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# A STUDY OF THE INFLUENCE OF 650 nm LASER INTERFERENCE ON VISIBLE LASER LIGHT COMMUNICATION SYSTEM

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**ABSTRACT**

Visible Laser Light Communication System (VLLC) is a wireless communication system, using laser as the medium. In the data transfer process, it is possible to have optical interference where 2 laser beams coincide with one point on the reflector. Research on the effect of laser source interference has been carried out by several researchers including mitigation actions to reduce its effects. This experiment uses 2 optical distance sensors that produce a laser with a wavelength of 650 nm with a power <=4.1 mW and with the direction of the laser beam both of them cross each other. To determine the effect of the interference of two laser beams when crossing the communication process in the visible light communication system, a reflector is used which can capture the two laser beams and the reflector can be shifted gradually so that a condition can be obtained where the two laser beams meet at one point. From the measurements made at the points after the laser beam crossing, the measurements at the point where the beam crossed, and the measurements at the points before the beam crossing, it was obtained data, at the exact point where the laser beam crossed the interference occurred, which is indicated by unstable output voltage of the two lasers, so that communication at the point of intersection is disrupted. However, if outside the point of contact both before and after the point of contact, interference and communication systems will not occur.

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## INTRODUCTION

The Visible Laser Light Communication System performs wireless communication, transferring data anywhere freely using a laser beam. This system is effective because it does not overcrowd the spectrum and is not regulated by the Government [1], [2], [3], [4], no electromagnetic radiation [5], [6], good security [5], low cost [6], and high signal power [7]. This system belongs to the visible light category which works in the 350nm to 750nm spectrum [1], [2], [5], [8], [9]. As with radio communications, this system has no overhead of processing different regulatory rules and is quite fast. The system is secure because intercepting transmission interrupts uses low power, communicating at 1.25 Gbps up to a distance of 6 Km. However, they need a Line of sight [1], [4], [10], [11] where the sender's receiver pair can't be mobile. Communication is successful when the path is set accurately, and the transmitting receiving antenna is tilted properly. However, it is dangerous when living things are intensively exposed to laser light [10].

Optical interference is generated when two beams of the same laser source coincide. The intensity and phase of the relationship between these two beams create a pattern of light and dark areas. The phase difference between the two beams creates an interference pattern if it happens to occur at a distance lower than the coherence length [12].

Chen et al [13] conducted research on multi-cell VLC in an indoor area, which uses two LED sources to transfer information to the receiver. When the signal receiver is in the intersection area of several adjacent transmitter cells, the signal performance is greatly degraded due to the effects of interference between cells which cannot be ignored in Multi-cell VLC systems. To minimize the influence of interference from the two LED sources, the researchers modified the receiver angle with a method called Angle Diversity Receiver (ADR) where the results can increase the SINR value from 3 dB increase to 8.6 dB compared to the same VLC system that uses a single element receiver without angle diversity. The illustration like shown in figure 1.

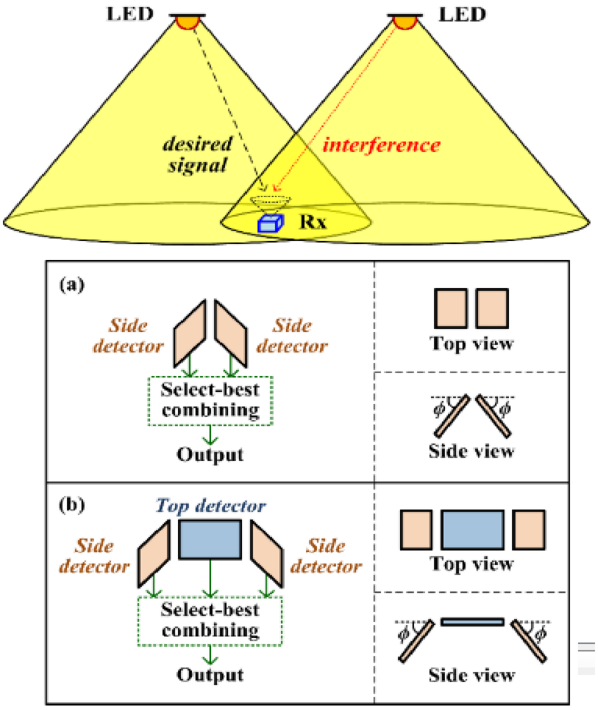


Figure 1. Illustration of Inter-Cell Interference in an Indoor Multi-cell VLC with Angle Diversity Receiver [13]

Hosney [14] conducted a study to reduce the effect of Co-Channel Interference (CCI) by optimizing the Field of View (FOV) and adjusting the tilt angle of the ADR and pyramidal, the results can reduce the influence of interference by designing ADR with a limited FOV angle to reduce the number of signals (Line of Sight) Disrupted LOS. The simulation results show that the optimum FOV is achieved for each ADR tilt angle. Also, an acceptable BER bit error rate can be achieved at the most disturbed position (centre of the room, and between the two LEDs) at an optimal tilt angle equal to 30º.

Serguey Odoulov et al [15] research on the effect of interference and laser holography with different colors using a femtosecond laser where the color are blue and green (fig.3).

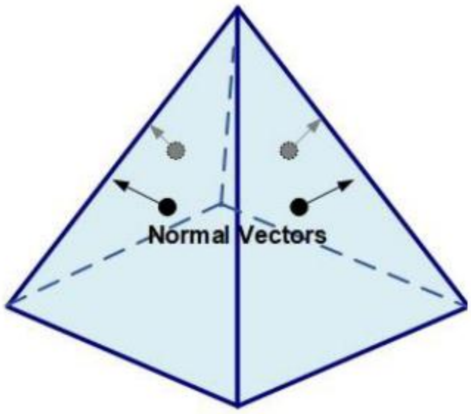


Figure 2. The Proposed ADR Receiver with PDs's Normal Vectors [14]

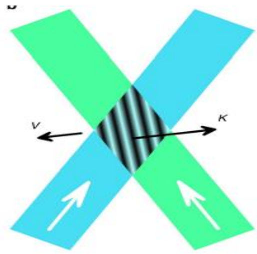

Figure 3. Interference and Holography in The Blue and Green Colors Femtosecond Laser [15]

From some existing research, it only describes the problem of interference from laser beams at the meeting point between 2 or more laser beams, does not explain whether there is an effect on the points located before or after the presence of these 2 crossing laser beams occurs.

This paper will discuss the experimental results to determine the effect of interference on the VLLC communication process if two red laser sources are made at a certain angle so that the two laser beams meet at one point on the reflector. The measurement of the effect of this interference is carried out in three areas, namely before the laser beam crossing occurs, right at the laser beam crossing point and the point after the laser beam crossing occurs. Section 2 will discuss the literature review which correlation with this research. Section 3, it is explained the research methodology carried out by the author to obtain data. Section 4 presents the data and analysis of the experimental results, and section 5 presents the conclusions from the results of this research.

## RESEARCH METHOD

### Material and Methods

In this study, the author uses an optical distance sensor O1D100 from IFM electronics where this sensor uses a 650 nm laser (Red colour, class 2 laser product), with a power of less than 4.1mW. This sensor is equipped with a transducer and amplifier so that it can convert the distance between the sensor and the reflector into an analogue voltage of 0-10 VDC or analogue direct current 4-20mA. The author uses these 2 lasers and makes the laser beams cross each other at a point.

This Optical Distance sensors haven a product characteristics and analogue type as shown in the following data (fig. 4, fig 5, fig 6):

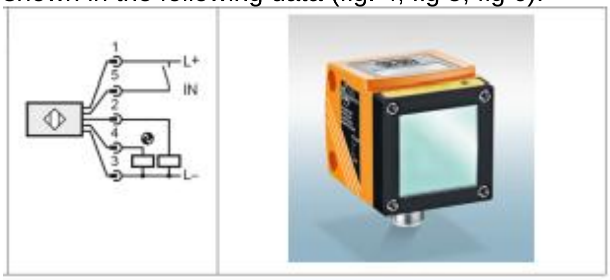

Figure 4. Optical Distance Sensor O1D100 [16]

| | |
|---|---|
| **Product Characteristic** | |
| Photoelectric distance Sensor | |
| Visible laser light, protection class 2 laser | |
| 4-digit alphanumeric display | |
| Measuring range 0.2...10 m (Range reffered to | |
| white paper 200 x 200 mm, 90% remission | |
| **Application** | |
| Application [m] | 0...19 |
| **Electrical data** | |
| Electrical design | DC PNP |
| Operating voltage | 18...30 VDC |
| Current Consumption | <150 mA |
| **Output** | |
| Current output | 4...20mA according to IEC 61131.2 |
| Max. load | 250 Ohm |
| Voltage output | 0...10 V according to IEC 61131.2 |
| **Remark** | |
| Caution : Laser | |
| Power <=4.1 mW wavelength = 650nm | |
| pulse 1.3 ns | |
| Do not state into beam | |
| Avoid exposure | |
| Class 2 laser product | |
| EN 60825-1:2003-10 | |

Figure 5. Product Characteristic of Optical Distance Sensor O1D100 [17]

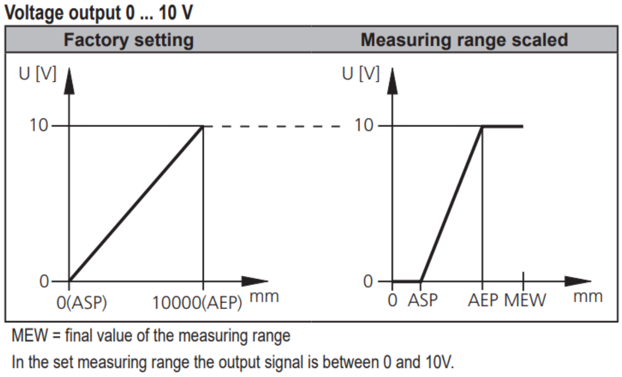


Figure 6. Analogue Output Characteristic of Optical Distance Sensor O1D100 [18]

For the reflector of this laser the author uses a book covered with white paper. The paper is equipped with a scale to read the distance between the points of the two lasers reflected on the reflector. The author measured the output voltage using a Fluke brand Voltmeter. The distance between the laser source and the reflector is read from the display on the distance display located on the sensor body. To turn on the sensor the author uses a 24 VDC Omron brand power supply.

The sequence of work is as follows: (fig. 7, fig. 8 and fig. 9). The sensor is supplied with a 24VDC voltage, then emits a laser beam. The distance between the two sensors is set to 100 mm, then made to form an angle so that the two laser beams intersect at a point Y. Each time data collection is complete, the reflector is shifted closer to the laser source so that the distance between the laser points is getting closer, then data is taken every time the reflector is shifted.

In this experiment the author uses two optical distance sensors that are capable of measuring distances by converting the output quantity in the form of a voltage of 0-10 volts or 4-20 mA depending on the settings of the device parameters.

This sensor emits a laser beam and if it hits an object or reflector, the sensor will read the distance between the sensor point and the reflector, which is shown on the sensor display. Analog output 0-10 V or 4-20 mA correlates with reflector point distance and can be measured using a Fluke digital Voltmeter.

The method of data collection is by measuring the value of X and then reading the distance L that is read, then measuring the output voltage on the sensor with a Voltmeter. The positive X distance is the distance between the laser points to the left of the Y point (the distance after the lasers cross), while the negative X distance is the distance between the laser points to the right of Y (the distance between the laser points before crossing). The block diagram of the component arrangement for the experiment is as shown in figure 7.

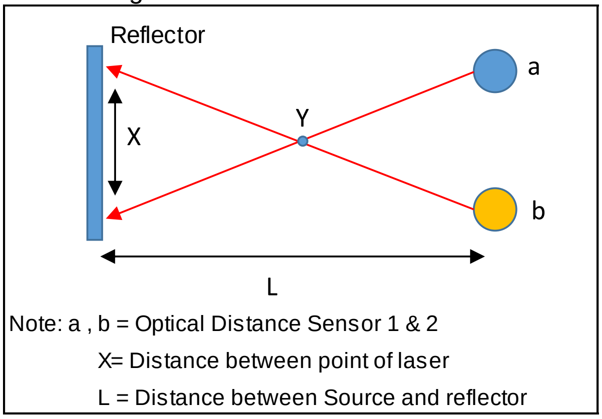


Figure 7. Block Diagram


Figure 8. Experiment Process

Table 1. Parameter Setting in Optical Distance sensor O1D100

| Parameter | Setting range | Factory setting | Own setting |
|---|---|---|---|
| Uni | mm, m, inch | mm | mm |
| OU1 | Hno, Hnc, Fno, Fnc | Hno | Hno |
| SP1 | 200...9999 | 1000 | 1000 |
| nSP1 | 200...9999 | 800 | 800 |
| FSP1 | 200...9999 | 1200 | 1200 |
| OU2 | Hno, Hnc, Fno, Fnc, I, U | I | U |
| SP2 | 200...9999 | 2000 | 2000 |
| nSP2 | 200...9999 | 1800 | 1800 |
| FSP2 | 200...9999 | 2200 | 2200 |
| ASP | 0...9999 | 0 | 200 |
| AEP | 0...9999 | 9999 | 670 |
| rATE | 1...50 | 50 Hz | 50 |
| dS1 | 0...0.1...5 | 0 s | 0 |
| dr1 | 0...0.1...5 | 0 s | 0 |
| dS2 | 0...0.1...5 | 0 s | 0 |
| dr2 | 0...0.1...5 | 0 s | 0 |
| dFo | 0...0.1...0.2...0.5...1...2...5 | 0 s | 0 |
| diS | d1...3; rd1...3; OFF | d3 | d3 |

Parameter settings on both sensors according to the table 1. In this table there are only 3 parameters that are changed, while the other parameters follow the factory settings. These parameters are OUT2 set to "U" which is the output voltage 0-10 VDC, the next parameter is "ASP" (Analog Start Point) which is the desired distance when the output is 0 VDC and the parameter "AEP" (Analog End Point) is a certain distance with the desired output. desired is 10 VDC[18]. For the settings in this experiment, ASP = 200, which means that when the distance between the sensor and the reflector is 200 mm, the sensor produces an output of 0 VDC and when the distance is 670 mm, the output is 10 VDC. The setting values for ASP and AEP can be reversed, for example ASP is greater than AEP so that the output voltage will also be reversed, when the short distance output is 10 Volts, and when the long distance is 0 volts.

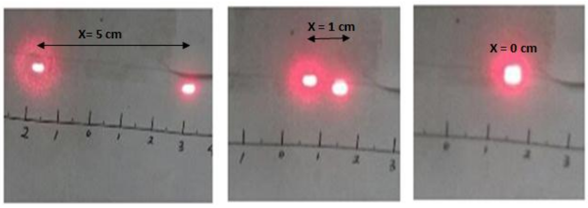


Figure 9. Experimental Results (distance between laser points on reflector=X)

## RESULTS AND DISCUSSION

The table 2 shows the measurement data from the experimental results. X notation is the distance between the laser points on the reflector, L1 is the distance between the laser source on 1st sensor and the reflector, L2 is the distance between laser source 2nd sensor and the reflector. V1 and V2 are the output voltages measured at 1st sensor and 2nd sensor when showing a certain L and X distance.

When X indicates a distance of 110 mm, 1st sensor reads the distance between laser sources no 1 and its reflector as 535 mm, and 2nd sensor as 538 mm. The output that can be measured on 1st sensor is 7.03 volts while the output on 2nd sensor is 7.23 volts.

The reflector is then shifted closer to the laser source, so that the distance between the X laser points is also getting closer. The determination of the X value is made in such a way, so that data is obtained that can describe the condition of the distance between the laser beams, if the X value is positive, it means that the distance between the laser beams is measured after the laser beam crossing point, if the X value is negative, it means that the distance between the laser beams is measured before the beam crossing point When the laser point distance is X= 110 mm, L1 = 535 mm, L2=538, the output is V1 = 7.03 Volt and V2 = 7.23 and so on, until the laser point distance is X= 10 mm, L1 = 304 mm, L2=310, the output is V1 = 2.173 Volt and V2 = 2.471. Up to this data there is no disturbance in the sensor output reading value, meaning that from the first experimental data up to this point the sensor output reading can be done by reading with a Voltmeter. However, when the laser points of the two sensors are brought together (laser point 1st sensor and 2nd sensor meet in one point on the reflector (X=0) where a reflector at point Y) the display that shows the distance to the hunting sensor is moving continuously (unstable). The indication cannot be stable at a certain number, even reading from 100 to “FAR” (if the sensor reads FAR, it means that the sensor reads the distance beyond its farthest reading capability, which is 9999 mm.) because reading the distance is unstable, the output voltage cannot be read either (at table filled with "error"). After the reflector passes through Y, the reading returns to normal. Detail of data measurement shown in the table 2.

Table 2. Data Measurement

| X (mm) | L1 (mm) | L2 (mm) | V1 (Volt) | V2 (Volt) |
|---|---|---|---|---|
| 110 | 535 | 538 | 7,03 | 7,23 |
| 90 | 488 | 489 | 6,063 | 6,442 |
| 70 | 432 | 438 | 4,92 | 5,132 |
| 35 | 361 | 368 | 3,36 | 3,592 |
| 10 | 304 | 310 | 2,173 | 2,471 |
| 0 | 270 | 279 | error | error |
| -10 | 242 | 251 | 0,916 | 1,446 |
| -40 | 172 | 184 | 0,415 | 0,45 |

From the table 2, for more details, it is presented in graphical form as Figure 10. From the graph it can be seen that the output voltage (V1 & V2) is directly proportional to the distance between the sensor and the reflector (L1 & L2) as long as there is no laser beam crushing on the reflector (X=0). When X = 0 the output voltage is unstable so it is difficult to determine the amount, and the author fills it with the value "error". This shows that interference occurs when the laser beams coincide at one point on the reflector because the laser beam used in this experiment cannot be seen in its line of light, but can only be seen at the end point on the reflector.

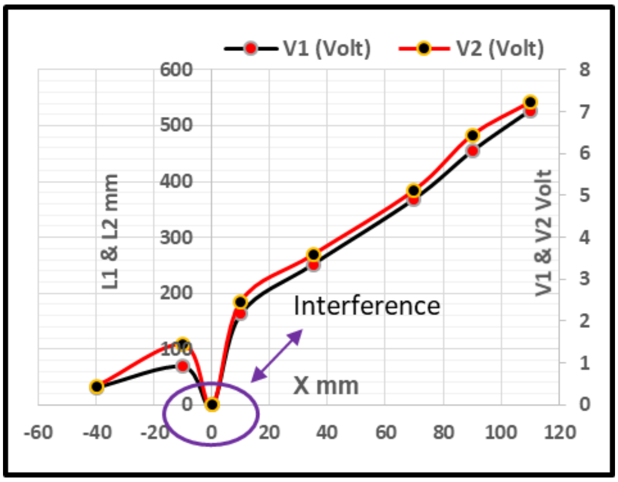


Figure 10. Graph of interference

## CONCLUSION

Interference occurs when the laser point on the reflector coincides with a laser point from another source. Whereas if the point does not coincide with one point on the reflector, even if a straight line is drawn, the paths actually intersect, there is no interference. This can be used as one of the things that must be considered when laser light is used for communication systems (Visible Laser Light Communication). This means that when using VLLC, even using multiple lasers and the laser beams touching each other will not interfere with the communication process if the recipient of the information is not at the point of contact of the laser.

The author suggests that if you want to know in more detail how much interference is and how the condition of the output voltage when interference occurs, use more complete measuring equipment such as an ossiloscope, so that the graph / chart can be seen in real time.

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