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Blood Analysis PCV (Packed Cell Volume) Using Arduino

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Abstract **- There are several methods that can be used to determine the packed red blood cell volume (PCV). Some are direct and others are indirect methods. Using a manual ruler to evaluate PCV is the easiest and most economical method that is commonly used as a direct method for determining PCV but with the potential for subjective errors and plasma entrapping. In our research, we designed and implemented an Arduino board-based electronic circuit for PCV evaluation. The new measurement device is compatible with red light emitters or diodes (006 nm RT) to take advantage of the reported absorption of this light by erythrocytes (red blood cells) compared to the lowest absorption of red light by blood plasma. The transmitted light is then received by the photocell the photocell signal is processed by the Arduino board. The difference in light intensity between the incident light and the transmitted light after it passes through the blood sample that was taken Ejection from the center makes the PCV assessment method reliable.71 The diodes and photocells included in this device make the process of determining the volume of red blood cells to the total blood volume easier and more accurate. Finally, it uses a programmable Arduino board2560MB (with specific mathematical equations stored in Arduino memory) to calculate and check PCV and HB (hemoglobin) values, it makes reliable PCV blood analysis a simple process.**

Keywords: Diagnosis, Hematology, Hematocrit, Packed Cell Volume, Hemoglobin.

I. INTRODUCTION

The PCV (packed red cells volume) or hematocrit terms are widely used to describe the volume percentage of erythrocytes to whole blood of blood sample [1].Normally PCV value is 45% for men and 40% for women [2]. Blood consists of red blood, platelets and white blood cells [3]. However the vital rule of red blood cells in transferring life gas (oxygen)[1], makes evaluating of PCV or hematocrit is widely used to diagnosis many disease such as anemia, polycythemia, etc. The most common process to determine PCV includes few steps must be done as illustrated below: Centrifugation of an anticoagulant blood sample at 10,000 RPM for five minutes is done. Blood will be separated into two layers. PCV is calculated by division of red blood cells height on total sample height because PCV is the ratio of HB. In many labs the PCV is automatically determined by counting the blood cells, as such as PCV values, the numerical values of blood cells count and their Hemoglobin values are listing in reference tables. Measuring of mean volume of red blood and multiplying it by red blood cells count is accurate method which is used by some labs[1]. Other methods are used to determine PCV values are depended on direct or indirect optical analysis of hemoglobin or its derivate compounds spectrophotometry [5]. Depending on errors sources in determination of PCV values, each method of PCV analysis can be evaluated [6]. PCV values which are resulted from manual method are higher than the PCV values of the same samples from automated methods because of plasma trapped in to red blood cells part [7]. The basic concept of this work is depended on selective absorbance of light diode by red blood cells part and led diode by blood plasma part. The transmitted light intensity is detected by photocells then Arduino board will processed photocell signal, calculate and screen PCV values. The packed cell volume (PCV) test are normally done to diagnose or evaluate anemia (decrease of red blood cells), polycythemia (increased in red blood cells). Conditions that can lead to low PCV include, bleeding, kidney disease (a healthy kidney secretes a hormone erythropoietin which stimulates red blood cell production in the bone marrow) and hemolysis (where the red blood cells are being destroyed prematurely either due to attack by the body immune system or organ damage). Hematocrit is the percentage of blood that is comprised of red blood cell. This is often referred to as packed cell volume (PCV) or erythrocyte volume fraction. It is considered as an integral part of a person's complete blood count, along with hemoglobin concentration, white blood cell count and platelet counts. The measurement of the packed cell volume (PCV) is useful in any hematologic workup and is a main tool in the quality control programs in the hematology laboratory. Incorrectly reported micro hematocrit result may bias clinical decision in follow up of patients, blood transfusion decision, and in diagnosis of hematologic diseases

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such as severe anemia. In spite of its significance it has received far less consideration in research from the standpoint of its reliability than have the measurements of hemoglobin or red cell counts.

II. METHODOLOGY

Packed Cell Volume (PCV) a hematocrit test is often part of a complete blood count (CBC), a routine test that measures different components of your blood. The test is also used to help diagnose blood disorders such as anemia, condition in which your blood doesn't have enough red cells, or polycythemia Vera, a rare disorder in which your blood has too many red cells.

2.1 System Design

The reference PCV procedure [1] was used for comparison with the spun micro hematocrit. The reference PCV method, in brief, consists of removing a few microliters of packed red cells from the middle of a properly centrifuged red cell column and dividing the hemoglobin value measure on this sample of completely packed red cells into the hemoglobin value of the well mixed original whole blood sample. Although it seems counterintuitive, the result of this hemoglobin ratio is the PCV of the original blood sample as shown in Figure (1) the hematocrit or PCV can be determined by place less than 0.1 ml of blood sample in a heparinized capillary tube. The tube is sealed with artificial clay and centrifuging blood sample at 10,000 (revolutions per minute) for five minutes. This separates the blood sample into layers. The volume ratio percent of erythrocytes cells to the total volume of the blood sample gives the PCV value. Since a capillary tube is used, this can be evaluated by measuring the layers lengths of the centrifuged samples instead of layers volumes [4].

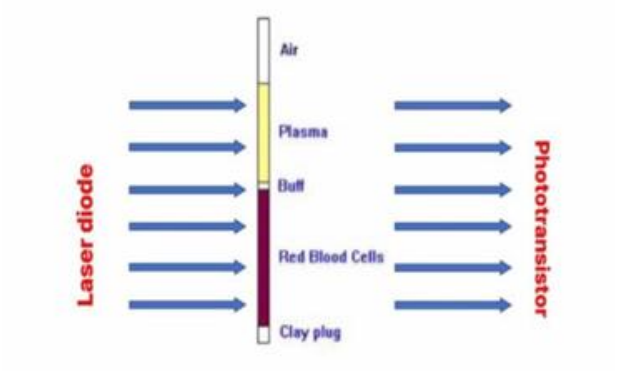

Figure 1: Pathway of Laser which is passed through centrifuged blood sample

In this search PCV measuring device consists of a Light Emitting Diode (LED), at 750nm, and a light collecting sensors. These sensors will be active when they sense to high intensity of light after it passes through the unabsorbed plasma part. The active signal above is processed by a programmable Arduino board and PCV value is reported our device is another work that is dependent on the light of Light Emitting Diode (LED) absorbance by packed red blood cells part and the Light of LED transmittance by plasma part, and both of them are related to lambert beer law. Because of nature of programmable Arduino board which is activated by transmitted light signal, it is more important for us to deal with transmittance (T) which is known as the fraction of light that passes through the sample. This can be determined using the equation below: Transmittance (T) =It/Io. Where the light intensity is after the LED beam passes through it the capillary tube and Io is the light intensity before the light beam it passes through the capillary tube. According to the expression below, permeability is related to absorption by: Absorbance (A) = − log (T) = − log (It/Io). With modern lab equipment, the hematocrit is calculated by an automated analyzer and is not directly measured. It is determined by multiplying the red cell count by the mean cell volume. The hematocrit is slightly more accurate as the PCV includes small amounts of blood plasma trapped between the red cells. An estimated hematocrit as a percentage may be derived by tripling the hemoglobin concentration in g/dL and dropping the units. [8] The packed cell volume (PCV) can be determined by centrifuging heparinized blood in a capillary tube (also known as a micro hematocrit tube) at 10,000 RPM for five minutes. [9] This separates the blood into layers. The volume of packed red blood cells divided by the total volume of the blood sample gives the PCV. Since a tube is used, this can be calculated by measuring the lengths of the layers. Another way of measuring hematocrit levels is by optical methods such as spectrophotometry. [10] Through differential spectrophotometry, the differences in optical densities of a blood sample flowing through small-bore glass tubes at Vasospastic wavelengths for deoxyhemoglobin and oxyhemoglobin and the product of the luminal diameter and hematocrit create a linear relationship that is used to measure hematocrit levels. [11]There are some risks and side effects that accompany the tests of hematocrit because blood is being extracted from subjects. Subjects may experience a more than normal amount of hemorrhaging, hematoma, fainting, and possibly infection. [12] While known hematocrit levels are used in detecting conditions, it may fail at times due to hematocrit being the measure of concentration of red blood cells through volume in a blood sample. It does not account for the mass of the red blood cells, and thus the changes in mass can alter a hematocrit level or go undetected while affecting a subject's condition. [13]Additionally, there have been cases in which the blood for testing was inadvertently drawn proximal to an intravenous line that was infusing packed red cells or fluids. In these situations, the hemoglobin

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level in the blood sample will not be the true level for the patient because the sample will contain a large amount of the infused material rather than what is diluted into the circulating whole blood. That is, if packed red cells are being supplied, the sample will contain a large amount of those cells and the hematocrit will be artificially very high. On the converse, if saline or other fluids are being supplied, the blood sample would be diluted and the hematocrit will be artificially low.

2.2 Procedure and Used Equipment's

2.2.1 Blood Samples

Figure 2: Blood sample

2.2.2 Capillary tube

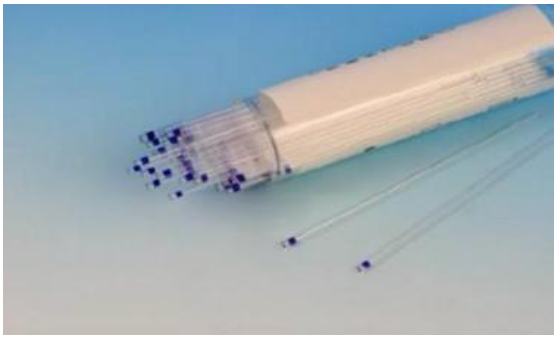

Figure 3: Capillary tube

2.2.3 Tube Sealant

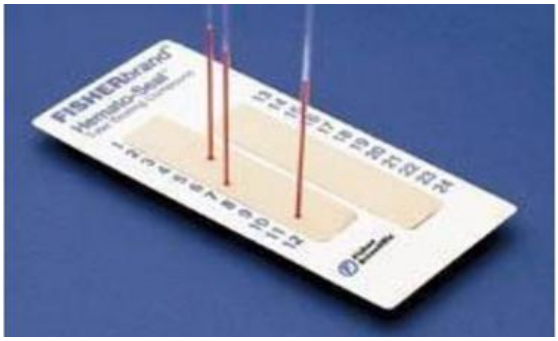

Figure 4: Tube Sealant

2.2.4 Micro Centrifuge

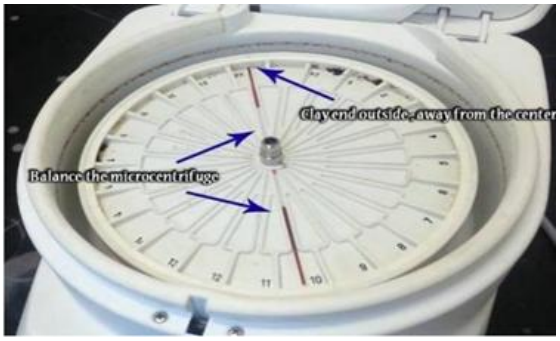

Figure 5: Micro centrifuge

2.2.5 PCV Reader

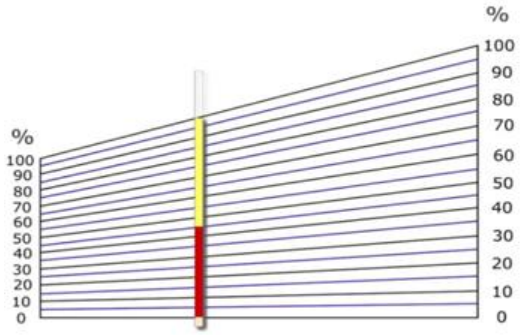

Figure 6: PCV reader

2.3 Method of calculating the value of hematocrit on the special ruler

The lower end of the capillary tube is placed at the zero line on the ruler from the left and then moves to the right until the top line of the blood (plasma, the transparent part of the fluid in the tube) intersects with any line on the ruler. The value along the line between the red and transparent lines of the tube this reading is the value of hematocrit.

2.4 The Components

In our project, we've utilized essential components that form the foundation of our endeavor, with Arduino at its core for seamless management. These carefully chosen and integrated components constitute the bedrock of our project's functionality. Arduino, serving as the central control unit, orchestrates the interaction and operation of these components. Let's delve into a detailed exploration of the key elements driving the core functions of our project.

2.4.1 Arduino Nano

The Arduino Nano is an open-source breadboard friendly microcontroller board based on the Microchip ATmega328P microcontroller (MCU) and developed by Arduino.cc and

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initially released in 2008. It offers the same connectivity and specs of the Arduino Uno board in a smaller from factor.

Figure 7: Arduino Nano

2.4.2 Components of LCD 16x2 I2C

1. There are 4 Pins as listed below:

- PIN GND: PIN GROUND
- PIN VCC: PIN POWER SUPPLY 5VDC
- PIN SDA: PIN Signal DATA of I2C-Bus System
- PIN SCL: PIN Signal CLOCK of I2C-Bus System

2. Adjustable Resistor adjusts the brightness and contrast LCD Display

3. Jumper chooses Address (A0-A2) of LCD Display. If this Jumper is disconnected, it becomes Logic "1"; but, if it is connected, it becomes Logic "0" instead. Normally this Jumper is not soldered, the initial Address is 0x3F (A2=1, A1=1, A0=1). If user requires changing the Address, there are 8 available values.

1. Use IC No.PCF8574A to expand Port.
2. LED POWER shows state of supplying Power of LCD Display.
3. Jumper disables Power Supply of Backlight at the back of LCD Display. If is connected, it enables Power Supply of Backlight at the back of LCD Display, Light sensor it.

Figure 8: I2C component

2.4.3 Photocell

The Photocell includes a light sensor (also known as a photon kit) which is a variable resistor that changes its resistance in response to the amount of ambient light in the environment.

The light sensor is a variable resistor: its resistance changes (depending on the amount of light it is exposed to). A static resistor (which has a fixed resistance) will be connected in series with the photocell to create a voltage divider. This will allow the Photon to measure the resistance of the photocell, which indicates the amount of light reaching the sensor.

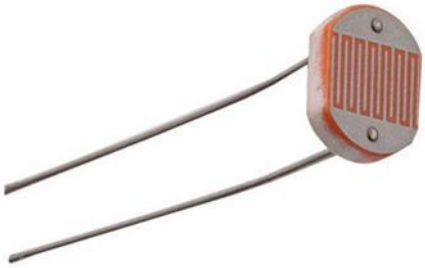

Figure 9: Light Sensor

2.4.4 Servo motor

Servo is a general term for a closed-loop control system. A closed-loop system uses the feedback signal to adjust the speed and direction of the motor to achieve the desired result.

A servo motor is a small device that has an output shaft. This shaft can be positioned to specific angular positions by sending the servo a coded signal. As long as the coded signal exists on the input line, the servo will maintain the angular position of the shaft.

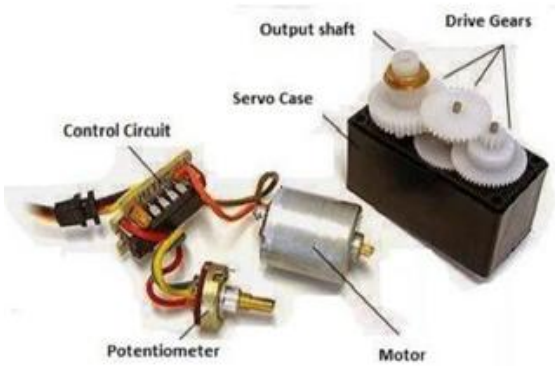

Figure 10: Ingredients Servo motor

There are four main components inside a hobby servo, a motor, a gearbox, a potentiometer and a control circuit.

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Figure 11: Another type of ingredients Servo motor

A servo gear unit reduces the speed of a motor. The potentiometer provides position feedback to the servo control unit where the current position of the motor is compared to the target position. According to the error, the control unit corrects the actual position of the motor so that it matches the target position. If the motor as a controlled device is DC motor, then it is commonly known as a DC Servo Motor. If AC operates the controlled motor, it is known as an AC Servo Motor. The main difference between the two motors is their source of power.AC servo motors depend on an AC power source whereas DC Servo motors depend on DC power source (like Batteries).In AC servo motor speed is directly proportional to the frequency of the supply voltage and the number of magnetic poles, while in DC servo motor speed is directly proportional to the applied voltage.

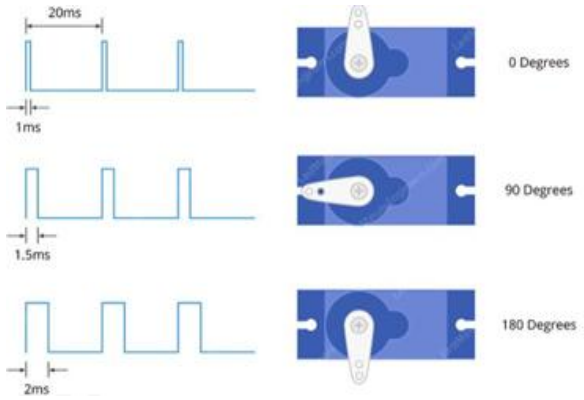

Figure 12: Servomotor positions

- If the pulse is high for 1ms, then the servo angle will be zero.
- If the pulse is high for 1.5ms, then the servo will be at its center position.
- If the pulse is high for 2ms, then the servo will be at 180 degrees.
- Pulses ranging between 1ms and 2ms will move the servo shaft through the full 180 degrees of its travel.

Note:

The minimum and maximum duration of the pulses can sometimes vary with different brands and they can be 0.5ms for 0 degrees and 2.5ms for 180 degrees position.

III. RESULTS AND DISCUSSIONS

After implementation of the electronic circuit of the PCV measuring device, the program is worked using Arduino software 1.6.4 which is considered a very high level language, because it deals with commands that are implemented in any program. The Arduino software of this program is shown in Appendix. According to the following steps, the program is worked:

1. When the device startup, the program is started at the same time with LCD starting.
2. The program is checked the analog input (serial port).
3. When the Laser diode is ON, light passes through capillary tube to photocells (in this step the LCD will show word it id: IN PROGRESS). Photocells convert energy light to current which is processed by Arduino NANO according to mathematical equations that existed in program and display the results on the LCD.

Figure 13: LCD in progress

The sensor detects light at a specific intensity stored in the device. If the intensity of light passing through the sample is lower than this set value, the device records a reading in this area, and the sensor continues to move, performing a light scan across the entire sample. We notice that the first row of the screen is used to display the PCV test result, obtained by scanning the sample with light. The second row is programmed to display another value, which is HB, using Arduino programming to apply the following formula.

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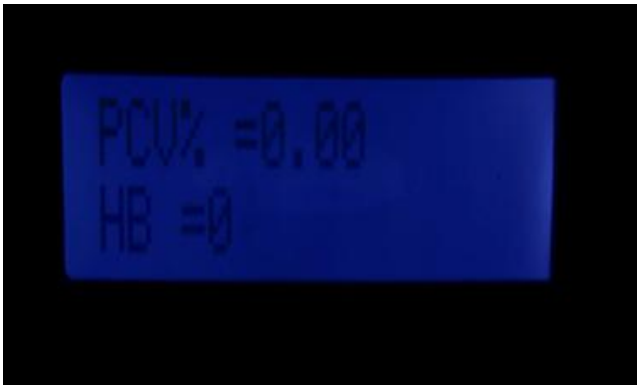

Figure 14: Parameter in the LCD

Your health care provider may have ordered a hematocrit test as part of your regular checkup or if you have symptoms of a red blood cell disorder, such as anemia or polycythemia Vera. These include:

Symptoms of anemia:

- Shortness of breath
- Weakness or fatigue
- Headache
- Dizziness
- Cold hands and feet
- Pale skin
- Chest pain

Symptoms of polycythemia vera:

- Blurred or double vision
- Shortness of breath
- Headache
- Itching
- Flushed skin
- Tiredness
- Excessive sweating

If test results show your hematocrit levels are too low, it may indicate:

- Bone marrow diseases
- Chronic inflammatory disease
- Deficiencies in nutrients such as iron, folate, or vitamin B-12
- Internal bleeding
- Hemolytic anemia
- Kidney failure
- Leukemia
- Lymphomasickle cell anemia

IV. CONCLUSION

The packed cell volume (PCV) test are normally done to diagnose or evaluate anemia (decrease of red blood cells), polycythemia (increased in red blood cells). Conditions that can lead to low PCV include, bleeding, kidney disease (a healthy kidney secretes a hormone erythropoietin which stimulates red blood cell production in the bone marrow) and hemolysis (where the red blood cells are being destroyed prematurely either due to attack by the body immune system or organ damage). Hematocrit is the percentage of blood that is comprised of red blood cell. This is often referred to as packed cell volume (PCV) or erythrocyte volume fraction. It is considered as an integral part of a person's complete blood count, along with hemoglobin concentration, white blood cell count and platelet counts. The measurement of the packed cell volume (PCV) is useful in any hematologic workup and is a main tool in the quality control programs in the hematology laboratory. Incorrectly reported micro hematocrit result may bias clinical decision in follow up of patients, blood transfusion decision, and in diagnosis of hematologic diseases such as severe anemia. In spite of its significance it has received far less consideration in research from the standpoint of its reliability than have the measurements of hemoglobin or red cell counts.

REFERENCES

[1] Sembulingam K., Sembulingam P., Assentials of Medical Physiology, *Jaypee Brothers Medical Publisher (P) Ltd, 6th. edition*, pp. 59-88, 2010.

[2] Estridge B., Reynolds A., Walters N., Basic Medical Laboratory Techniques, *Delmar Thomson Learning 4th edition*, pp.125-127, 2000.

[3] Phonphruksa P., Chaichanyut, International Congerss on Biological and Medical Engineers (ICBME), Sigapour, 2002, Vol.14/2 page 878.

[4] Brian B., M.D., John A. Koepka, M.D, Procedure for determing packed cell volume by the Microhematocrite Method; Clinical and Laboratory Standard Institute, Approved Standard, *Carden Jennings Publishing Co., Ltd. Third Edition*, Volume 20, Number 18. Laboratory Hematology 7:191–196, 2001.

[5] Wheeler L. Medical Instrumentation: Application and Design, *John Wiley & Sons, Inc., 4th ed. Hoboken*; 498-527, 2010.

[6] Ruckman J., Master of Science Thesis, University of Connecticut, a comparative study of total hemoglobin measurement technology: noninvasive pulse cooximetry and conventional methods, 2011.

[7] Bosshart M., Stover J., Stocker R., Lars M Asmis L., Feige J., Bosshart et al. *BMC Research Notes*, 3:65, 2010.

ISSN (online): 2581-3048
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https://doi.org/10.47001/IRJIET/2025.908012

[8] Chang R., Physical Chemistry for the Biosciences. *USA: University Science Books*, p.521, 2005.

[9] Barrett S, "Arduino Microcontroller processing for everyone", *A Publication in the Morgan & Claypool Publishers series, Third Edition* 2013, pp. 12-22.

[10] Monk S., "programming Arduino next step going further with sketches", *McGraw –Hill education publishers, first edition*, pp. 4-7, 2014.

[11] Lin S. and Huang X., "Advances in computer science environment, conformations and education", *Verlag berlin Heidelberg publishers*, part V, 2011, pp. 241-243.

[12] Boxall J., "arduio workshop" Publisher: William Pollock, first edition2010, chapter 7 (LCD). Scele M., "fundamentals of light sources and lasers" *Publisher: John Wiley & Sons, Inc, first edition* 2004, page38-47.

[13] Huda Farooq Jameel Baban. Design and Implementation of PCV Device Based on Arduino Board Vol.19 (4), December, 2016, pp.16-20.

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