



“MEASUREMENT OF HEMOGLOBIN (HB) IN BLOOD USING PHOTO DETECTOR BY REFLECTION METHOD”

Physics

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ABSTRACT

The detection of blood Hemoglobin using own developed, compact & cost-effective device containing optical sensors by reflectometry is aimed in the work. Hemoglobin is a protein in red blood cells, which carries oxygen throughout our body. The low Hb count may indicate anemia, which is a severe nutritional disease. The device is developed using light sensor & RED LED with specific circuit designing. The blood sample is illuminated by RED LED using the $45^{\circ}/0^{\circ}$ geometry. The RED light is illuminated on the sample at an angle of 45° from the perpendicular to the sample surface. The light sensor (detector-L14G3) receives the reflected light at a location 0° from the perpendicular to the sample. Using the linear interpolation method, the hemoglobin value is determined and the results are compared with the Hemocheck™ validated color scale approved by WHO with the range from 4 gm/dl to 14 gm/dl. From the values obtained, the status of anemia can be known. The results are also compared with pathology lab measurements and found in good agreement.

KEYWORDS

L14G3, Hemocheck™, $45^{\circ}/0^{\circ}$ geometry, Tristimulus, etc.

INTRODUCTION:

In rural areas of India, since the quick & accurate detection of anemia-status is not done, most of the times, directly the iron supplements are given to the pregnant women & children, in this the side effects is a serious issue. Even the necessary treatment according to the anemia-status is not readily given. A solution is dreamed through the use of own developed handy & cost-effective device, which can be effectively used in P.H.Cs & even for the individuals for the quick detection of anemia-status. (Generally value of Hb, 8 to 11 g/dl- Mild to moderate anemia, 6-7 g/dl-marked anemia & 4-5g/dl –severe anemia.) [1]

The device is developed using simple optical components in which main photo detector, Red LED, prisms and a lens is used. The photo detector which is most sensitive in visible range, converts light into voltage.

THEORITICAL BACKGROUND:

A molecule of hemoglobin consists of two pairs of polypeptide chains or globin and four prosthetic heme groups each containing one atom of ferrous iron. A Hb molecule is able to bind 4 molecules of oxygen by means of its heme-groups. Thus more the hemoglobin molecules the red blood cells contain; the more oxygen will be transported. [2]

The brightness comparison method is the part of measurement; hence the red led is used as the blood samples are red, in color. The red object reflects red light & absorbs the other. The human eye has three cones with peak color sensitivities at wavelength 580 nm-red, 540nm-green and 450nm-blue.

Colorimetry is a physical science that deals with objective and quantitative ways of describing color. Since the impression of color is something subjective – what one person perceives as “light blue” may look “medium blue” to another – it is not quite clear how to describe and identify different colors. Colorimetry tries to connect the notion of a standard color sample with the physical concept of light as a form of energy. [3].

It is thought that the retina of the human eye has three kinds of color sensors or cones with peak sensitivities for red, green and blue light. This tristimulus theory is attractive since it allows us to think of color as a positively weighted sum of the primary colors red, green and blue. It turns out that large number of colors can be reproduced by mixing red, green and blue color lights with proper proportions. [4].

It has been known since the inception of color science that object colors are determined not only by the spectral composition of the light reflected from them but also by the spectral composition and brightness of the light reflected from the objects. [5].

Before a system to measure and specify color could be developed, it

was necessary to understand the nature of the color sensing mechanism in the human eye. While some progress in this direction was made in the late 18th century, the prevalent anthropocentric views contributed to confusion between color vision and the nature of light. The wider acceptance of the wave theory of light paved the way for a better understanding of both light and color. Both Palmer and Young hypothesized that the human eye has three receptors, and the difference in their responses contributes to sensation of color. However Grassmann and Maxwell were the first to clearly state that color can be mathematically specified in terms of three independent variables. Maxwell demonstrated that any additive color mixture could be “matched” by proper amount of three primary stimuli, a fact now referred to as trichromatic generalization or trichromacy. Around the same time, Helmholtz explained the distinction between additive and subtractive color mixing and explained trichromacy in terms of spectral sensitivity curves of the three “color sensing fibers” in the eye. [6].

The three CIE standard weights can be calculated by using following equations:

$$X = \int_{380}^{780} R(\lambda)E(\lambda)\bar{x}d\lambda \quad Y = \int_{380}^{780} R(\lambda)E(\lambda)\bar{y}d\lambda \quad Z = \int_{380}^{780} R(\lambda)E(\lambda)\bar{z}d\lambda \quad (1)$$

Where $R(\lambda)$ is surface reflectance and $E(\lambda)$ is light source distribution. The weights X, Y and Z define a color in the CIE space $x + y + z = 1$, the result in a 2D space known as the CIE chromaticity diagram. The coordinates in this space are usually called x & y and they are derived from XYZ using following equations:

$$x = \frac{X}{X+Y+Z} \quad y = \frac{Y}{X+Y+Z} \quad z = \frac{Z}{X+Y+Z} \quad (2)$$

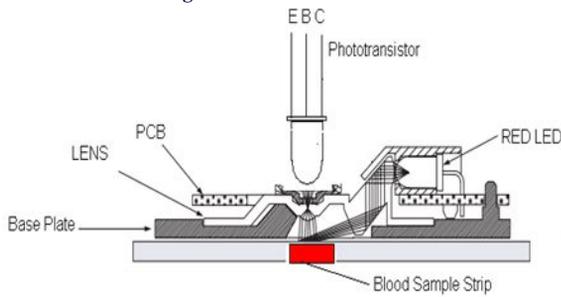
$$x + y + z = 1 \quad \text{or} \quad z = 1 - x - y$$

EXPERIMENTAL WORK:

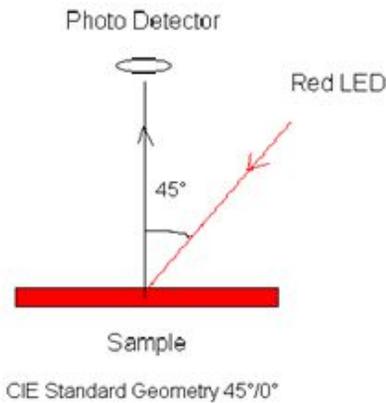
In this method Light to analog voltage convertor, photo detector is used. The light reflected from the sample is passed through the RGB color filter. The photometric method uses color sensors to measure color over particular wavelength range. Light falling on the photo detector is converted into photocurrent, which is converted into voltage, using current to voltage converter. When there is no incident light, there is only a small thermally generated collector to emitter leakage current. This is dark current and it is of the order of nA. When the sample is illuminated with light through RED L.E.D, the reflected light falls on the, collector to base junction of phototransistor, base current I_{λ} is produced which is proportional to light intensity. This produces collector current increasing with I_{λ} . The collector current and light generated base current in a phototransistor are related by, $I_c = \beta_{DC} I_{\lambda}$

The output voltage varies according to the light intensity variation across the base. Phototransistors are most sensitive to particular wavelengths in RED and visible region.

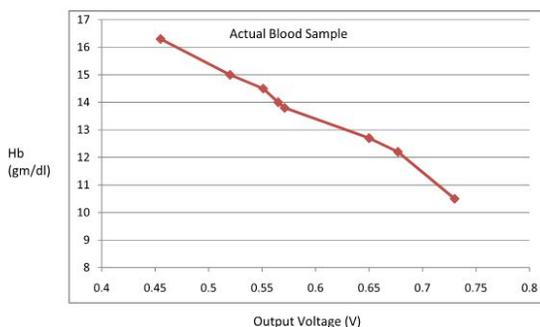
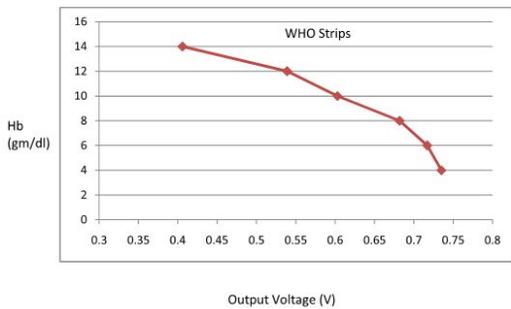
Schematic of the designed device:



CIE standard Geometry:



Result & discussion



The indigenously developed device for measuring hemoglobin works on the principle of color reflectometry and brightness comparison method. The 45°/0° measuring geometry is used for the RED L.E.D. (source) and photo detector alignment. The voltage ranges from 0.4v to 0.8v corresponding to Hb. values 4g/dl to 14g/dl. The size of sample is 8mm in diameter.

Through the measurements, it is observed that Hb increases, the redness of blood decreases. Initially the measurements are taken with the Hemocheck color strip, which is approved by W.H.O (graph 1), Then the actual samples of blood from the path lab are used (graph 2)

By linear interpretation method, the corresponding value of Hb for the particular redness measured (in terms of voltage signal in this study) can be determined. The graphical variation of Hb with voltage is used for the same.

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