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CONSTRUCTION OF A SIMPLE DENSITOMETER FOR MEASUREMENT OF RADIOGRAPHIC FILM OPTICAL DENSITY

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ABSTRACT:
This project is to study the way to construct a simple densitometer by using a phototransistor as a detector of light intensity. According to Beer-Lambert Law, we can measure the light intensity passing through a radiographic film to obtain an optical density. To measure the optical density of the film over a very wide range, a logarithmic operational amplifier is needed to measure a current flowing through a phototransistor which will give a calibration curve to obtain an optical density indirectly. This can be a main principle for construction of a densitometer.

Keywords:- Densitometer, optical density, radiographic film, phototransistor

INTRODUCTION :

Densitometer is a device used to measure the optical density of a radiographic film by allowing light with a constant intensity of a certain value I_0 to pass through the film at the point where the optical density is to be measured. Light penetrating the film at that point has intensity I. The optical density of the film at that point will follow Beer-Lambert Law as follows:

Optical density $D=\log\left(\frac{I_0}{I}\right)$ (1)

Measuring this light intensity, current I can be measured indirectly by using a medium that changes the intensity of light to some physical property of that medium. In this experiment, we use a phototransistor to measure the electric current Ic flowing through a phototransistor to calculate the value of optical density. By using standard optical densities of the radiographic film and the collector current Ic of the phototransistor, we can get a calibration curve to obtain the optical density of an unknown film.

MATERIAL & METHODS:

We use a phototransistor as a detector for measuring of light intensity for making a densitometer. Instead of using a base current to bias a phototransistor, we use light as an input signal being fed to the transistor. The collector current (Ic) of a transistor is directly proportional to the intensity of light striking it. Therefore, we can measure the intensity of this light using a collector current (Ic) instead, when current Ic, is measured, it can be converted back to the opacity of the film using Equation 1.

In the experiment, we used a phototransistor number L14G1 connecting in a circuit as shown in Figure 1. When changing the intensity of light falling on the phototransistor, the value of Ic on the current meter in the circuit will change.

We used radiographic films with known optical densities as standard films for calibration. When the stable intensity from a standard light source shines directly onto the phototransistor connected in the circuit of Figure 1, standard films of various optical densities are used to block the light from the lamp. Various values of collector current Ic related to those optical

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densities are recorded. The values of Ic and Optical density D, are plotted together. This will give a standard calibration curve.

The important thing in this experiment is to use a light source with a constant intensity using a regulator circuit that controls the electric potential supplied to the light bulbs to be constant.

To measure the optical density of the film over a very wide range, we need meter that measures the collector current Ic over a very wide range too. Such a meter is difficult to find or therefore requires the use of several meters with different scales. Meters that can measure a small amount of current with a fine scale such as 0-100 microampere will work better. But it will require some circuits to help, as shown in Figure 2.

The circuit in the dotted lines of Figure 2 is a circuit called a logarithmic operational amplifier. It establishes a relationship between Ic in Figure 2 and Ic*, as measured by a fine-scale meter. The relationship of Ic and Ic* is according to equation (2).

$$Ic^* = P \log (Ic) + Q \qquad (2)$$

where P and Q are constants.

The films used in the experiment are standard films that have already been calibrated in Germany (Courtesy of the Bureau of Radiation and Medical devices, Department of Medical Science, Ministry of Public Health). The present experiment is to study the relationship between Ic and the optical density D of the films.

RESULTS AND DISCUSSION:

Experimental Results and discussion

The values of light intensity and collector current Ic in the table 1 give a characteristic curve in Figure 3. The graph shows that current Ic is directly proportional to the light intensity I.

Experimental results from the measurement of the current Ic values in relation to the D value, were shown in Table 1.

When D and Ic values are plotted together on graph paper Semi-logarithm as shown in Figure 4. The calibration curve shows a straight line. This linear relation between Optical density D and collector current Ic is an important principle for construction of a simple densitometer. If we want to know the optical density of an unknown radiographic film, we can use this film to measure the current Ic. By using this calibration curve, we can obtain the optical density.

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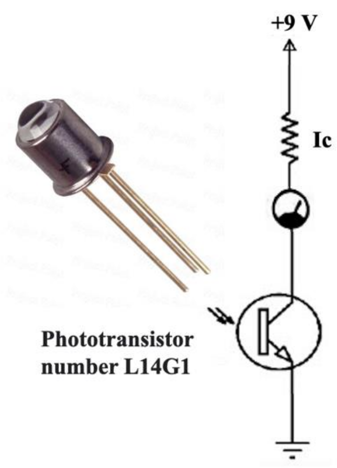

Figure 1. showing a phototransistor number L14G1 connecting in a circuit for measurement of collector current Ic

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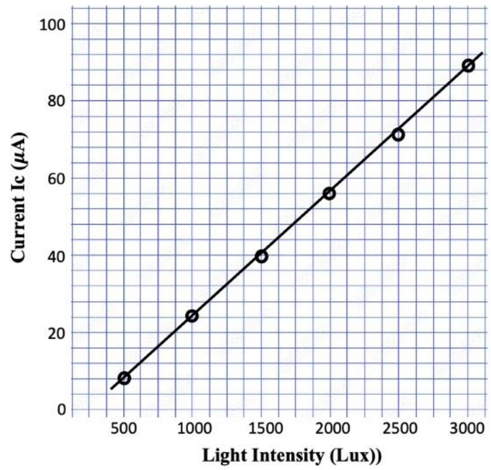

Figure 3. showing a phototransistor number L14G1 connecting in a circuit for measurement of collector current Ic

Optical density	0.07	0.29	0.84	1.16	1.52	1.89	2.11	2.32	2.66	2.86
Current Ic (μA)	2100	940	180	58	19.2	6.1	3.3	1.8	0.7	0.4

Table 2 shows the D values associated with the experimental collector current IC.

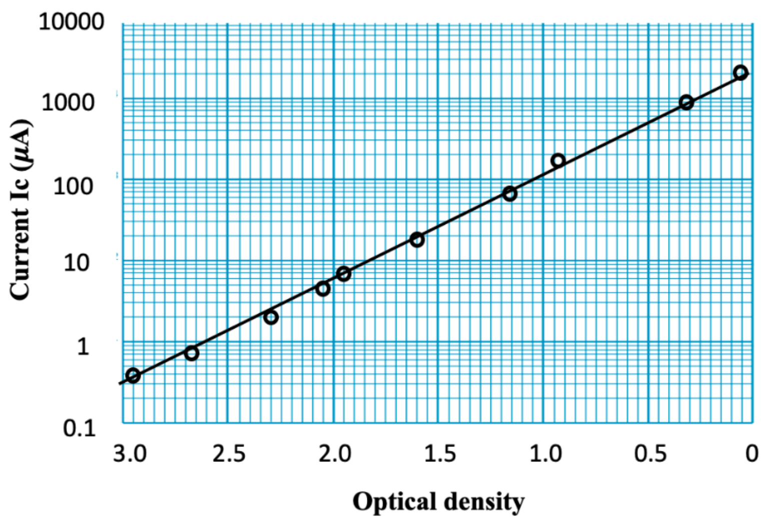

Figure 4 graph shows the relationship between optical density D and collector current Ic from the experiment.

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