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Photovoltaic effect in Light Emitting Diodes

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Abstract: This paper describes an experimental work on the electrical characterization of commercial LED of different colors and their photoelectric effect.
A research work has been carried out to develop the experimental measurement in order to show the presence of a photovoltaic effect on LEDs. For this purpose, we measured the electrical characteristics of individual LED and studied their light intensities using a pyranometer EPLEY. This work focused mainly on red, green and yellowLEDs. Moreover, we have implemented an experimental system for the measurement of sensitivity of different LEDs depending on the power of light from a light source. A comparison was made between theoretical model and experimental results.
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Keywords: LEDs; Photovoltaic; effect; Characterization; light intensity.

1. INTRODUCTION

It was not until 1962 that the first red LED was created by Nick Holon yak Jr and S. Bevacqua. For several years, researchers have been limited to a few colors such as red (1962), yellow and blue (1972) [1, 2] .or green. Conventional low power LEDs are an attractive alternative in comparison to conventional products such as fluorescent lights, incandescent or discharge. They offer such a great advantage which is low power consumption, long life time and the ability to select a very specific color among many others.
In recent years LEDs are widely implemented and used in our daily life. They have a huge advantage over other types of lighting: the photon creation process of a LED is extremely effective; indeed in one LED each electron gives a photon. Thus, with a current of one ampere, a light output gives about one Watt, whereas a bulb will give only 0.1W for the same current. The more widespread use of LEDs for lighting will have an extremely important impact on the energy savings and the environment. The LED performance doubling every 3 years for the price divided by 10 every ten years [3] . At present, they are widely used in illumination and indication, billboards, traffic lights and flat panel televisions. The widespread use of these devises in both the domestic and external lighting would make substantial energy saving. However, this development raises a number of measurement problems for both aspects of characterization of lighting equipment for the security-related problems in the use of these sources. The light emitting diodes are sources of very small dimensions emitting a large flow in a solid angle reduced.
At the international level, in particular the International Commission on Illumination (CIE), several technical committees have carried out research work on different aspects of these measurements [4].
Concerning the photovoltaic effect, some research work has been done regarding this aspect; this is due to the fact that LEDs are made of a PN junction which is not opaque, the photons may reach and thereby produce a photovoltaic effect, like in the junctions case of a conventional solar cell.

This same effect can probably be observed in organic LEDs (OLEDs) according to the process described by Karzazi ([5],
It is the fact that LEDs were not suitable for this function: the hood probably suffers no antireflection coating. However, it is not quite certain that this effect exists.

2. II MATERIALS AND METHODS

A.Electrical Characterisation of conventional LEDs of different colors

Bench block diagram is shown in Figure 1 [6], temperature was controlled by the bench and the outside temperature of the LED assembly.

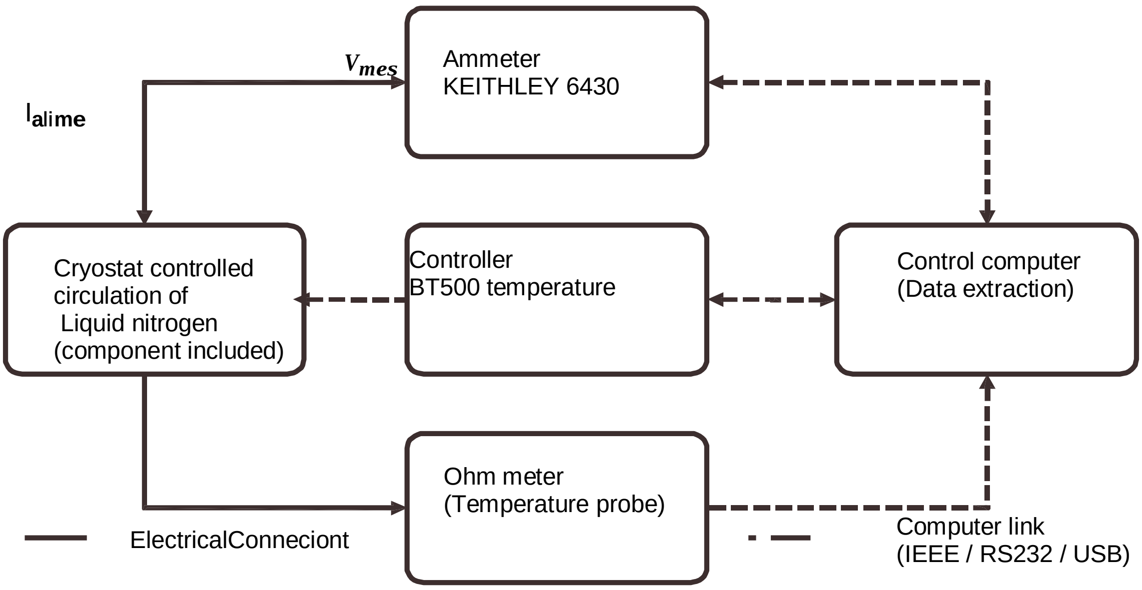


Fig.1: Schematic diagram of the bench I =f(V)

The equipment used consists of:

1- Analyzer semiconductor parameters KEITHLEY 6430 connected by an IEEE bus connected to the CPU of the control computer. This device consists of a current source (10^{-16} A to 0.1 A) 10^{-17} A resolution (error 0.1%) and a voltage source (0 to 10 V) resolution 10^{-6} V (error 0.1%) ;
2- Liquid nitrogen flow cryostat LN2 is controlled where in the component. It allows temperature regulation in a range of 80 K to 350 K with a precision of 0.1 K;
3- Temperature control unit (Temperature Controller BT 500) used for temperature regulation during measurements. It controls the heating resistor of the cryostat using a PID automatic system (Proportional Integral Derivative;
4- Drypump (ADIXEN) whose role is to conduct a primary vacuum (1: -2 Torr) in the vacuum chamber of the cryostat;
5- Ohmmeter giving a resistance value denoted Rsonde, corresponding to the value of the resistance of the PT100 heat sensor. This probe provides access to the TP package temperature of the LED;
To overcome the resistance of electrical cables, the LED is connected in measure 4 son with Triaxcables (Keithley) [7, 8].

B. PV different LED Effect:
The measuring device is based on a pyranometer device which measures the luminance in W / m^2 and which is disposed in the same plane as the LED under test. We choose the correct orientation of the LED for maximum current flow at its terminals. Several measures will be taken (twenty) one day. The coefficient of the pyranometer is:

$$C = 9,56 \times 10^{-6} V / (W / m^2)$$

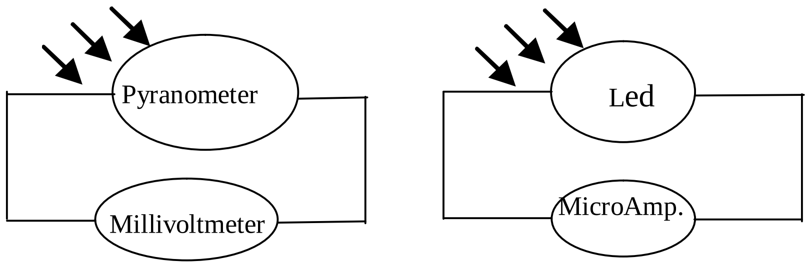


Figure 2: Diagram of the light measuring device according to the current of the LEDVp=f(Id)

C. Measurement of the sensitivity of various green LEDs, yellow and red according to the power of the illumination source.

The used equipment :

1- A stabilized voltage supply V = 12V and a current I = 4A for the operation of the lamp
2- A light meter to measure the luminance
3- A digital multimeter used in ammeter to measure the current across the yellow and red LED according to the power of illumination of a light source.

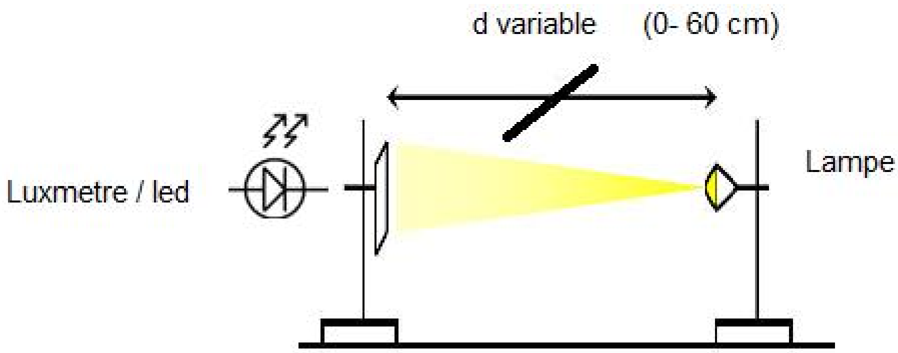


Fig. 3 measuring device Scheme E (v) =f(Id LED)

3. RESULTS AND DISCUSSION

A. Current -voltage characteristic of a classic red LED

The current-voltage characteristic of a conventional LED is given in Figure 4. The first drawn in linear scale shows a threshold voltage Vs between two main areas: B where the diode is conducting (V >Vs) and where A diode is blocked (V <Vs). The behavior is the one of a diode. This plot is ideal for high injection levels (V >Vs). The characteristic I (V) characteristic of a red LED is shown in

Figure 4. Feature red LED directly.

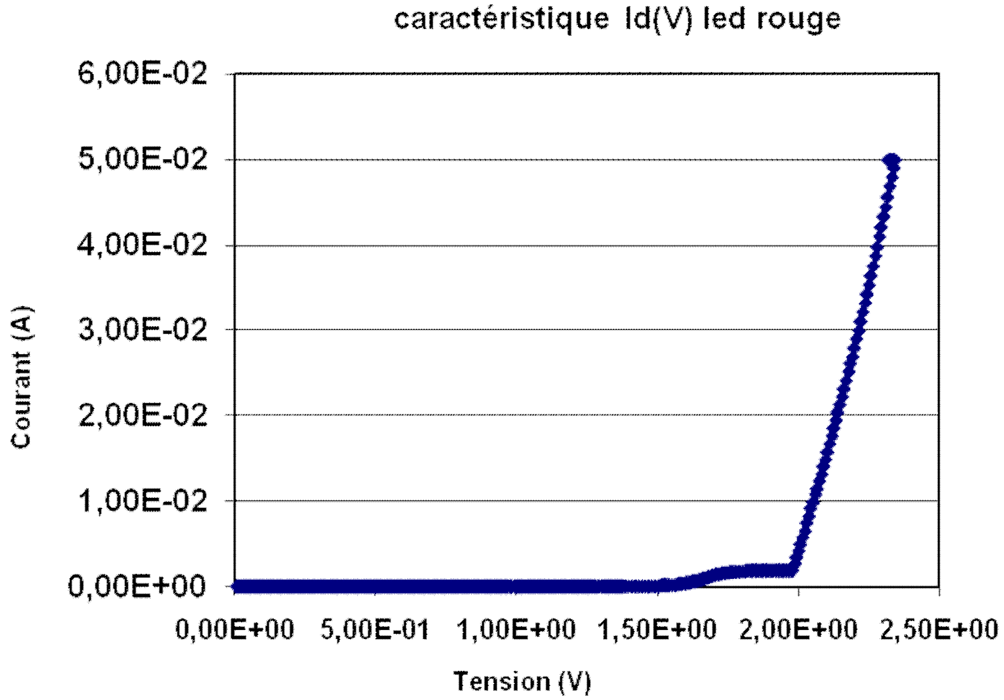


Fig 4 Characteristic I =f(V) obtained from a red LED in direct

The second figure log I (V), complementary to the firestone four distinct current injection regions: possesses

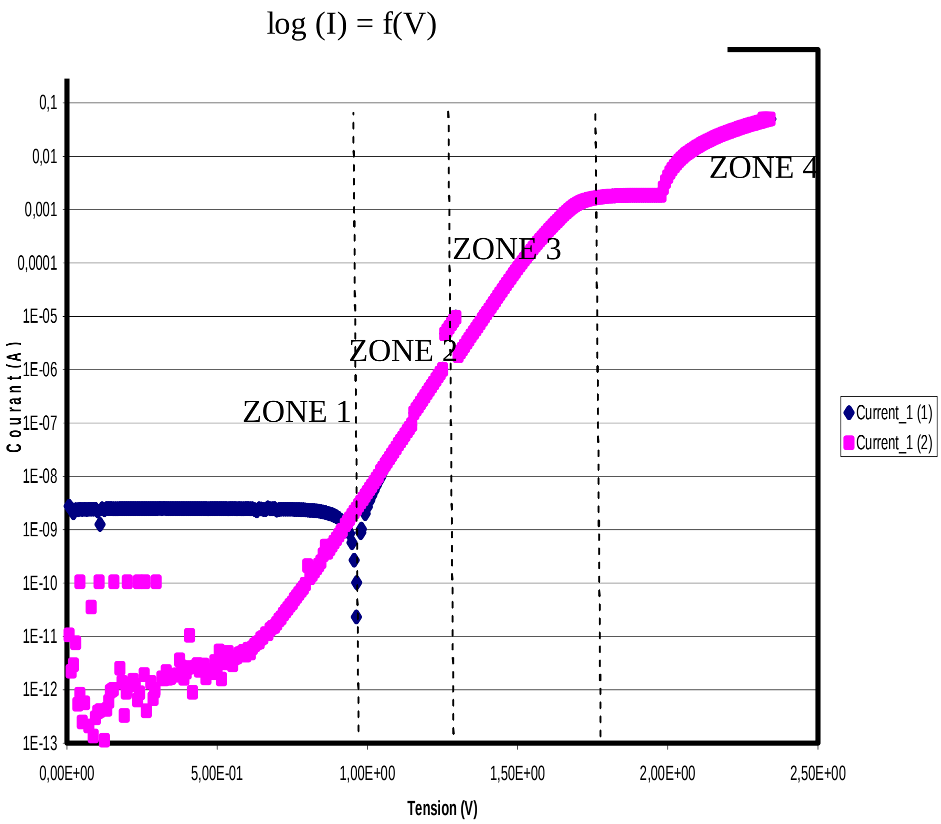


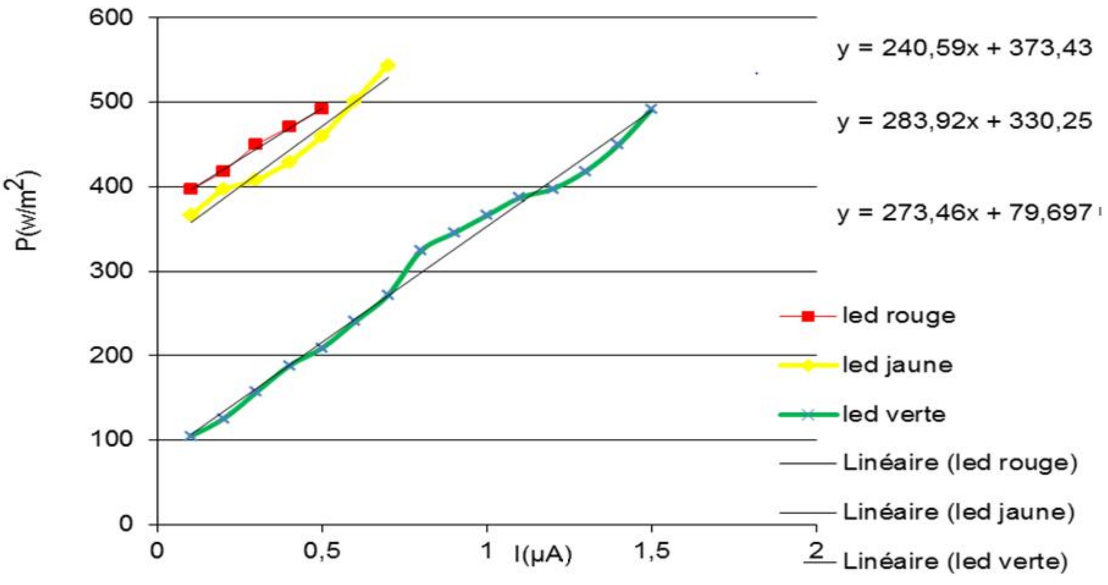
Fig. 5 Characteristic I (V) characteristic of a red LED in opposite

The second figure log I (V), complementary to the firestone possesses four distinct current injection regions:
* Very low injection level (Zone I): I ≤ 100 nA;
* Low level of injection (Zone II): 100 nA ≤ I ≤ 1uA;
* Middle injection level (Zone III): 1 uA ≤ I ≤ 3 mA;
* Fort injection level (Zone IV): I ≥ 3 mA;

This plot is very well suited to low injection levels (V <Vs). It is noted that the development of the models will following the route I (V) or log I (V), depending on the injection levels. The objective of this part is to remember the analytical model, well known, transport phenomena in the four areas of operation on a

B. Power of a classic red del Models.

Photovoltaic effect of different LED:
C= 9, 56x10-6V/ (W / m^2) this coefficient allows us to transform the voltage (v) across the pyranometer in light intensity (W / m^2) Table light intensity depending on the current through the various LEDs.



This graph shows a photovoltaic effect of these LEDs and we see that the green LED (79 w / m^2) is more sensitive after then the yellow (330 w / m^2)) and the red (373 w / m^2)) the least sensitive and that the curve is linear for all the led's P = Aid + b with $A = \frac{Dp}{Di}$

slope of the graph and b: light power when the current I = 0

C. Measuring the sensitivity of the different LED green, yellow and red depending on the power of the illumination of the light source (lamp).

It illuminates a light meter is a hundred centimeter distance. It simultaneously measures the light intensity, which passes through the LED and the voltage across the light meter. When the distance vary from zero to sixty centimeter between first the LED lamp powered by a DC voltage generator and for a second time between the illumination and the illuminated lamp, measuring each time the voltage across the LED with a precision digital multimeter and lamp illumination with a light meter. Figure 8 shows the following results in table form

This graph shows that illumination is quasi proportional to the terminal voltage of these different leds ,the goal of this experiment is to show that there is an effect of the lampe light on these most leds and that the same tension of the led illumination is different and that the green led is sensitive, then the yellow, the least sensitive is the red.The absolute values given by the luxmeter are not considered right strictly speaking

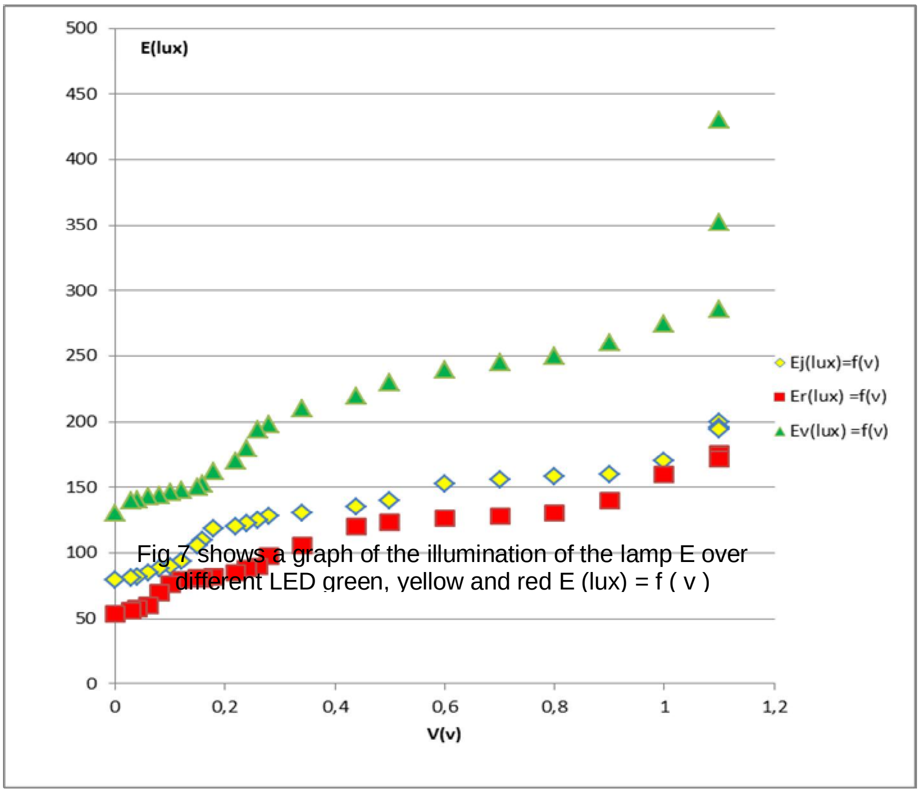


Fig 7 shows a graph of the illumination of the lamp E over different LED green, yellow and red E (lux) = f (v)

Indeed, the photometric head of the luxmeter recovers all the luminous flow contained in the half spaces and thus the one reflected by the objects of the part, or sent by the lamps of the ceiling light of the room if those were not extinct during theexperiment. These elements will tend to modify the values of illumination really due to the LED

Moreover, the lux-meter is not calibrated. The photometric head generates errors which can be about 20% if the real filter of the photometric head is very different from the curve of sensitivity of the human eye V (lambda). Generally the luxmeter are gauged compared to one illuminating A which has a spectrum in the visible well-known one. The LED have a completely different spectra , the interaction with the shape of the filter can cause important errors on the values of illumination

We described in this work three principal experiments on the electric characterization of commercial light-emitting diodes of various colors and theirphotoelectric effect

The measures were voluntarily taken under real conditions of use

The First graph (V) of the characteristic voltage into direct of a classical led, in linear scale (Figure 4), it is possible to extract two functional parameters corresponding to the mode from strong level of injection: The tension of Vs threshold (X-coordinate in the beginning) and resistance series Rs (opposite of the slope). The tension of threshold is related to the tension of Vd diffusion. Vs separating two principal zones: B where the diode is busy (V >Vs) and A where the diode is blocked (V <Vs). The behavior is well that of a diode. This layout is adapted perfectly to the strong levels of injection ($V \geq Vs$).

For a polarization in tension $V \geq Vs$, the system always does not allow the transportation by diffusion. Only the recombination in the active zone is possible. The zones of containment have the role of barrier of potential. The limitation of the current is due only to the equivalent resistance of the various layers constituting the chip. The Following equation 1 models the Vd tension at the boundaries of the del.

$$Vd = Vs + RsId \tag{1}$$

Vs tension off seuil on (V) of the led
Id current direct on (ma)of the led
I (V), complementary the second layout log to the first, distinguishes four modes from injection of current adapted to the low levels of injections (V <Vs).

IV-CONCLUSION:

This work allowed us to underscore the feasibility of using leds in photo detector The current photo armature induced is about 100 Na and we are very optimist forthe future results of this research. The industrial repercussions are also very important. Currently, the integration of new features in a solar candelabrum is one of the industrial priorities. One of the research activities is to develop new features within this device.

The obtained results will validate our hypotheses, which was already established, they will also make it possible to appreciate the potentialities of the LED in the photovoltaic field and to examine the niches in which they would be likely to be integrated. We had already retained of them one which is in the field as of sensors of sunning

This second work allowed us to set up means of measurement to show that there is a photovoltaic effect on the leds in ENP “El Harrach”(polytechnic school of Algiers). For this we measured the electric characteristics of various LED and studied their luminous intensities using a pyranometer EPLEY
And with the ENS of Kouba we used a device of measurement that measures the sensitivity of different leds according to the power of illumination from a source of light.

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