Electro-optical Method for Polarimetric Measurement

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***Abstract*- When passing a pulsing beam of polarize light of a light emitter diode (LED) or a semiconductor laser through an optical system, two photodiodes spatially arranged at 90^0 to each other and both with their detection surfaces parallel to the transmission shaft of light, and polarization axis oriented at 45^0 of the vertices of the edges where the photodiodes join, in the outputs of two operational amplifiers, we have two signals with the same shape in time, i.e. a pulse train with the same phase. But when you turn the polarization plane, change the radiance of the light projected onto the photodiodes, being out of phase signals to the outputs of the amplifiers, where the difference between the fronts of the pulses is proportional to the angle of rotation of the plane of polarization of polarization light. In a digital circuit phase discriminator, a pulse is obtained equal to the time difference between two sides of the rise time in the output of two amplifiers. The width of this is directly proportional to the value of rotation the plane of polarization of light, that is to say, the greater the rotation is, the greater the width of this will be.**

Keywords- Polarization; Optic; Lens; Measurement

I. INTRODUCTION

Using a very simple optic system with a luminous source to light emitting diode (LED) and as sensor two Optic-Electronic Amplifiers associated to front wave differentiating digital circuits, we have been able to determine the polarized light plane rotation. In this comfortable and precise form, it is not necessary to use analyzers, rotational modulators, or magnetic coil which is more commonly employed for the polarized light plane measure. Given that the outlined method has the advantage that the mobile mechanical parts total lack, and the method does not have to use big currents densities in induction coils, its precision depends on the pulses modulation electric sign stability and the optic system alignment precision, including the photodiodes spaced to 90^0 degrees among them incidence faces.

When passing a pulsing beam of polarize light of a light emitter diode (LED) or a semiconductor laser through an optical system and two photodiodes spatially arranged at 900 to each other and both with their detection surfaces parallel to the transmission shaft of light, with polarization axis oriented at 450 of the vertices of the edges where the photodiodes join in the outputs of two operational amplifiers, we have two signals with the same shape in time, i.e. a pulse train with the same phase. But when you turn the polarization plane and change the radiance of the light projected onto the photodiodes, being out of phase signals to the outputs of the amplifiers, where the difference between the fronts of the pulses is proportional to the angle of rotation of the plane of polarization of polarization light. In a digital circuit phase discriminator, a pulse is obtained equal to the time difference between two sides of the rise time in the output of two amplifiers. The width of this is directly proportional to the value of rotation the plane of polarization of light, that is to say, the greater the rotation is, the greater the width will be.

When you affect linearly polarized light in a lens, it will reflect and refract along the curves lines arising from the interception of a plane with a sphere on the surface of the lens while maintaining the orientation of the plane of polarization. This effect is significant only looking at the lens side. Therefore, the lens acts as an analyzer side if we rotate the polarization plane of polarized light that falls on it.

Following this principle and that over the spherical surface lens, few can put n circle of radius r, where n is inversely proportional to r, and each circle is in turn a lens. So if we shine a beam of light in one of these areas, the phenomenon of polarization is expressed by lateral side and is diametrically opposite to the incident linearly polarized light.

II. EXPERIMENT

When linearly polarized light is incident on a lens, it will reveal the algebraic properties of geometric figures intercept such as plane and spherical surface. A beam of polarized light is composed of electromagnetic waves that oscillate in planes parallel to each other and in the same address. If we take one of these planes and shine orthogonal spherical surface of a convex lens, the light is reflected and refracted without leaving the plane to which it belongs as shown in Figure 1a, which has represented the central section above the lens for better understanding. Now if we rotate the polarization plane of polarized light beam, not the lens, then also change the direction of the beams reflected and refracted because they have to stay within the plane of polarization of light, which is shown in Figure 1b.

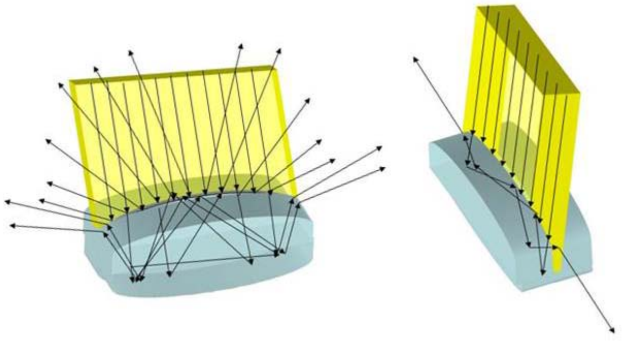

a b

Figure 1 Representation of refraction and reflection to affect polarized light in a convex lens

If we put two observers, one on the right and the other on the left of Figure 1a, the right observer will see the opposite side of the image of the light source, because the rays that reach it are refracted and reflected inside the lens that side of the light source, while the left observer sees the right side of image source.

Moving to the position of Figure 1b, both observers will reduce the light intensity of the image and completely stop view it completely when the plane of polarization is orthogonal to the plane of the paper.

For all the above say, a lens can be used as an analyzer of polarized light, giving us information on the orientation of the polarization plane. Figure 2 a shows this effect, and in the Figure 2 b, it is the polarize plane rotation sequence, where the circle in the middle of the lens is the representation of how the intensity light variations is.

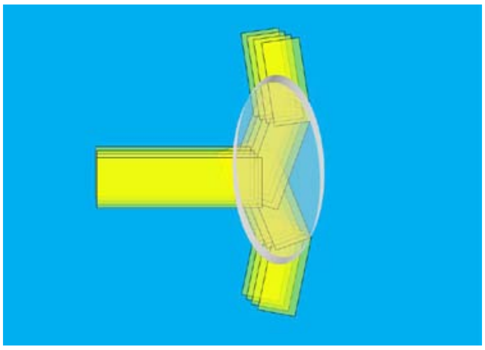


Figure 2a The reflection and refraction at a convex lens representation

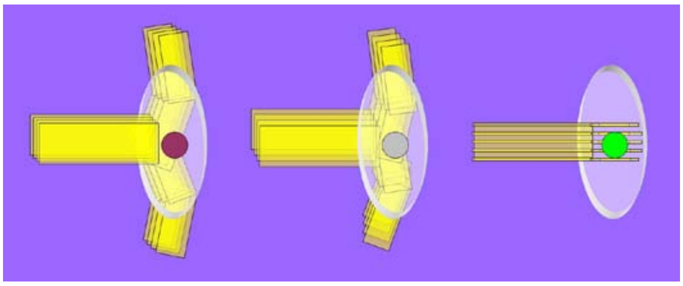


Figure 2b Polarize plane rotation sequence

III. RESULTS AND DISCUSSION

A. System with Only One Lens

To use this phenomenon in the construction of an instrument to determine the value of the rotation of the plane of polarization of light, we would have two light sensors placed parallel to the optical axis 90^0 spaced from each other and on the sides of the lens. In Figure 3, the green color circles are the photodiodes and when the plane of polarization of light rotated, the light over photodiodes detection surface change. But this has two disadvantages, one is that the light intensity is low and the other is the absorption effect on distorting information because there is a lighted space between the sensors that would not touch the surface of both.

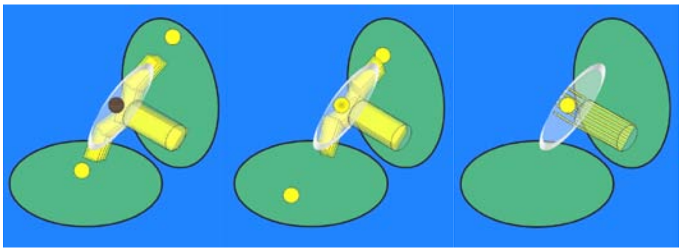
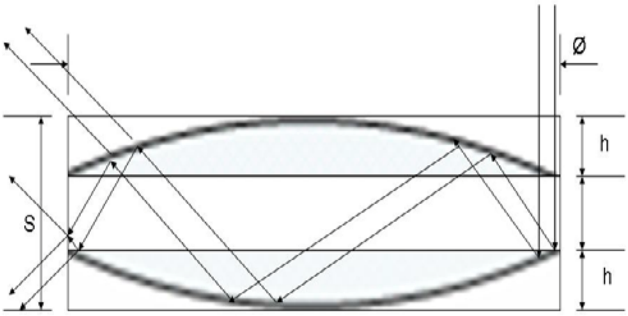


Figure 3 Sequence that show how two photodiodes spatially to 90 degree are illuminated when the polarize plane change.

B. System with Two Lenses

Using a geometric study of the lenses we find out the solution to this problem. As the spherical surface lens on it can be matched perfectly circles of radius r, the amount will be inversely proportional to that radius. Each circle may be regarded as a lens. Given this consideration, if linearly polarized light we shine on the edge of the lens, everything will happen as explained above. But in the region of incidence, the light will go over the edge of the lens is diametrically opposed to incident beam and it can only be observed the image at that point but not in any other region of the lens. In this way we will not have a cone-shaped beam on the side of the lens, but a point where we will get the whole picture and therefore with greater intensity. In Figure 4, we have represented what has been explained here, including an equation to determine the number of reflections that occur within the lens geometry to select the appropriate lens.



$$Reflections = \frac{\phi(1/S + 1/2h_{arc})}{2}$$

Figure 4 Reflections on the lens to make an impact on its edge beam perimeter

In this case, the sequence is showing in Figure 5, where the outcoming light intensity is a function of the polarize plane incident position over the border lens surface.

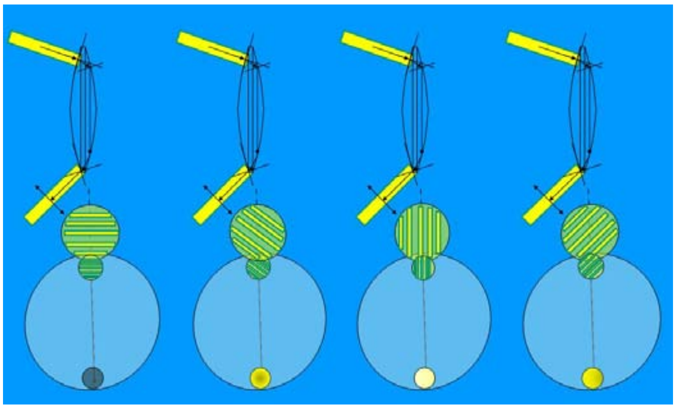


Figure 5 Sequences that show how the outcoming light lens change in a lens side view

But we still have a problem and we have to use two sensors to polarized light to come on as a light source. The solution of this problem is to use a system of two identical lenses placed in the same plane so that they cross a line where you play two of its edges with another drawn from the edges that touch the two lenses, with orthogonal to the first being the center of the beam. This ensures that the two points of light coming out diametrically opposed in each of the lenses are at 900 from each other. Figure 6 is the geometric representation.

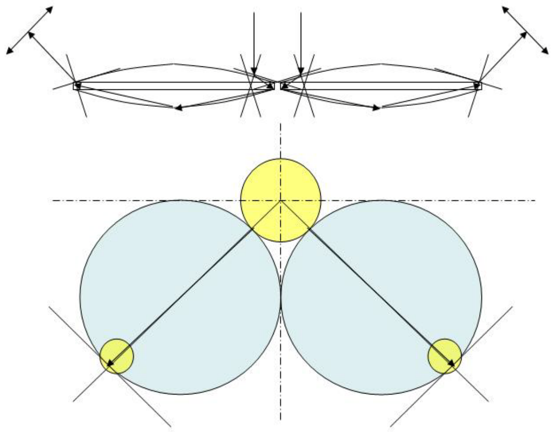


Figure 6 Parallel lens system

By rotating the linearly polarized light beam, the lens diameter path coincides with the orientation of the polarization plane will have a very bright image of the light source, while the diametrically opposite position of the other lens will not light. If we continue to rotate the plane of polarization in the direction of the lens with less intensity than light, it will grow in intensity and decreasing the other, when both intensities are equal will be in the place where the instrument has its zero. There will be a gap of 900 between the points.

Now the light sensors are always under the light field (see Figure 7), recording exactly light variations that are proportional to the rotation of the polarization plane of light. So that by modulating the polarized light with a train of pulses of light and use it as sensors photodiodes, electric current generated in them will be directly proportional to the amount of light reaching them. There is a gap between rising fronts amplified signal pulses obtained in photodiodes if they do not receive the same amount of light and that is the value of rotation of the polarization plane.

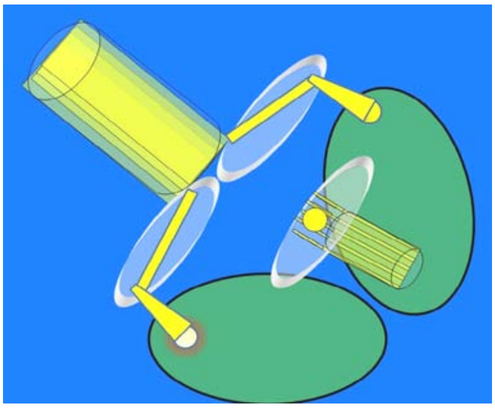


Figure 7 With two lenses the light sensors are always under the light field

C. Malus's Low Behavior

Between a pulsating light source and a radiometer we place two polarizing sheets, with their polarization axes at 900, the radiometer will measure zero or minimal candle power, then as broken the polarizing sheet, it will go increasing the light intensity reading in the measuring instrument, until a maximum that will correspond when we have rotated it 900 (Malus`s law). If now we retire the polarizing sheet utilized as analyzer and instead of the radiometer, we place our amplifier, its exit, view in an oscilloscope, we will have a pulse that will go increasing their width until a maximum valor when going rotating the polarizing sheet in oneself sense, and starting from there it will begin to diminish until a minimum and a phase shift will take place, increasing the width until a maximum, but now in opposed sense (Figure 8).

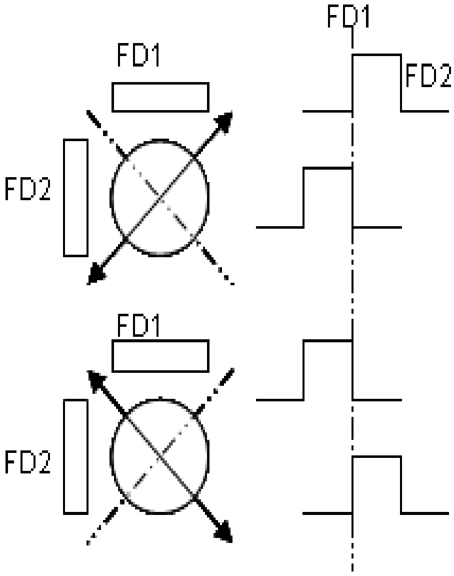


Figure 8 Operational amplifier output following the rise time of the pulse signal in each output amplifier, according to the Malus`s Low

Comparing both methods has obtained more information with our amplifier than with the radiometer.

When in the oscilloscope we have a minimum, the plane gives the polarized light that will be exactly at 450 or – 450 regarding the horizontal one give the paper plane and like the line with double arrow represent, that is to say, what already know is the fact that the sense the polarization plane is oriented of and to identify this in the polarizing sheet.

Now then, if we place an active optic substance in that trajectory, being the plane of polarization at 450, superior image gives the drawing in Figure 8, we will have a pulse that will increase its width toward the right if the substance is levorotary, and counter-clockwise if it is not levorotary, being its magnitude in agreement with the angular quantity that the substance has rotated the plane of polarization.

If initially the plane of polarization is to – 450, inferior image gives the drawing in Figure 8, we will have a pulse that will increase its width counter-clockwise if the substance is levorotary, and toward the right if it is not levorotary. FD1 and FD2 in the Figure 8 represent the photodiodes space disposition utilized.

D. Wave Form at the Output Electronic Amplifier

In the Figure 9 the signs time letters, where we only use the rise time between the pulse signals in each output of both operational amplifiers. That difference is equivalent to the rotation of the polarize axis, this value is equal to signal pulse in the last one line.

E. System Design

In the Figure 10 the whole system has been represented in blocks diagram in order to understand how the equipment works and what the function of its parts is. The Figure 11 shows the optic system utilized

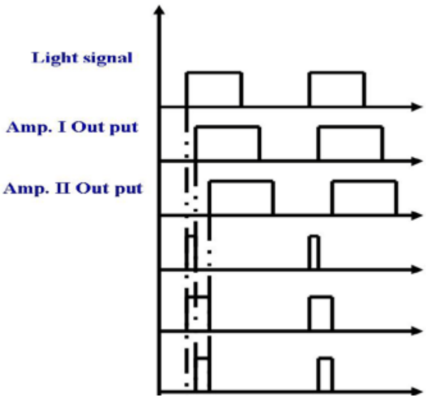


Figure 9 Electronic circuit letters time

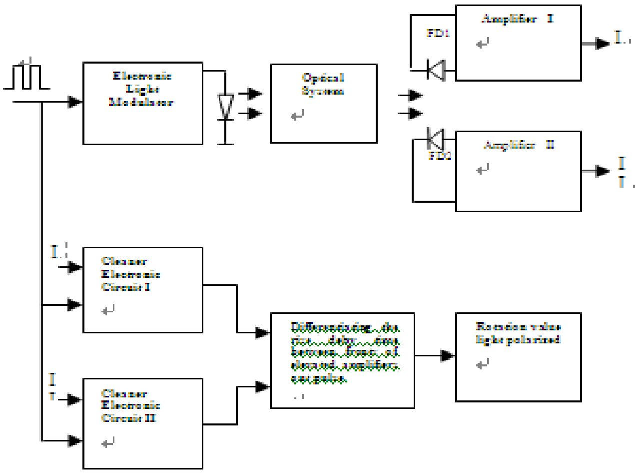


Figure 10 Equipment block diagram

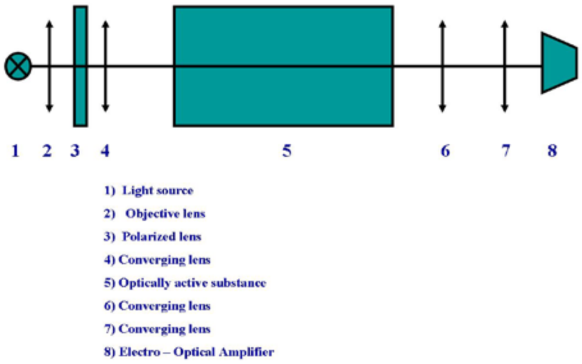


Figure 11 Optic system

IV. CONCLUSIONS

The Constant Height and Variable Phase Electro-Optic Amplifier allow determine the beam of light polarization plane orientation. It also allows to determine the magnitude that has been rotated when introducing an active optic substance and to also know if the same one is levorotary or not.

It is the first time to use a parallel lens systems and this is a new optical method for polarimetric measurement, with this, extremely simple, sure and precise polarimeters can be built.

The optical system and the phenomenon that collects can be used in various applications.

1) The transmission of binary data using polarized light in a position of the plane of polarized light would be a zero or one, by varying the angle of polarization by polarizing electric. This would be very advantageous as there would be loss of information, as light intensity levels would remain the same and even vary does not matter, because the polarization, which is the one who carries the information, would not change.
2) Signaling air and seas, using light beacons of guidance by the polarization effect.
3) In weighing systems, in which the rotation of a polarizing film would be proportional to the weight of a given body.
4) In polarimetry instruments.
5) In determining if a light source is polarized.

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NOTE: References have been mentioned rather to indicate the field belonging the subject matter hereof, as the phenomenon is not reflected in the literature.

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Education

University or equivalent Name and place	Years attended from	to	Degrees
BRNO UNIVERSITY. CZECH REPUBLIC	1989	1989	Robotic specialist
UNIVERSITY JOSE A. HECHEVERRIA	1977	1982	Engineer

Research interests

Automatic Control Theory

The development of new mathematical equations in order to make process regulator electronic design for automatic control process and new arithmetical method in order to grow up a new automatic control theory. This project has been developed in collaboration with the Mathematical Cathedra of Havana University, UNIVERSITY CITY JOSE A. HECHEVERRIA (CUJAE) and Oil Refinery Ñico López.

Optic polarmetry

The development of new methode in order to make a new equipment for polarymetric measurement.

Patents and author's certificades:

Pneumatic Transducer .No 45/86 Author's certificated. Scientific Academic of Pinar del Rio.
Electro-Pneumatic Converter No47/86 Author's certificated. Scientific Academic of Pinar del Rio.
Patent No 21969, Alarm and Signaling Electronic Module. Author's certificated. Industrial Property Cuban Office (OCPI). Cuba.
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G01J 4/04 (2008.04). Industrial Property Cuban Office (OCPI). Cuba. 2007.