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Design of a Compact Test-Jig For Opto-Interrupters in The Crop Field Perimeter Control

Varsha Bapat[1], A.D.Shaligram[2]

Assistant Professor, Dept.of Electronic Science,Modern College,Ganeshkhind,Pune, Maharashtra,India[1]

Professor & Head, Dept. of Electronic Science, Svitribai Phule Pune University, , Pune , Maharashtra, India[2]

ABSTRACT : Protection of the crop in the agricultural field is an important issue for the growth in the yield. Animal and Bird attack on the crop directly affect the agricultural production. Suitable Technology assisted Perimeter Control System can decrease the crop damage and improve yield. The primary step of the perimeter control system is the detection of the presence of an animal (Intruder) in and around the crop field. Opto-interrupter is used here for detecting the Intruder presence. Transmitters and receivers are fixed on the posts at specific distances, along field. This forms an invisible fence around the field. In this study a Laser-phototransistor based Opto-interrupter is developed in the Laboratory. To analyze this Opto-interrupter in the Laboratory and to achieve reasonable distance a Compact Test-jig is designed. In this paper, the measurements taken during the experimentation and their interpretations for the Test-jig are reported considering different calibration parameters.

KEYWORDS: Crop damage, Intruder, Opto-interrupter, Perimeter control, Test-jig.

I INTRODUCTION

Farmers all over the globe are facing the problem of considerable crop losses due to animal attack leading to huge financial loss. For achieving high yield in the field one of the attribute is the protection of the crop from birds and animals around the field. To control these crop damages a variety of technology assisted methods can be used. At different stages technology can be put into action in order to achieve the task for the protection of the crop. The use of Precision agriculture techniques gives agronomists the potential to apply new and continuously developing techniques which help to manage better the production [1] [2].The damage caused by the animals such as wild pigs, deer, wild boars and elephants is significant in many areas. Traditional wire fencing along the perimeter of the crop field is not affordable by most of the farmers .Intrusion presence Detection and diverting them from the perimeter gives a design of an effective security system. Technology assisted systems are now admired in Agriculture.

This paper describes a design of a compact Test jig which will be useful to estimate the distance between the source and detector of an Opto-interrupter system used in the crop field. The effective distance covered is dependent on several parameters associated with the propagation of beam from source to detector. The effective distance between the source and the detector facilitates to decide the number of posts to be placed along the perimeter of the farm.

II. RELATED WORK

The laser range sensors widely used in robotic research are mostly too big, heavy and power hungry for practical use by small size mobile robots.[13] Another very important parameter which can be considered for a Laser beam propagation is the Beam Propagation factor M^2.The beam propagation factor (M2) was specifically created to enable accurate calculation of the properties of laser beams which depart from the theoretically perfect TEM00 beam.[14]. Light produced from the lasers have several valuable characteristics not shown by light obtained from other conventional light sources, which make them suitable for a variety of scientific and technological applications. Their monochromaticity, directionality, laser line width, brightness, and coherence of laser light make them highly important

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for various materials processing and characterization applications. In practice, every laser system has some angle of divergence, which increases the spot size of laser beam and reduces its brightness. [15]

III PROBLEM STATEMENT

For the detection of existence of an Intruder in the crop field an appropriate Perimeter Control system is required. If a Crop field area of one Hector (100m X 100m) is considered as shown in the Fig 1. Then it is essential here that the distance covered by the signal to establish a communication link must be 100m or else there should be several posts with source and detector pair at certain distances along the perimeter which will cover the boundary around the field and detect the existence of an Intruder. It is difficult to test the source –detector module in the field directly for the estimation of the range in such a large field area. So in order to extend the range and to determine the effective distance between the source and the detector within the laboratory this Compact Test –jig is developed.

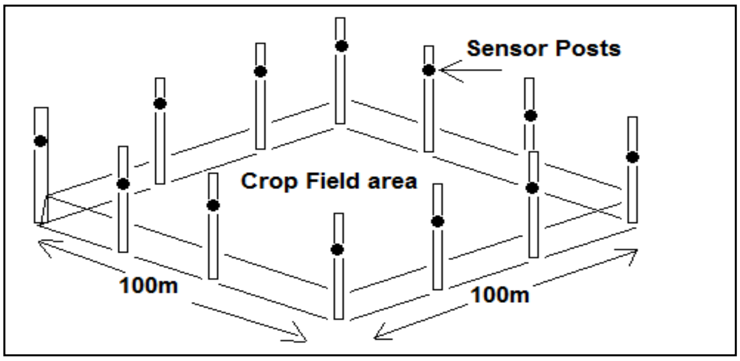

Fig 1. Crop field area surrounded by sensor posts

In this study Opto-interrupters are been used to form an invisible fence around the perimeter of the crop field. Using minimum number of Opto-interrupters maximum crop area should be covered. To achieve this the distance between the source and the detector should be optimized in order to establish a communication link. A Compact Test jig is designed for Source to detector distance estimation in the Opto-interrupter. In this paper, analysis of the Compact Test-jig is done so as to estimate the effective distance with an appropriate correction factor.

IV . EXPERIMENTAL SET-UP AND THEORETICAL CONSIDERATIONS

In this study a Compact Test-jig is designed to estimate the effective distance between the source and the detector. This Compact Test-jig includes a Laser source and a photo-transistor used as an Opto-interrupter. Two plane mirrors are placed in front of each other. As shown in Fig 2. the Laser source is placed at one end of the mirror arrangement in such a way that the Light ray goes through multiple reflections through the mirror arrangement.

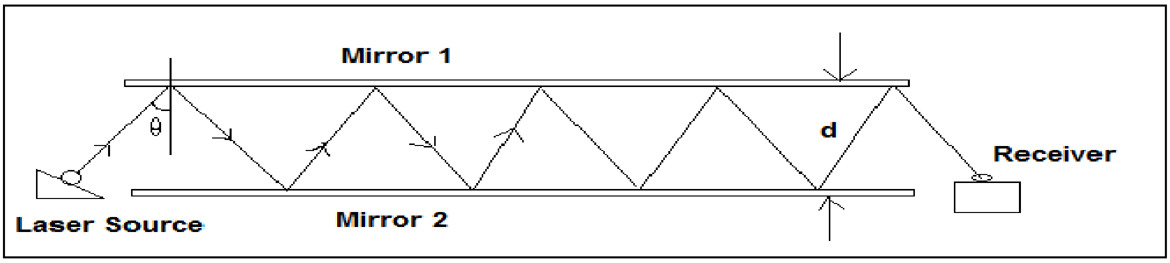

Fig 2. Arrangement of the Test-jig

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The effective distance covered between the Source and the detector to establish a communication link is dependent on the angle of incidence , distance between the two mirrors and their placements, type of the light source etc. The equation for the effective distance covered can be stated as follows:

$$L = \frac{N*d}{cos\theta} \qquad \text{.......................(1)}$$

Where L : Effective Distance

N : Number of reflections

d : distance between the two mirrors

θ : Incident angle

Fig 3 Experimental arrangement for the Test-jig

V. RESULT AND DISCUSSIONS

Table 1 shows the observations for the compact Test jig with the calculations of the effective distance. Here, the angle of incidence is changed and the distance between the two mirrors were kept constant. The length of the mirror is 1 meter.

Table 1. Observations for Effective distance with d=0.33m

Incidence angle ‘θ’ in Degrees	Number of Reflections N	Effective Distance in meters.
30	5	1.732051
20	7	2.234773
10	9	2.741652

In order to evaluate the loss in the intensity due to multiple reflections, experiment was carried out with the He-Ne Laser source. Since the divergence angle of this source is almost zero it is expected that the intensity of the light at the source and that at detector end should be the same. But from the experiment it is clear that there is loss of intensity with every reflection through the mirror. Observations shown in the Table 2 were noted. Fig.4 shows a graph of number of relections versus Intensity shows that at every reflection there is loss of intensity.

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Table 2 Light intensity variation with increase in number of reflections

Number of reflections(N)	Intensity(lux) (I)
0	1590
1	1096
3	749
5	489
7	302
9	233
11	114

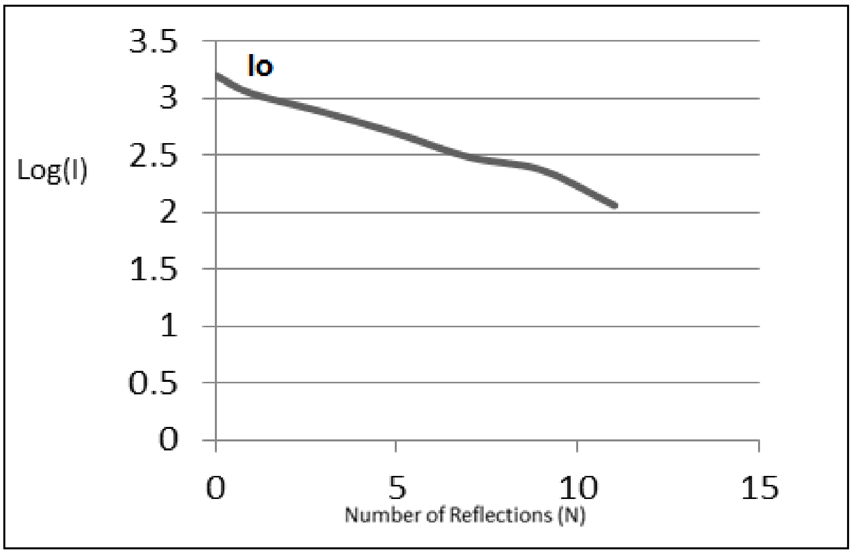

Fig 4. Graph of Number of reflections Vs Log(I)

From the experimental set up as in Fig 3. it is noted that as the light ray goes through the mirror, at every reflection it gives rise to a small amount of Intensity loss. It is found that this is due to two parameters associated with the mirror: The Reflection coefficient and the Absorption coefficient of the mirror.

The relation between the Intensity of the Light, number of reflections and the reflection coefficient can be stated as equation (2)

Log(I) = Log (Io) + N* Log(R) ……………(2)

Where, Io : Initial intensity of the source

N : Number of reflections

R : Reflection coefficient

VI. ESTIMATION OF CORRECTION FACTOR FOR DIVERGENT SOURCE

In this study a laser source is used whose divergence is negligible but if the source is a divergent source then there are many other parameters which may reduce the intensity at the detector end. As the light ray propagates through multiple reflections, it is observed that the beam diameter is increased as a effect of divergence. This beam diameter is a also a function of angle of incidence at the source end. Increase in the divergence angle cause reduction in the beam intensity at every reflection. The relation between the beam diameter and beam divergence angle(ɵ) is given as

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Beam Diameter D = 2L*tanɵ …………………(3)

Thus, when practical aspect of this is considered another parameter which may arise can be the absorption of light at every reflection. So, this absorption can be expressed in terms of Absorption Coefficient (A).

Further the absorption coefficient (A) can be estimated from the analysis as stated.

$$I = I_o * R^N - N * A \qquad \text{………………(4)}$$

Where A= 1- R

Equation 3 shows that the intensity of the light passing through the two parallel mirrors is a changing with the Reflection and Absorption Coefficient.

Experiments were carried out to determine the reflection and absorption coefficient for this Test-jig. The observations were noted using the Luxmeter. It is observed that using this Test jig we can cover more operational range between the Source and the detector. This effective distance majorly depends on the angle of incidence (number of reflections), distance between the two mirrors. It is also observed that at every reflection there is loss in the light intensity which is due to the reflection and absorption coefficient of the mirror. It can be noted here that the effective operational distance covered by the light signal is actually little more than the calculated value as there is reduction in the intensity due to the reflection and absorption coefficients.

Using the Inverse Square Law here we can estimate the corrected distance as:

$$I \propto \frac{1}{d^2}$$

$$N * R = \frac{d^2 - 1}{d^2}$$

$$\boxed{\Delta d = \frac{1}{\sqrt{1 - N * R}}} \qquad \text{….…..(5)}$$

Equation (5) shows the correction factor which should be added to the calculated distance in order to determine the exact effective distance covered using this Test-jig arrangement. Table 3 shows the estimated distance with the correction factor included in the effective distance.

Table 3 Observations for estimated distance with the correction factor

Distance ‘d’ in Meters	Incidence angle ‘θ’ in Degrees	Number of Reflections N	Effective Distance in meters.	Estimated Distance with correction factor
0.3	30	5	1.732051	2.0710
0.3	20	7	2.234773	2.7046
0.3	10	9	2.741652	3.1462

VII. CONCLUSION

Thus, this correction factor will have to be considered here to get the effective distance covered between the source and the detector if there were no losses in the Intensity due to these coefficients. Using proposed setup of the Compact Test-jig one can estimate and evaluate the effective distance covered between the source and the detector for establishing a communication link. Also, by analyzing the received power at the receiver end one can test the quality of the detector.

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BIOGRAPHY

Varsha Bapat is currently Assistant Professor in Department of Electronic Science , Modern College of Arts Science & Commerce,Ganeshkhind,Pune-16. She is presently pursuing Ph.D in Electronic Science from Departement of Electronic Sc.,Savitribai Phule Pune University,Pune, India. She has 20 years of teaching experience. Her research interests include Agrielectronics,Wireless Sensor Networks,Embedded Systems etc.

Professor and Head, Department of Electronic Science at University of Pune, has a professional experience of 28 years. Graduation, post graduation and Ph.D. from University of PuneMain fields of research interest are Embedded systems and VLSI design, Nanoelectronics, Optoelectronic sensors and systems, LED Lighting systems performance and reliability and Wireless Sensor Networks Published more than 29 books (3 international) and laboratory manuals, 462 research papers with 356 Citations, out of which 138 papers are in National/ International Journals, 34 Invited talks and the rest in conference proceedings .He has been a IEEE member for 16 years. He is Member of board of studies and research recognition committees of most of the Universities in Maharshtra. He has guided 28 students for Ph.D. and 18 students for M.Phil .He has completed 22 research projects funded by various Government funding agencies in India, including DOE, UGC, DIT, DAE, CSIR, DST, DRDO and ISRO as Principal or co-investigator. He works as Industrial Consultant to several Industries in the fields of electronics, embedded systems, instrumentation and automation, optics and Information Technology Supervised RDSO standard testing of LED Signals for Indian Railways He has worked as corporate trainer on Embedded Systems and VLSI Design for many industries

Specific professional assignments:

- Vice chairman –IEEE AP/EDS Bombay chapter (1999-2003)
- International consultant on "Digital IC design" under Ministry of Science and Technology of Sri Lanka Govt.