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Design and Implementation of Shaking and Weight of Blood Bag

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ABSTRACT

The blood bag shaking machine plays a crucial role in the blood donation process. Typically, blood begins to clot once it exits the body, necessitating the incorporation of an anti-clot solution through agitation in the blood bag. The shaking machines utilized in this process are often imported and come at a high cost. This paper outlines the design of a shaking machine specifically for blood bags, which also estimates volume without the use of sensors. The volume of blood within the bag correlates with the load torque exerted on the DC motor. As blood is collected, the volume in the bag increases, resulting in a corresponding rise in current. By applying the principles of a closed-loop speed control system, along with an observer and adaptive compensator, both the volume of the blood bag and the blood flow rate can be estimated through the current and load torque measurements.

Keywords (Blood bag shaking. Blood bag weight measurement. Blood component separation. Medical device design)

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Chapter One

Chapter one

General idea of project

1.1 Introduction

Criteria for the selection of blood donors stipulate that only individuals in optimal health should be accepted. While defining good health can be challenging, certain parameters can be established through a concise medical history, observation, and basic tests. Personnel responsible for assessing donor health and risk must be thoroughly trained in recognizing donor appearance and identifying signs of illness. They should receive clear instructions on what indicators to monitor and when to refer a donor to a healthcare professional for additional medical evaluation. The weight of the donor is a critical factor in establishing weight limits for blood donation, aimed at safeguarding donors from potential adverse effects, particularly vasovagal episodes and anemia. Research indicates that low body weight and reduced blood volume are independent predictors of vasovagal reactions. In setting a lower weight limit for blood donors, blood transfusion services (BTS) should take into account the weight norms of the population; If a considerable portion of the donor population has a weight of less than 45 kg or 50 kg, the volumes collected may need to be adjusted accordingly. It is essential to ensure that blood collection bags and their anticoagulant contents are modified to align with the volumes being collected. Prospective whole blood donors should have a minimum weight of 45 kg to donate 350 ml ±10% and 50 kg to donate 450 ml ±10%. In determining whether to routinely, selectively, or not at all measure pulse, temperature, or blood pressure (BP) during blood donation, the BTS should take these factors into account:

- Clinical value of these parameters in the blood donation setting (refers weight of donor).

- The presence of suitable equipment, which should be calibrated and sterile when necessary, along with sufficient space and time, is essential. In cases where blood pressure is utilized as a criterion for selecting blood donors, it is recommended to establish arbitrary acceptable ranges for systolic blood pressure between 100 and 140 mmHg, and for diastolic blood pressure between 60 and 90 mmHg.

1. The proficiency and expertise of personnel, along with their capability to execute procedures accurately, are essential. Additionally, there are three categories of blood donation available for individuals to consider. Whole blood donation entails the collection of three blood components: red blood cells, plasma, and platelets. There is a constant demand for O negative donors, as this blood type is universally compatible and can be safely transfused to individuals of any blood type, earning it the designation of 'universal donors.' Individuals are eligible to donate every 12 weeks.
2. Plasma donation entails the provision of a concentrated volume of plasma through a procedure known as apheresis. The actual donation process typically lasts around 45 minutes; however, it is advisable to allocate approximately 1.5 hours in total to accommodate the interview and post-donation refreshments. Individuals are eligible to donate every two weeks, as their red blood cells are returned during the procedure. There is a particular demand for plasma donations from individuals with blood types A, AB, and B.
3. Platelet donation is the act of providing a concentrated collection of platelets through a procedure known as apheresis. Donors are permitted to contribute every two to four weeks, as the body replenishes platelets within a few days after donation. There is a notable demand for individuals with blood types A and O for platelet donations. Blood banks can maintain freshly donated blood for a maximum of six weeks before it is considered outdated and must be discarded. However, recent studies suggest that recipients of blood transfusions older than two or three weeks may face adverse health consequences. Some patients received packed red blood cells that had been stored for

a minimum of 29 days, which remains within the acceptable shelf life, while others received fresher red blood cells, stored for 28 days or less. Those who received the "older" blood were found to be three times more likely to develop infections affecting the bloodstream, respiratory system, heart valves, and other organs. Additionally, numerous factors influence blood quality, placing a significant workload on staff. Currently, there is a shortage of personnel available to continuously agitate the mixture of blood and solution at donation sites, both in fixed locations and mobile units. The blood bag shaking machines, which are essential for this process and must be imported from abroad, are prohibitively expensive, resulting in a limited number of machines available for effective service This research has outlined the design and development of innovative blood shaking machines that operate by simultaneously weighing and shaking blood. This process utilizes the principles of volume estimation and the changes in workload of the blood tray that supports the blood bags, which are related to the volume or weight of the blood. The variations in workload result in changes in torque that can disrupt the functioning of the sensors. The conventional system employs DC motors, which rely on increasing electrical input to achieve the necessary torque and rotational speed under varying load conditions. As the DC motor requires an observer to estimate state variables for system control, such as Full-state Feedback Control, any alterations in torque can lead to errors in the estimation of these state variables, as determined by the sensors. Consequently, the efficiency of DC motor control is compromised. In practical applications, while changes in torque cannot be directly measured, they can be estimated.

This article has outlined the methodology for estimating torque and the influence of electricity on DC motors. It describes how the volume of a blood bag is monitored through an adaptive compensator that estimates load torque using an adaptive observer, designed based on the principles of the Gradient Method. This approach operates within the framework of a stable system, offering a variety of data, including

the temporal variations in the blood bag's volume, without the need for additional sensor installations.

Chapter two

Chapter two

Project components

2.1 Introduction

In this chapter, we will talk about the materials that we used in our proposed project (**design and implementation of shaking and weight of blood bag**)

Where we will learn about the materials that we will use by knowing the entrances and exits for each element

2.2 ARDUINO

Arduino represents an open-source electronics platform that utilizes user-friendly hardware and software. The boards developed by Arduino can interpret various inputs, such as light detected by a sensor, a finger pressing a button, or a message from Twitter, and convert these inputs into outputs, which may include activating a motor, illuminating an LED, or publishing content online [4]. You can direct your board's actions by transmitting a series of commands to the microcontroller installed on it. Throughout the years, Arduino has served as the central processing unit for countless projects, ranging from simple everyday items to intricate scientific devices [5].A global community of creators, including students, hobbyists, artists, programmers, and professionals, has come together on this open-source platform. Their collective contributions have resulted in a vast repository of accessible knowledge, which can significantly benefit both beginners and experienced individuals [6].

Arduino was developed at the Ivrea Interaction Design Institute as an accessible tool aimed at facilitating rapid prototyping, particularly for students who may not have a background in electronics or programming. As it garnered interest from a wider audience, the Arduino board underwent significant development, adapting to new demands and challenges. This progression led to an expansion of its product line, transitioning from simple 8-bit boards to a variety of options tailored for Internet of Things (IoT) applications, wearable technology, 3D printing, and embedded systems. All Arduino boards are completely open-source, allowing users to build them on their own and modify them according to their individual needs [7].

The software, too, is open-source, and it is growing through the contributions of users worldwide.

2.2.1 Important of the Arduino

Due to its straightforward and user-friendly interface, Arduino has been employed in a multitude of projects and applications. The Arduino software is designed to be intuitive for novices while also offering the flexibility required by experienced users. It is compatible with Mac, Windows, and Linux operating systems. Educators and learners utilize it to create affordable scientific instruments, demonstrate principles of chemistry and physics, or to initiate their journey into programming and robotics [8]. Designers and architects create interactive prototypes, while musicians and artists utilize it for installations and to explore innovative musical instruments. Additionally, makers employ it to construct numerous projects showcased at the Maker Faire, among other applications [8]. Arduino serves as an essential resource for acquiring new skills. Individuals, including children, enthusiasts, artists, and programmers, can begin experimenting by adhering to the detailed instructions provided in a kit or by exchanging ideas with fellow members of the Arduino community online.

In addition to Arduino, there exists a variety of other microcontrollers and platforms designed for physical computing. Options such as the Parallax Basic Stamp, Netmedia's BX-24, Phidgets, MIT's Handyboard, among others, provide comparable capabilities[9]. All of these tools take the messy details of microcontroller programming and wrap it up in an easy-to-use package[10]. Arduino also simplifies the process of working with microcontrollers, but it offers some advantage for teachers, students, and interested amateurs over other systems:

1. **Inexpensive** - Arduino boards are generally more affordable than many other microcontroller platforms. The most economical variant of the Arduino module can be constructed manually, and even the pre-assembled versions are priced below $50
2. **Cross-platform** - The Arduino Software (IDE) is compatible with Windows, Macintosh OSX, and Linux operating systems. In contrast, the majority of microcontroller systems are restricted to Windows.
3. **Simple, clear programming environment** - The Arduino Software (IDE) is user-friendly for novices while also offering sufficient flexibility for experienced users to utilize its features effectively. For educators, it is particularly advantageous as it is built upon the Processing programming environment, allowing students who are learning to program in that context to easily adapt to the functionalities of the Arduino IDE.
4. **Open source and extensible software** - The Arduino software is released as open-source tools, allowing experienced programmers to enhance and modify it [11]. The

language can be enhanced by utilizing C++ libraries, and individuals interested in grasping the technical intricacies can transition from Arduino to the AVR C programming language, which serves as its foundation. Likewise, it is possible to incorporate AVR-C code directly into your Arduino projects if desired.

5. **Open source and extensible hardware** - The designs of Arduino boards are released under a Creative Commons license, enabling proficient circuit designers to develop their own variations of the module, thereby improving and fine-tuning its features. Furthermore, individuals with minimal experience can assemble a breadboard version of the module, which provides an opportunity to understand its functionality while also minimizing expenses [12].

In this project we used Arduino UNO **which is shown in Figure (2.1)**

1- Arduino Uno The device in question is a microcontroller board that utilizes the ATmega328P (refer to the datasheet for details). It features 14 digital input/output pins, of which 6 are capable of functioning as PWM outputs, along with 6 analog input pins. The board is equipped with a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB interface, a power jack, an ICSP header, and a reset button. It encompasses all necessary components to facilitate the operation of the microcontroller; simply connect it to a computer via a USB cable or power it using an AC-to-DC adapter or battery to begin your project. Users can experiment with their Uno without significant concern for errors, as the worst-case scenario involves replacing the chip at a minimal cost and starting anew [13].

"The term "Uno" translates to "one" in Italian and was selected to signify the launch of Arduino Software (IDE) version 1.0. The Uno board, along with version 1.0 of the Arduino Software (IDE), served as the foundational versions of Arduino, which have since progressed to more advanced releases. The Uno board represents the inaugural model in a series of USB Arduino boards and serves as the reference model for the Arduino platform. For a comprehensive list of current, past, or obsolete boards, please refer to the Arduino index of boards [14].

In figure (2.1) show the shape of board and pins description.

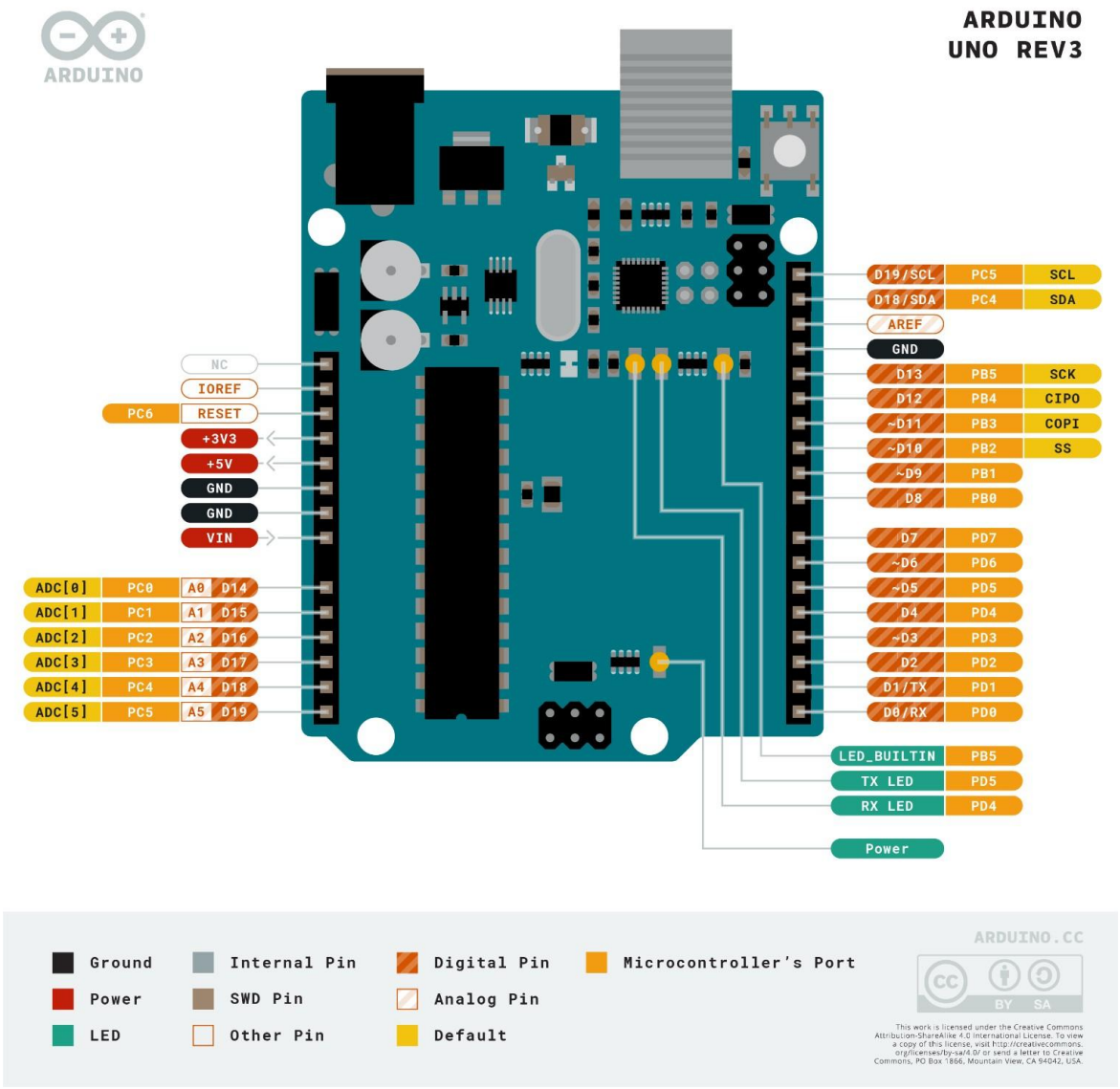


Figure 1(2.1) Arduino Uno

table (2.1) Tech specs

MICROCONTROLLER	ATmega328P
OPERATING VOLTAGE	5V
INPUT VOLTAGE (RECOMMENDED)	7-12V
INPUT VOLTAGE (LIMIT)	6-20V
DIGITAL I/O PINS	14 (of which 6 provide PWM output)
PWM DIGITAL I/O PINS	6
ANALOG INPUT PINS	6
DC CURRENT PER I/O PIN	20 mA
DC CURRENT FOR 3.3V PIN	50 mA
FLASH MEMORY	32 KB (Atmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (Atmega328P)
EEPROM	1 KB (Atmega328P)
CLOCK SPEED	16 MHz
LED_BUILTIN	13
LENGTH	68.6 mm
WIDTH	53.4 mm
WEIGHT	25

2.3 DC 12V 200RPM Gear Motor High Torque

A DC motor refers to a category of rotary electrical motors that transform direct current (DC) electrical energy into mechanical energy. The predominant types of these motors utilize the forces generated by magnetic fields. Almost all varieties of DC motors incorporate an internal mechanism, whether electromechanical or electronic, to periodically reverse the direction of current within a portion of the motor.

DC motors were the earliest motors to gain widespread usage, as they could be operated using the existing direct-current lighting power distribution systems. The speed of a DC motor can be regulated across a broad spectrum by either adjusting the supply voltage or modifying the current strength in its field windings. Smaller DC motors find applications in tools, toys, and household appliances. The universal motor, which can function on direct current, is a lightweight brushed motor commonly employed in portable power tools and appliances. Larger DC motors are now utilized in the propulsion of electric vehicles, elevators, hoists, and in the drives for steel rolling mills. The development of power electronics has facilitated the replacement of DC motors with AC motors in numerous applications.

Figure 2(2.2) dc motor

Specifications:

Rated Voltage: 12V

Speed: 200RPM

Material: Metal

Rated Torque: 2.2Kg.cm

Reduction Ratio: 1:24

Rated Current: 0.5A

D Shaped Output Shaft Size: 6*14mm (0.24" x 0.55") (D*L)

Gearbox Size: 37 x 24.5mm (1.46" x 0.96") (D*L)

Motor Size: 36.2 x 33.3mm (1.43" x 1.31") (D*L)

Mounting Hole Size: M3 (not included) **Application:**

Vending equipments, pan camera, slot machine, money detector, coin refund devices, automatic doors, peritoneal machine, toys motor etc.

NOTES

1. Exercise caution regarding tolerance: It is essential to monitor the voltage and current levels, as neglecting this can lead to a deterioration in motor performance and a reduction in the motor's lifespan.

2. When managing motors, it is advisable to handle them with care, minimizing contact with the motor shell component whenever possible.
3. Motor wiring: Connect the red lead to the positive terminal and the black lead to the negative terminal; if these connections are reversed, the motor will rotate in the opposite direction.
4. Overload: It is essential to avoid motor blockage or prolonged operation near the stall condition within the designated load range. Failure to adhere to this guideline may result in motor burnout. 5. Motor storage:

-- Storage temperature: 0 to 40 degrees Celsius.

-- Storage humidity range: 15% to 90% relative humidity (RH).

-- It is advisable to refrain from exposing the item to elevated temperatures, high humidity levels, and corrosive gases.

6. Motor use temperature: 0℃ - 70℃ .

2.4 LM2596S DC-DC Power Supply Step Down Module

The voltage-regulating module can output voltage values ranging from 1.25V to 35V by adjusting potentiometer with ease.

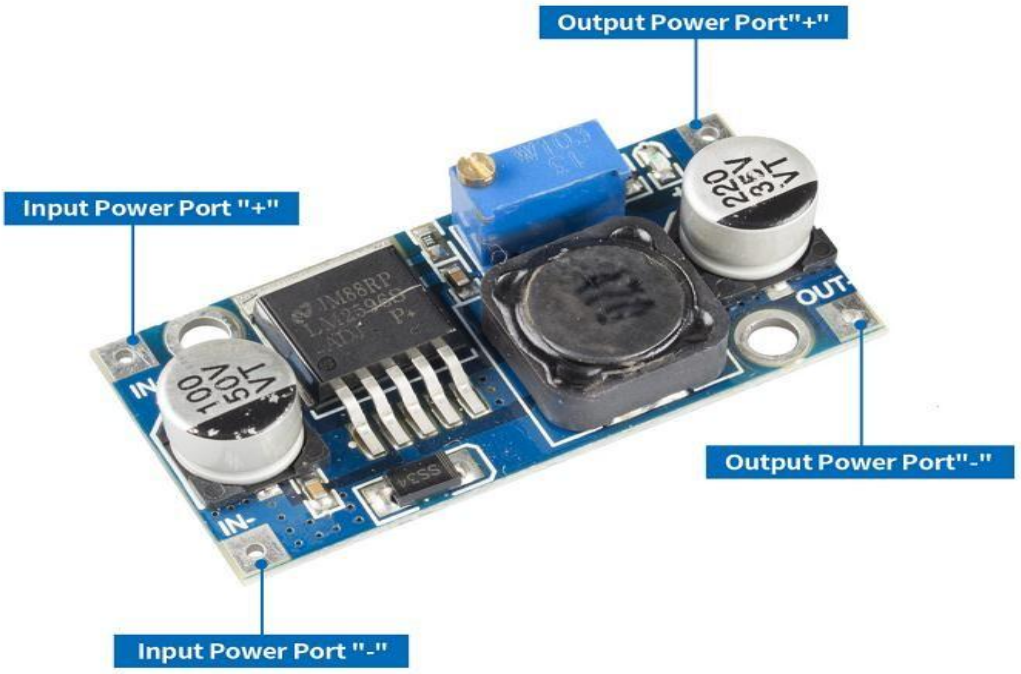


Figure 3(2.3) DC-DC converter pinout

2.4.1 Main Features

- Input Voltage: 3.2V ~ 40V
- Output Voltage: 1.25V ~ 35V(Adjustable)
- Output Current: ≤ 3A □ Conversion Efficiency: ≤ 92% □ Output Ripple: < 30mV
- Switching Frequency: 65KHz
- Working Temperature: -45℃~ +85℃
- Standard Size: 43.2mm x 21.0mm x 14.0mm (Length x Width x Height)

2.4.2 Working Principle

1. The input voltage range is from DC 3.2V to 40V, with the requirement that the input voltage must exceed the output voltage by at least 1.5V.

2. The output voltage range is continuously adjustable from DC 1.25V to 35V, achieving high efficiency levels of up to 92%. The output current can reach a maximum of 3A. When connected to a power supply within the range of 3-40V, the power indicator light activates, indicating that the module is functioning properly.

3. Modify the blue potentiometer knob, as typically a clockwise rotation will increase the boost, while a counter-clockwise rotation will decrease it.

2.5 LCD 16×2

In contemporary society, we frequently utilize devices that incorporate LCD technology, including CD players, DVD players, digital watches, and computers. These devices have largely supplanted the use of cathode ray tubes (CRTs) in the display industry. Compared to CRTs, which consume significantly more power and are bulkier, LCDs are notably thinner and exhibit much lower power consumption. The operational principle of the LCD 16×2 involves blocking light rather than dissipating it. This article provides an overview of the LCD 16×2, including its pin configuration and functionality.

LCD, an abbreviation for liquid crystal display, represents a category of electronic display modules utilized in numerous applications, including mobile phones, calculators, computers, and televisions. These displays are especially preferred due to their compatibility with multi-segment light-emitting diodes and seven-segment displays. The benefits of employing this module encompass its affordability, simplicity in programming, ability to support animations, and the lack of limitations on the display of custom characters special symbols.

Figure 4(2.4) Lcd 16 x 2

2.5.1 LCD 16×2 pinout is shown below.

- Pin1 (Ground/Source Pin): This pin serves as the ground connection for the display, facilitating the connection to the ground terminal of the microcontroller unit or power supply.
- Pin2 (VCC/Source Pin): This pin functions as the voltage supply for the display, allowing for connection to the power source's supply pin.
- Pin3 (V0/VEE/Control Pin): This pin is responsible for adjusting the display's contrast, and it connects to a variable potentiometer that can provide a voltage range from 0 to 5V.
- Pin4 (Register Select/Control Pin): This pin is utilized to switch between the command and data registers, connecting to a pin on the microcontroller unit to receive either a 0 or 1 (0 indicates data mode, while 1 indicates command mode).
- Pin5 (Read/Write/Control Pin): This pin is used to alternate between read and write operations for the display, connecting to a microcontroller unit pin to obtain either a 0 or 1 (0 signifies a write operation, and 1 signifies a read operation).
- Pin6 (Enable/Control Pin): This pin must be maintained at a high state to perform read/write operations, and it is connected to the microcontroller unit, remaining consistently high.
- Pins 7-14 (Data Pins): These pins are designated for transmitting data to the display. They can be configured in two modes: 4-wire mode, which connects four pins to the microcontroller unit (pins 0 to 3), and 8-wire mode, which connects eight pins (pins 0 to 7).
- Pin15 (+ve pin of the LED): This pin is linked to a +5V supply.
- Pin16 (-ve pin of the LED): This pin is connected to ground.

Figure 6(2.5) LCD

2.5.2 Features of LCD16x2

The features of this LCD mainly include the following.

- The operating voltage of this LCD is 4.7V-5.3V.
- It includes two rows where each row can produce 16-characters.
- The utilization of current is 1mA with no backlight.
- Every character can be built with a 5×8-pixel box.
- The alphanumeric LCDs alphabets & numbers.
- Is display can work on two modes like 4-bit & 8-bit.
- These are obtainable in Blue & Green Backlight.
- It displays a few custom generated characters.

2.6 HX711 Load Cell Amplifier

The Load Cell Amplifier is a compact breakout board designed for the HX711 integrated circuit, facilitating the straightforward reading of load cells for weight measurement. By interfacing the amplifier with your microcontroller, you can monitor variations in the load cell's resistance, and with appropriate calibration, achieve highly precise weight readings. The HX711 employs a two-wire communication interface (Clock and Data). Any GPIO pins from a microcontroller should suffice, and a variety of libraries are available, simplifying the process of data retrieval from the HX711. For further details, please refer to the hookup guide provided below. Load cells are typically connected to the HX711 using a four-wire Wheatstone bridge configuration, with wires commonly color-coded as RED, BLACK, WHITE, GREEN, and YELLOW, corresponding to standard load ce color conventions.

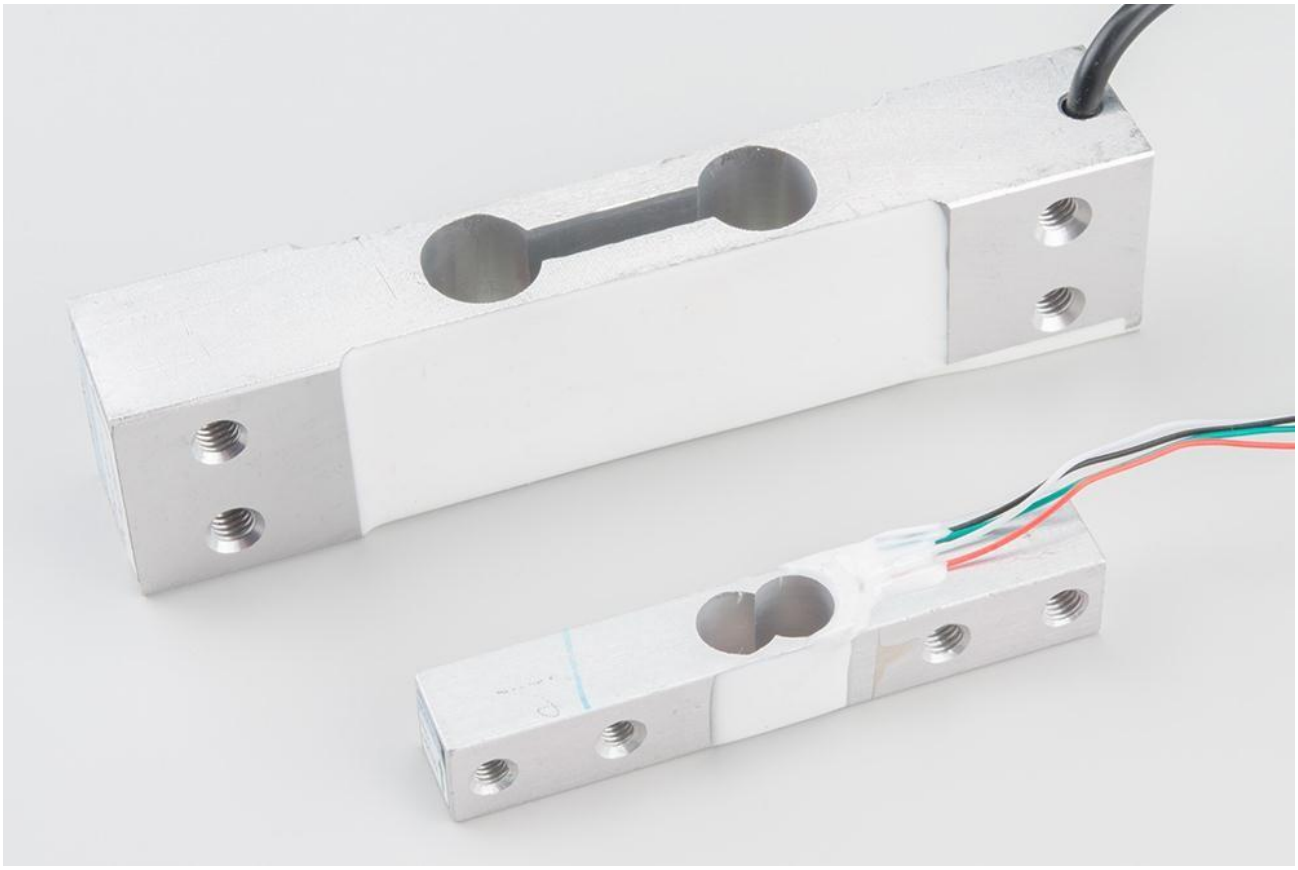


Figure 7(2.6) load cell

Red (Excitation+ or VCC)

Black (Excitation- or GND)

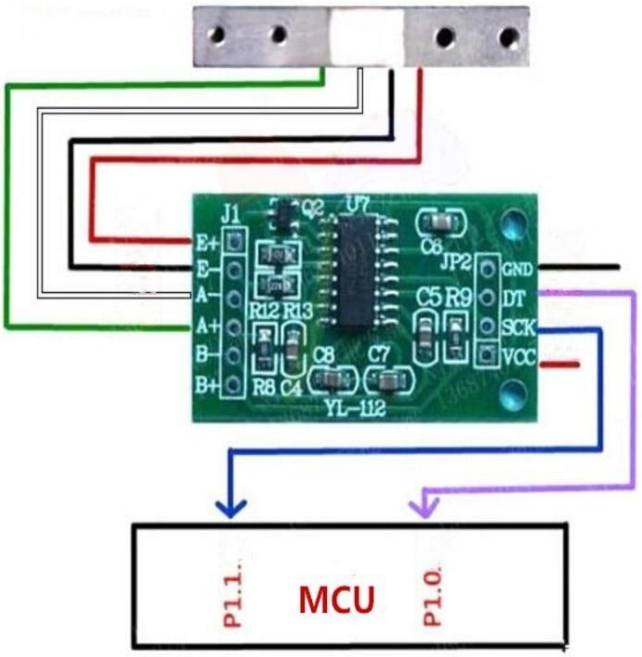
White (Amplifier+, Signal+ or Output+)

Green (A-, S- or O-)

Yellow (Shield)

Design & Consideration

Load Cell and HX711 Connection:



1 RED Wire is connected to E

2- BLACK Wire is connected to E-

3 WHITE Wire is connected to A

4- GREEN Wire is connected to A+

Figure 8(2.7) load Cell and HX711 Connection

Chapter three

Chapter three

Design and implementation

3.1 introduction

In this chapter, we will talk about connecting the electronic parts that we explained in the previous chapter

3.2 Block diagram

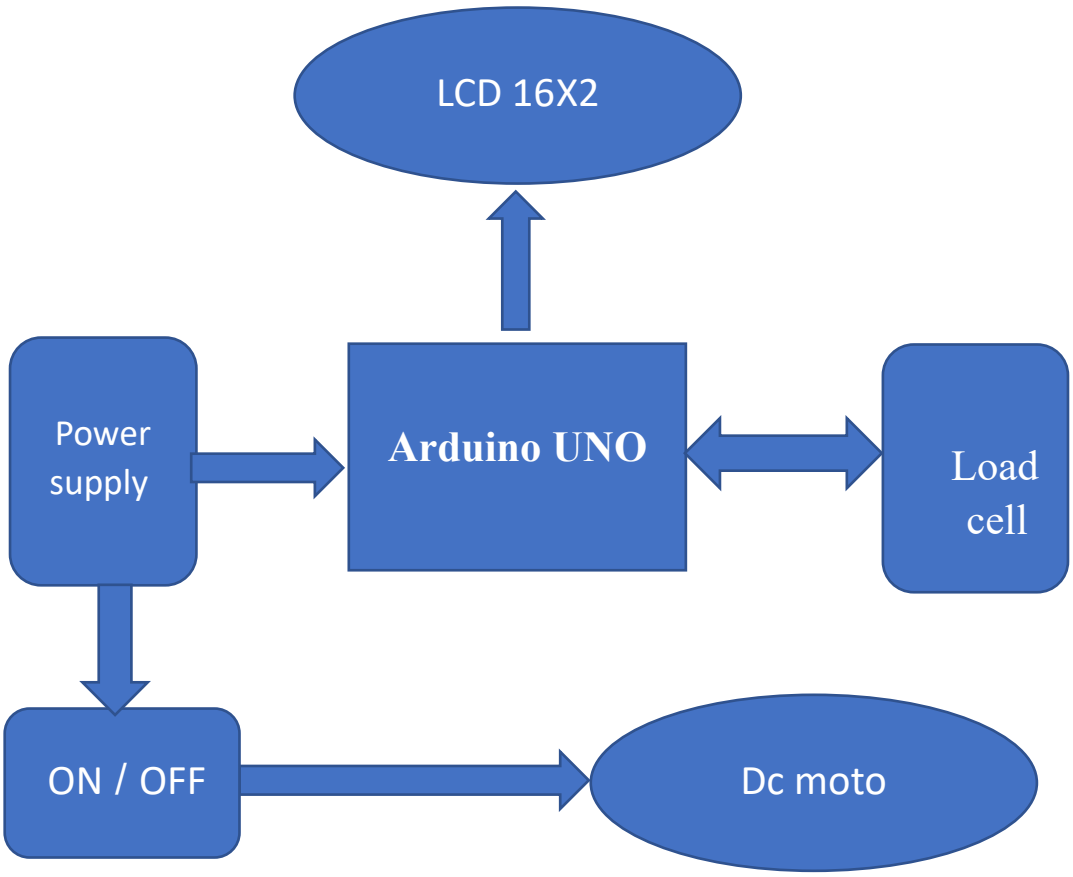


Figure 9(3-1) block diagram project design

The above diagram shows how to connect the components that we used in the project

3.3 circuit diagram connection

1- connected the load cell (Hx711) to Arduino uno as shown in figure (3.2) below.

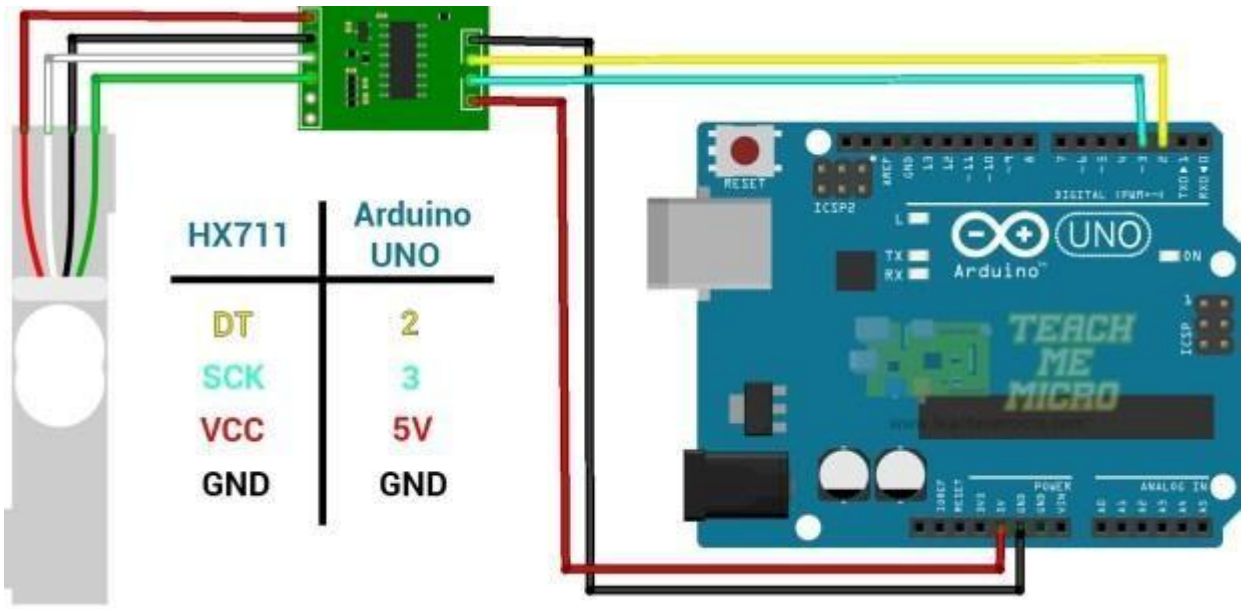


Figure 10(3.2) Arduino to load cell connection

2- Connected LCD 16 x 2 to Arduino uno as shown in figure (3.3) below.

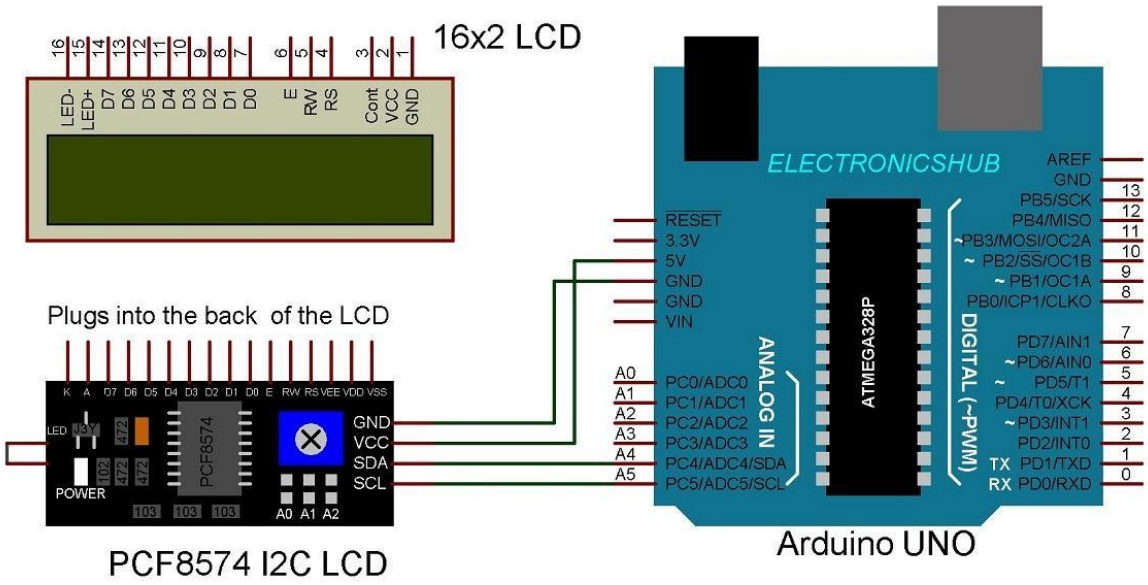


Figure 11(3.3) Arduino to lcd connection

3- After connected all components we upload the code on Arduino board by using Arduino IDE as shown in figure (3.4)

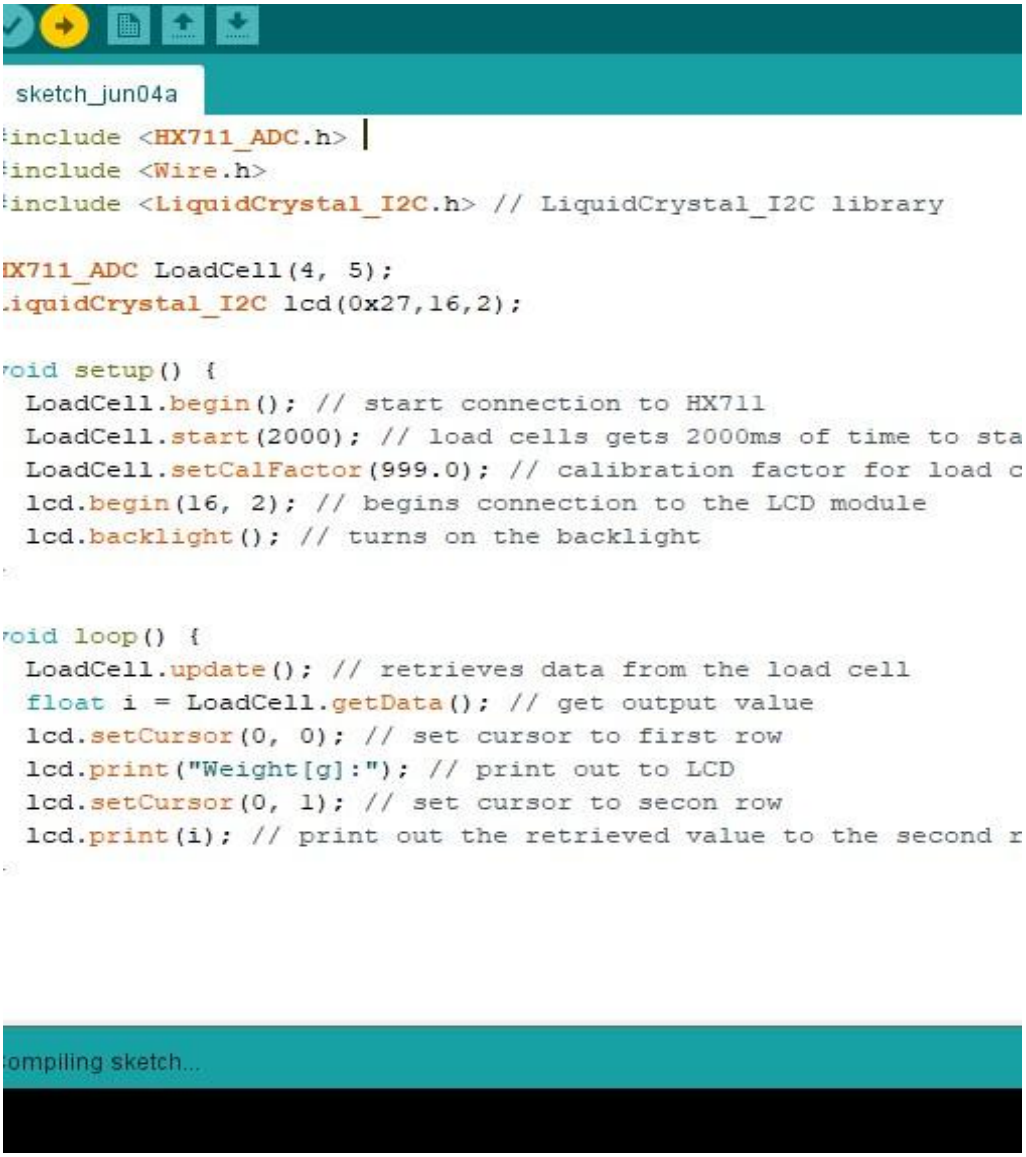


Figure 12(3.4) Arduino code uploading

4- Install the components on suitable box and put DC motor in side it as shown in figure (3.5) below

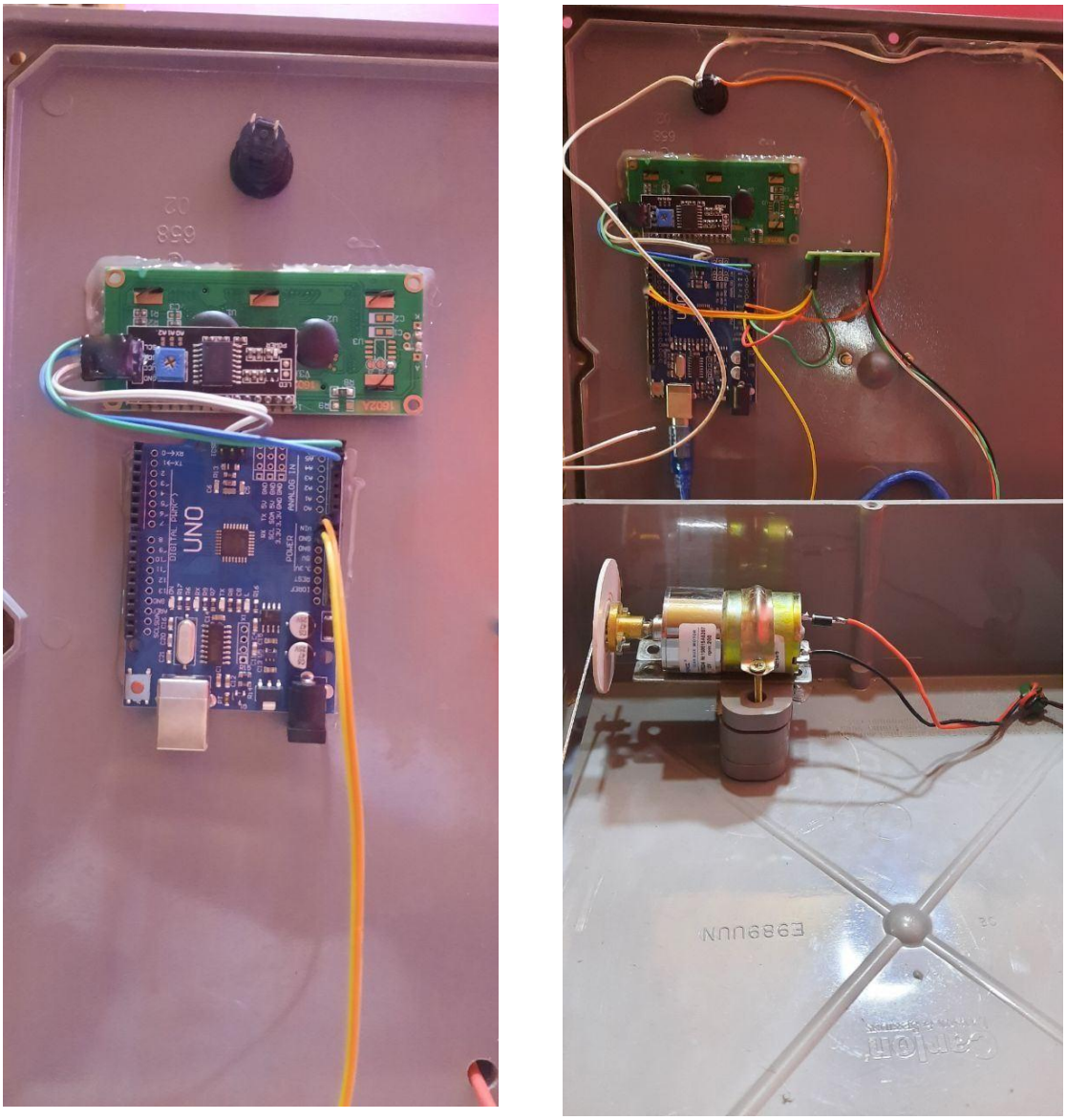


Figure 13. (3.5) A: Arduino uno with lcd connection B: Arduino uno with lcd connection and load cell driver. C: Servo motor.

5- After installed all components we close the box ant turn on device .after finish work the device becomes as figure (3.6) below

Figure 14(3.6) the final shape of the device

Chapter four

Chapter four Results and future work Result

Results

1. After the device was connected according to the design, it was powered on using a 220V AC power source.

2. The device has two main switches: the first to start the motor, and the second to measure the weight of the blood bag.

3. When the start button is pressed, the motor starts moving the blood bag continuously.

4. The second button allows for high-precision weight measurement using the HX711 load sensor.

5. The measured values are displayed on a 16×2 LCD screen, making the results easy to read.

6. The system is designed to operate efficiently with low power consumption.

7. The device has been tested practically, and has proven its ability to measure weight accurately up to ±0.1 grams.

8. The device provides an effective solution for blood donation centers by automating the vibration and weighing process.

9. The motor operates at variable speeds according to the amount of blood inside the bag, which maintains sample stability.

10. The design is based on the Arduino UNO module to control various processes.

11. System settings can be easily modified using Arduino IDE software.

12.The device features a fast response when turned on and off without noticeable delay.

13. This innovation helps reduce the need for manual intervention during the donation process.

14. The system allows for real-time measurements and immediate display of results.

15. The device readings were compared with other commercial devices, and showed accurate and standard-compliant results.

16. The device can be developed in the future to include a wireless connection to transfer data to a central database.

17. It can be used in clinics and hospitals as an economical alternative to expensive imported devices.

18. Overall, the device has proven effective in improving the blood donation process and increasing its efficiency.

Future work

The device can be enhanced by establishing an Internet connection, which allows for remote operation control and extinguishing. Additionally, it can be designed to manage multiple devices simultaneously, facilitating data reception, storage, and timely display as needed.

REFERENCES

1. Murphy S, Gardner FH. Effect of storage temperature on maintenance of platelet viability–deleterious effect of refrigerated storage. N Engl J Med 1969;280:1094-8.
2. Murphy S, Gardener FH. Platelet storage at 22°C: role of gas transport across plastic containers in maintenance of viability. Blood 1975;46:209-18.
3. Roh SG, Joung US, Choi WC, Wee JH. Effect of interrupted agitation and removal of leukocyte on platelet quality during the storage of platelet concentrates. Korean J Lab Med 2008;28:221-9.
4. Dumont LJ, Gulliksson H, van der Meer PF, Murphy S, Nixon JG, de Wildt-Eggen J, Vandenbroeke T, AuBuchon JP. Interruption of agitation of platelet concentrates: a multicenter in vitro study by the BEST Collaborative on the effects of shipping platelets [published erratum appears in Transfusion 2007;47:2172]. Transfusion 2007;47:1666-73.
5. Hunter S, Nixon J, Murphy S. The effect of the interruption of agitation on platelet quality during storage for transfusion. Transfusion 2001;41:809-14.
6. Wagner SJ, Vassallo R, Skripchenko A, Einarson M, Seetharaman S, Moroff G. The influence of simulated shipping conditions (24- or 30-hr interruption of agitation) on the in vitro properties of apheresis platelets during 7-day storage. Transfusion 2008;48:1072-80.
7. Wagner S, Vassallo R, Skripchenko A, Einarson M, Seetharaman S, Moroff G. Comparison of the in vitro properties of apheresis platelets during 7 day storage after interrupting agitation for one or three periods. Transfusion 2008 Aug 27. Transfusion 2008;48:2492-500.
8. van der Meer PF, Liefting LA, Pietersz RN. The effect of interruption of agitation on in vitro measures of platelet concentrates in additive solution. Transfusion 2007;47: 955-9.
9. van der Meer PF, Gulliksson H, Aubuchon JP, Prowse C, Richter E, de Wildt-Eggen J; Biomedical Excellence for Safer Transfusion (BEST) Collaborative. Interruption of agitation of platelet concentrates: effects on in vitro parameters. Vox Sang 2005;88:227-34.
10. Wagner S, Myrup A, Awatefe H, Thompson-Montgomery D, Hirayama J, Skripchenko A. Maintenance of platelet in vitro properties during 7-day storage in M-sol with a 30-hour interruption of agitation. Transfusion 2008 Aug 27. 2008;48:2501-7.

11. Brafield AE, Chapman G. Diffusion of oxygen through the mesogloea of the sea anemone calliactis paresitica. J. Exp. Biol 1983;107:181-7.

12. MacDougall JD, McCabe M. Diffusion coefficient of oxygen through tissues. Nature 1967;215:1173-4.

13. Vaupel P, Kallinowski F, Okunieff P. Blood flow, oxygen and nutrient supply, and metabolic microenvironment of human trumors: a review. Cancer Res 1989;49:6449- 65.

14. Bibby SR, Jones DA, Ripley RM, Urban JP. Metabolism of the intervertebral disc: effects of low levels of oxygen, glucose, and ph on rates of energy metabolism of bovine nucleus pulposus cells. Spine 2005;30:487-96.

15. Gnaiger E, Steinlechner-Maran R, Mendex G, Eberl T, Margreiter R. Control of mitochondrial and cellular respiration by oxygen. J Bioenerg Biomembr 1995;27:583-96.

16. Murphy S. Platelet storage for transfusion. Semin Hematol 1985;22:165-77.