FSO System for Students Training

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Abstract – **A specialized optical communication system for students training is designed. The system gives the opportunity to do exercises at short distances in a laboratory and also at longer distances in the corridors of some of the Technical University blocks. Problems related to the alignment and adjustment of the optical blocks are solved. In this paper we discuss the problems which arise with the using of cheap fixing of the photoreceiver to the walls of the box.**

Keywords – **Free Space Optics, Engineering Education.**

I. Introduction

The free space optic communication systems (FSO) typically use two transceiver blocks with line of sight between them [1-3]. Usually in each of these blocks there is an analog transmitter and receiver and a module for respective converting of the signals to a form suitable for existing digital computer networks. With FSO systems, a strong fluctuation of the atmosphere transparency as well as spot movements in the receiver plane are observed. It is very important for the system to have a good alignment and adjustment of the optical blocks. To implement the latter is necessary a relatively expensive fixing of the photoreceiver, the light source and the boxes as a whole.

II. General Setting of the Analysis

Some of the physical parameters of the FSO systems are relatively weakly determined. It turns out that the significant changes of the intensity of the optical radiation in the receiver aperture are one of their major problems.

The performance of a FSO link is primarily dependent upon the climatology and the physical characteristics of its installation location. In general, weather and installation characteristics that impair or reduce visibility also affect FSO link performance.

One of the key challenges with FSO systems is maintaining transceiver alignment. FSO transceivers transmit highly directional and narrow beams of light that must reach the receiver aperture of the transceiver at the opposite end of the link. For a FSO link to function, it is very important that both the transmitted beam of light and the receiver cone encompass the transceiver at the opposite end of the link.

It is very important to have a clear methodology in order to create a coupled structure of a receiver and a transmitter rather than a separate receiver and a separate transmitter. This is important for a further mounting and alignment.

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III. Experimental Setup

To able to illustrate the methodology for alignment and adjustment we have made an experimental setup shown with a photo in fig.1 and schematically in fig.2.

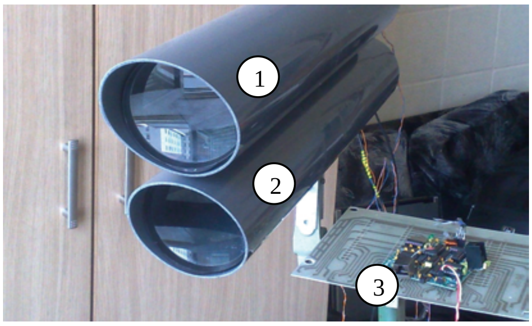

Fig. 1. Experimental setup - photo
(1 – transmitter box; 2 – receiver box; 3 – interface)

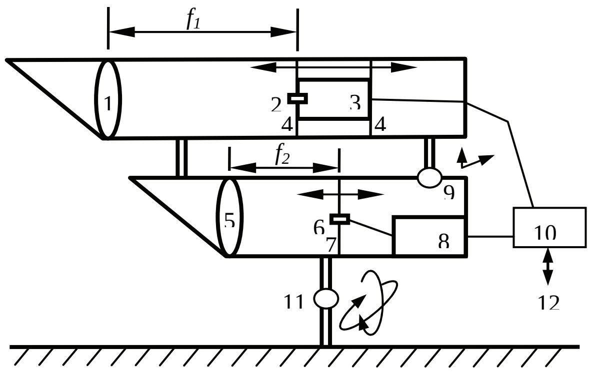

Fig. 2. Experimental setup - schematic
(1 – lens of receiver; 2 – photodiode; 3 – analog amplifier; 4 – fixation; 5 – lens of transmitter; 6 – transmitter; 7 – fixation; 8 – transmitter driver; 9 – adjustment bolt with two degrees of freedom; 10 – interface; 11 – mounting; 12 – computer network device)

We have prepared models in boxes resistant to the atmosphere, so that we can make outdoor experiments.

IV. Experimental Procedure for Students

In this section we will present an example step by step algorithm for a student Lab experiment. Described in this way, the task is suitable for practical work with students in the corridors of block 2 of the Technical University of Sofia. There the distance with line of sight is of a suitable order.

The measuring of the optical power in 1,2 and 3 is done by using the receiver - item 2 and 3 in fig. 2 without the lens. During the measuring is used modulated light to avoid the influence of the background light.

Algorithm:

1. The focal length of the transmitter lens f_1 is determined by using some of the popular methods [4]

2. The transmitter is placed near the focal point and is fixed (to make the system simpler and cheaper we do not use high precision X,Y translation and Z rotation mounts)

3. The profile of the optical beam is checked at several distances from the transmitter head and corrections are made if necessary. It must be ensured that a collimated beam is derived. If it is necessary, we correct the fixing in 2.

4. The same type of optical system is used (with the same type of lens $f_2 = f_1$) for the receiver too. The photodiode is placed in the probable focus.

5. A second system like the one in fig. 2 is placed at several meters and the level in its receiver part is checked. If, despite the alignment (which we apply with item 11 in fig. 2) there is a low power level, we move the receiver along the optical axis until the derivation of a sufficient level. It is possible, during this moving, for the photodiode not to be exactly at the focus distance. This is a compromise which is made in order to fix the receiver in the box more simply. In the next section has been made an evaluation of the influence of this over the attenuation.

6. 1 to 5 are repeated for the transmitter of the second couple of optical systems. The alignment with the first couple is made with item 9 in fig. 2.

7. The distance is increased to several tens of meters, now using only item 11 in fig. 2.

8. If the experiments from 7 are successful, the performance of the system is checked respectively at 100 and 200 meters.

V. EXPERIMENTAL AND SIMULATION RESULTS

With the real setup shown in fig. 1 (lens diameter 100 mm) and using the algorithm in the previous section we derive a focal length of 380 mm and diameter of the lightspot 400 and 900 mm respectively at 100 and 200 meters distance.

To evaluate the added losses due to incorrect placing of the receiver, we have created a simulation program evaluating the overlapping of the photodiode aperture with the lightspot formed by the lens. At the same time we have taken into account the decreasing of the power density during movement along the optical axis (fig. 3).

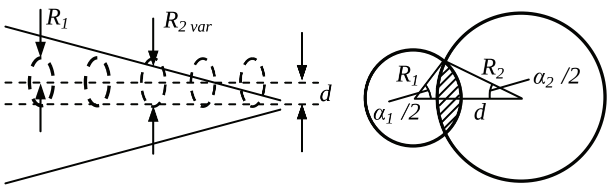

Fig.3.Change of the photodiode location on the optical axis

From the law of cosines we derive respectively the angles

$$\alpha_1 = 2\arccos\frac{R_1^2 + d^2 - R_2^2}{2R_1 d}\ ,\ \alpha_2 = 2\arccos\frac{R_2^2 + d^2 - R_1^2}{2R_2 d} \quad (1)$$

We derive the overlapping by the formula

$$J = \frac{R_1^2}{2}\left(\alpha_1 - \sin\alpha_1\right) + \frac{R_2^2}{2}\left(\alpha_2 - \sin\alpha_2\right) \quad (2)$$

We present the attenuation resulting from the moving in dB, and at the same time we take into account the decreasing of power density

$$Attenuation[dB] = 10\lg\frac{\pi R_2^2}{J}\ . \quad (3)$$

Using (1), (2), (3) we can easily present the attenuation as a function of R_2 and d. The results from the numerical experiment for intervals of light spot radius change from 2,5 mm to 7,5 mm and the interval of the distance between the centers from 3 mm to 4mm with photodiode radius 2,5 mm have been shown in fig.4.

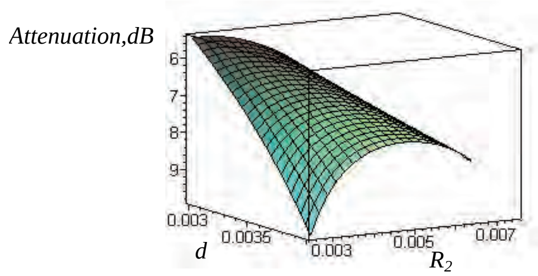

Fig.4. Simulated data for the attenuation in dB as a function of the light spot radius and the distance between the light spot center and the photodiode aperture center

VI. CONCLUSION

The research we have conducted can be useful for the creation of cheap and simple FSO systems. Our work has shown that when we use specific methodology for pointing and aligning, we can evaluate the deviation of the geometrical path loss. This paper would also be useful in that it provides concrete experimental guidelines.

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