73,8	78,2

To compare the results more easily, we need to calculate the arithmetic mean sound level of the 10 attempts on each diode.

The calculation of an arithmetic mean value in decibels is considered an inaccuracy and the value must be converted to a linear one and then the arithmetic mean must be calculated. In our case, the difference between the two methods of calculation is minimal, so we choose the more convenient way for us by calculating the arithmetic of the values in decibels. The results of the calculations are shown in Table 2.

TABLE I

THE SIGNAL LEVEL WHEN CHANGES THE LED DIODES AT 20 CM DISTANCE.

ARITHMETIC MEAN SOUND LEVEL OF THE 10 ATTEMPTS ON EACH LED DIODE.

Diode	Infrared	Green	Red	Blue	White
SPL, dB	86,11	80,68	76,28	74,33	77,26

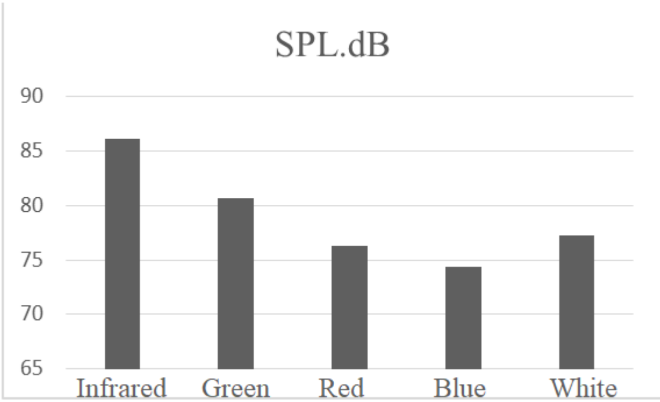

Fig. 9. Graphic representation of the experimental signal level when changes the leds at 20 cm distance.

From Fig. 9 we found that the infrared LED has the highest level of audio signal, and the blue with the lowest level. The red and white LEDs gave similar results with a difference of approximately 1 dB.

IV. CONCLUSION

After the research, the experimental theoretical solution of the task and the experimental setup with the experiments conducted through it, it can be said that the designed system for transmission of audio signals wirelessly by optical methods could be used in applications where conventional methods are not applicable.

The designed system has advantages, such as faster transmission of information and in larger quantities, as well as lower latency compared to standard methods for transmitting audio signals.

From the results obtained in Table 1. and Table 2. we see that of the 5 LEDs tested, the infrared LED has the highest level of the audio signal. The other diodes are in the visible spectrum of light and of them the highest level of the audio signal was given by the green and white as the green LED gave a slightly better result.

In practice, there are many devices operating with remote controls set in the range of the infrared diode, therefore it would be appropriate if we have a good "isolation" of the communication channel in order to avoid additional interference.

The other four diodes of the light spectrum show relatively close signal levels, which means that a system for transmitting audio signals by optical methods could be implemented, with the possibility of frequency separation of the channels for transmitting information as a result of which is possible to transmit multiple audio signals, at high speed, without interference between channels.

In the future, experiments involving two or more light sources to one receiver could be performed. Such a method would be useful in various processing of audio signals, mixing and real-time music performances.

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