Palestine Polytechnic University

College of Engineering & Technology
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Graduation Project

Microcontroller Based Clotting Time Meter

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جامعة بوليتكنك فلسطين

الخليل-فلسطين

كلية الهندسة و التكنولوجيا

دائرة الهندسة الكهربائية والحاسوب

اسم المشروع

Microcontroller Based Clotting Time Meter

أسماء الطلبة

أسماء سرور **يوسف احمد**

بناءً على نظام كلية الهندسة والتكنولوجيا وإشراف ومتابعة المشرف المباشر على المشروع وموافقة أعضاء اللجنة الممتحنة تم تقديم هذا المشروع إلى دائرة الهندسة الكهربائية والحاسوب، وذلك للوفاء بمتطلبات درجة البكالوريوس في الهندسة تخصص هندسة الاجهزه الطبية.

توقيع المشرف

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توقيع اللجنة الممتحنة

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توقيع رئيس الدائرة

.....

Abstract

This project presents a system that can be used to measure the clotting time of blood, the system depends on the light absorbance technique. The light passes through a sample of blood using photo source then taken the light absorption of the light using photo detector to measure the clotting for this sample of blood.

In our project the microcontroller will be used to process the data coming from light detecting circuit and store the data in EPROM memory.

The clotting time of the blood is very important for laboratory technicians, doctor, and hospital. Blood coagulation is very important to human life since it stops and limits the Blood cut drain.

Respect of the project measuring time clot blood plasma components, has found through experience that the time for plasma coagulation ranging between 9-16 second person and varies depending on age and also the method used to measure time coagulation

Without blood coagulation, many of the body's important biological functions will not be able to proceed. For instance, some platelet disorders make people more prone to hemorraghing; such persons may be candidates for bone marrow transplants, or for constant reception of clotting factors. If you have a platelet disorder, you may be banned from playing strenuous sports or engaging in dangerous activities that will put you at greater risk for injury and bleeding

مُلخص المشروع

يهدف المشروع إلي بناء نظام متكامل يعمل علي قياس زمن تجلط الدم بناء علي ظاهره الامتصاص الضوئي " قانون بير" . وهو يمثل تجربه بسيطة بتطبيق الظاهرة بمجال الهندسة الطبية.

يختص المشروع بقياس زمن تجلط البلازما المكونة للدم , وقد وجد من خلال التجارب أن زمن التجلط للبلازما تتراوح بين 9-16 ثانيه يختلف بحسب الشخص والعمر وكذلك ألطريقه المستخدمة لقياس زمن التجلط.

يعتمد مشروعنا علي إظهار نتيجة الفحص بالاعتماد علي " PIC " الذي يحتوي بداخله علي العديد من الأمور التي تُسهل استخدامه .

الاهداء

بسم الله الرحمن الرحيم

بدأنا بأكثر من يد وقاسينا أكثر من هم، وها نحن اليوم وبحمد الله نطوي سهر الليالي وتعب السنين وخلاصة مشوارنا بين دفتي هذا الكتاب ...

الى منارة العلم والى سيد الخلق وإمام المرسلين، الى الأمي الذى علم العلماء ... سيدنا رسول الله صلى الله عليه وسلم ...

الى الذين روو بدمائهم الطاهرة ثرى أرضنا المباركة لينيروا دربنا في العلم والمعرفة، الى الذين بذلوا روحهم لله والوطن .. شهدائنا الأبرار ...

الى الينبوع الذي لايمل العطاء.. الى من حاكت سعادتي بخيوط منسوجة من قلبها، الى من انتظرت هذه اللحظة بفارغ الصبر....امي العزيزة ...

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الى روح طاهر,روح ارتقت الى السماء العليا الي ميناس رحمها الله واسكنها فسيح جناته.....

الى أهل الوفاء ومنبع الإخاء، ورصيدي فى الحياة ... الأصدقاء و الأحباب ...

إليهم جميعاً أهدي هذا العمل ...

والله الموفق

اسماء سرور

يوسف ابو الدبس

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1

Introduction

Chapter One
Introduction

1.1 Introduction

The biomedical engineering is very important to design equipment and instrument for diagnosis some disease or to evaluate some time interval to some condition in the body like the clotting time which is important to the doctors and laboratory technicians to achieve and perform the test efficiently, with noticeable reduced time.

The system propose in our project is used in clinical laboratory or hospitals to measure the time of blood coagulation.

This technique is used to measure the clotting time of blood by applying the theory of light absorption & the transmission of the light through the blood sample; absorption is proportionally related to clotting time.

In this project we aim to design and implement a clotting time meter. This device will determine the value of time require by blood to coagulate and stop bleeding using microcontroller to process.

1.2 Project Objectives:

The main objectives of this project are:

- To determine the physiology of the blood coagulation and the effect on the body.
- To design and implement clotting time meter by using light absorption property.
- To design a model of clotting time meter to provide a correct way to use this instrument.

1.3 Literature Review:

The study of this project depends on some ideas of other projects:

1. **Ecarin Clotting Time but not a PTT Correlates with PEG-Hirudin Plasma Activity**, The present study evaluates the ecarin clotting time (ECT), a parameter based on the conversion of prothrombin by the snake venom enzyme ecarin, for the monitoring of PEG-hirudin therapy
   Martin Moser, Karlheinz Peter, Benedikt Kohler, Dietrich C. Gulba, University of Heidelberg, Germany, Franz-Volhard Klinik, Charite
   November/October 2004

2. **Laboratory studies in coagulation disorders:**
   Saxena Renu, Kannan Meganathan and Choudhry Ved
   Department of Hematology, All India Institute of Medical Sciences, New Delhi, India, The present study evaluates the clotting time.

3. **Clot time meter:**
   Muhammad Kamal Al-Amleh , Ashraf M.Abu-Areesh and Ibrahem Al-Wawi: this project used the PC to show its result by code of C In project is take about microprocessor put don't use it ,Palestine Polytechnic University in Hebron at 2002.

1.4 Scheduling Table:

The timing management will be divided to:

T_1: Choose the name of project and identifying it's contents, and discussing the initial information.

T_2: Choose the analysis process includes extensive study for all possible design options of the project.

T_3: The project requirements analysis tasks have to be implemented, equipments will be needed to be provided, and data should be processed. This stage depends on (**T_1**, **T_2**).

T_4: Design block diagram will be done and we will show how our system works. This stage depends on **T_3.**

T_5: Study the datasheet of the photo sensor to ensure that it will meet the requirements of the project. This stage depends on **T_3.**

T_9: Writing the documentation, the writing began from the first phase to the last one in parallel. (**T_4**, **T_5**).

T_6: Programming microcontroller: writing subprograms from project, and testing them on subsystem circuits in order to build whole system program.

T_7: Hardware implementation: include building electronic circuits,

T_8: Testing the system: testing the system, calibration, discovering the problems, and solve them.

T_9: Writing the documentation: writing the documentation of the project.

Table [1.1]: The Task Duration

Task	Duration(weeks)	Dependencies
T1	3	-----
T2	3	-----
T3	4	T1,T2
T4	2	T3
T5	2	-----
T6	8	
T7	8	-----
T8	3	T6,T7
T9	20	-----

Table [1.2]: Timing plane

Task / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
T1															
T2															
T3															
T4															
T9															
Task / Week	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
T5															
T6															
T7															
T8															
T9															

1.5 Cost

This section lists the overall cost of the components that are required in implementing the system.

There are many electronic Chips and electrical equipments have to be provided as shown in table below:

Table [1.3]: Hardware Cost

Component	Cost
Cuvette	$30.00
Electrical parts	$250.00
Personal work	$300.00
Microcontroller	$100.00
TOTAL	$680.00

1.6 Project Outline:

This report is divided into seven chapters; these chapters are described as follows:

Chapter 1: Introduction:

This chapter describes the importance of the project, objectives, and the literature review, cost, and schedule table.

Chapter 2: Theoretical Background:

This chapter talks about the blood, blood coagulation; it's dangerous, theory of project and project components.

Chapter 3: Project Conceptual Design:

This chapter describes the general block diagram and the principle of operation and the hardware component that are to be used in this project.

Chapter 4: Detailed Technical Project Design:

This chapter includes project phases, and subsystem detailed design.

Chapter 5: Software:

This chapter includes the software of the microcontroller "assembly language ".

Chapter 6: System Implementation:

This chapter includes the testing of our design, expermintal result, project safety and maintenance.

Chapter 7: Conclusion:

This chapter includes conclusion, recommendation and future work.

2

Theoretical Background

Chapter Two
Theoretical Background

2.1 Introduction:

When the skin is cut, the blood starts bleeding. After a few seconds, the bleeding stops, by forming a thickened mass. This thickened mass is constructed of substances in the blood. This operation is called coagulation. [4]

Coagulation is initiated almost instantly after an injury to the blood vessel damages the endothelium (lining of the vessel). Platelets immediately form a hemostatic plug at the site of injury; this is called primary hemostasis. Secondary hemostasis occurs simultaneously proteins in the blood plasma, called coagulation factors; respond in a complex cascade to form fibrin strands which strengthen the platelet plug. [5]

2.2 Blood:

2.2.1 The Composition of blood:

The total blood volume in an adult (5-6) liters, the (7-8%) of the body weight

Blood consist of cellular material (99% red blood cells, with white blood cells and platelets making up the remainder), water, amino acids, proteins, carbohydrates, lipids, hormones, vitamins, electrolytes, dissolved gases, and cellular wastes. [4]

Each red blood cell is about 1/3 hemoglobin, by volume. Plasma is about 92% water, with plasma proteins as the most abundant solutes. The main plasma protein groups are albumins, globulins, and fibrinogens. The primary blood gases are oxygen, carbon dioxide, and nitrogen. [4]

The average man has about 5 quarts of blood; this may be separated into 3 quarts of plasma which is liquid and 2 quarts of cells which is solid. The cells are classified as white cells. Red cells and platelets. In size the cells is vary as **fig. [2.1]:**

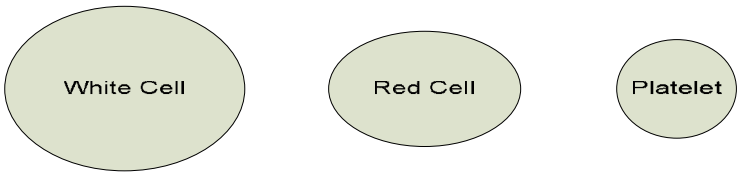


Figure 2.1: Cell sizes

In quantity, however, the red cells greatly predominate, for every (500) red cells there are approximately (30) platelets and only (1) white cells.

The main function of blood is to supply nutrients (oxygen, glucose) and constitutional elements to tissues and to remove waste products (such as carbon dioxide and lactic acid). Blood also enables cells (leukocytes, abnormal tumor

cells) and different substances (amino acids, lipids, hormones) to be transported between tissues and organs.

2.2.2 **Platelets**:

Platelets are formed when cytoplasm fragments of megakaryocytic, which are very large cells in the bone marrow, pinch off into the circulation as they age. The platelet is metabolically more active than the red blood cell and has a variety of functions.

Platelets play an important and not fully understood role in the formation of the blood clot by coagulating to occlude a cut blood vessel and provide a surface on which strands of fibrin form an organized clot, by contracting to pull the fibrin strands together to make the clot firm and permanent, and, perhaps most important, by providing or mediating a series of coagulation factors necessary to the formation of the clot.

Platelets also store and transport several chemicals, including serotonin, epinephrine, and histamine (the importance of which in this capacity is unknown), and they phagocytes (absorb) foreign bodies, including viruses. [5]

2.2.3 Parts of Coagulation:

- Normal coagulation: in this case, the bleeding stop by forming the thickened mass. The protein in blood work tiny with the platelets to form the clot and stop the bleeding. Coagulation is highly conserved throughout biology; in all mammals. Coagulation involves both a cellular (platelet) and a protein (coagulation factor) component.

- Abnormal coagulation: in this case, the tendency to clot is large and hyper than normal case. When this case occurs the formed of clot inside the veins. This format is dangerous which called hyper coagulation. There is many causes for the hyper coagulation and there is a treatment for it.

2.3 Coagulation and Hyper Coagulation:

2.3.1 Definition of Coagulation:

The coagulation in medicine - the clotting of blood. The process by which the blood clots to form solid masses, or clots. More than 30 types of cells and substances in blood affect clotting. [5]

The process is initiated by blood platelets. Platelets produce a substance that combines with calcium ions in the blood to form thromboplastin, which in turn converts the protein prothrombin into thrombin in a complex series of reactions.

Thrombin, a proteolytic enzyme, converts fibrinogen, a protein substance, into fibrin, an insoluble protein that forms an intricate network of minute threadlike structures called fibrils and causes the blood plasma to gel. The blood cells and plasma are enmeshed in the network of fibrils to form the clot. [4]

Figure [2.2] shows the steps of the clot and shows, all phases of clotting which are divided into:-

- Vascular Phase.
- Platelets Phase.
- Coagulation Phase.
- Clot Retraction.
- Clot Destruction.

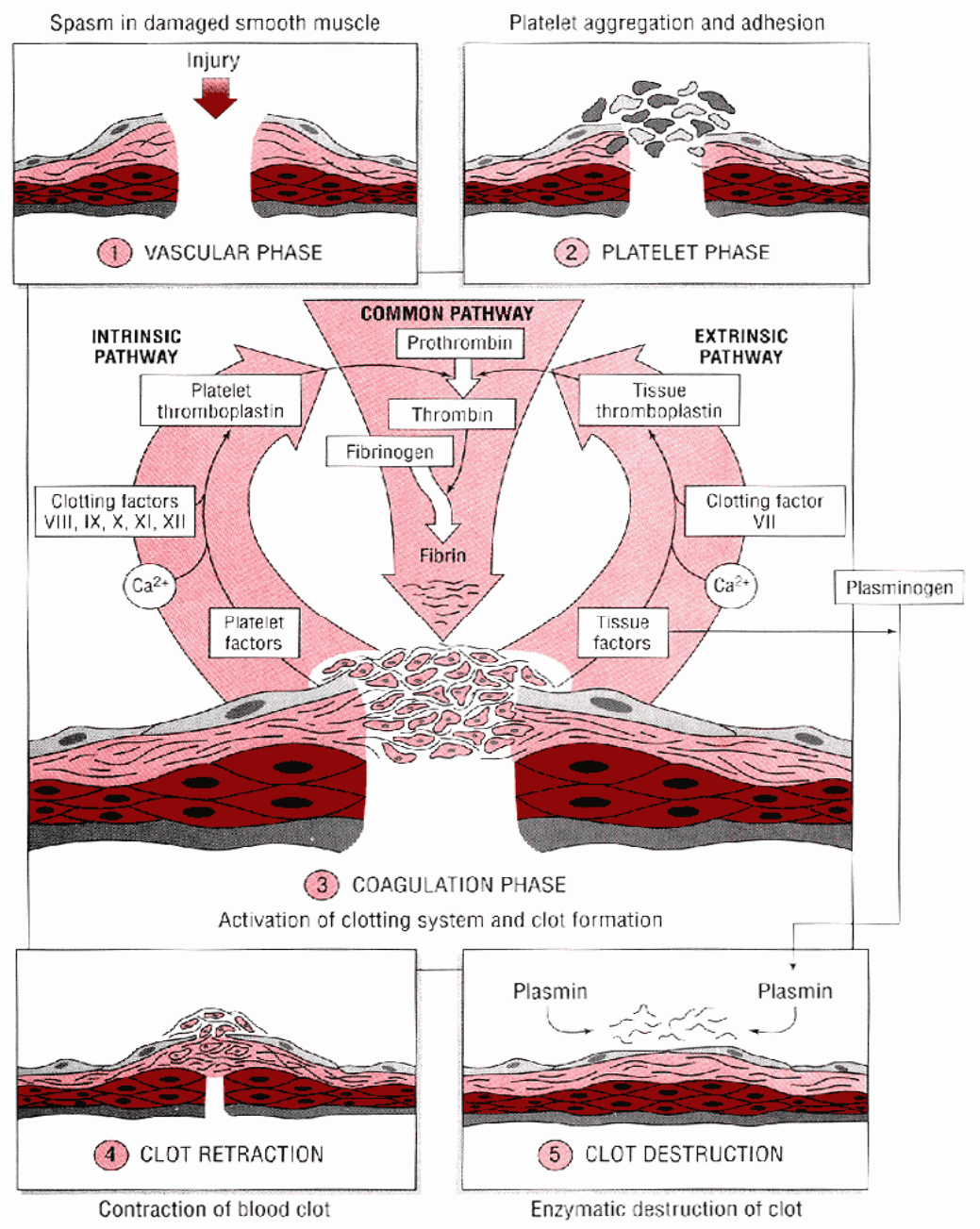


Figure 2.2: Coagulation Case. [14]

2.3.2 Hyper Coagulation :

Hyper coagulation disorders cause an increased tendency for clotting of the blood. In hyper coagulation disorders, the clots can develop in circulating blood. This may put a patient at risk for obstruction of veins and arteries (phlebitis, thrombosis, or thrombophlebitis). The hypercoagulable state and thrombophlebitis are common cases of cancer involving solid tumors such as pancreatic, breast, ovarian, and prostate cancer.

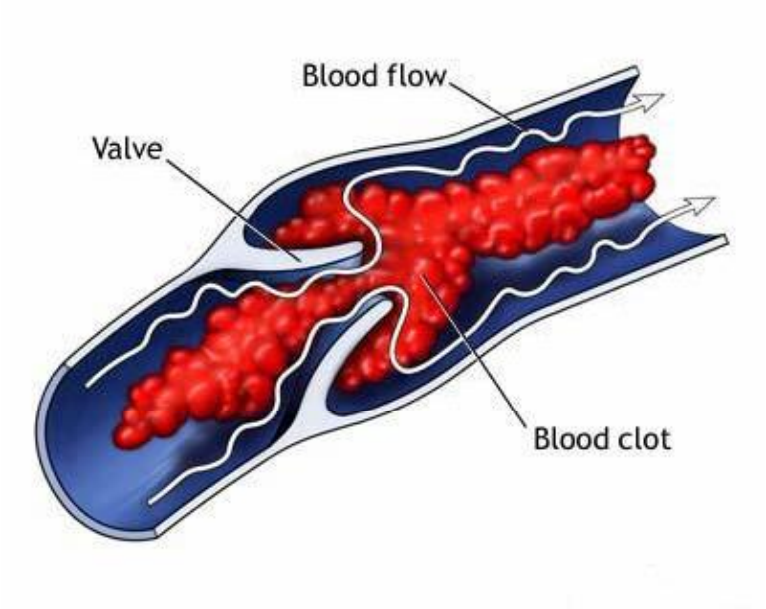


Figure 2.3: Hyper Coagulation Case [15]

Hyper coagulation dangerous:

- A clot inside a blood vessel is called a thrombus. Sometimes the thrombus can travel in the bloodstream and get stuck in lungs. This kind of clot (called a pulmonary embolus) keeps blood from getting to lungs. A pulmonary embolus can be life-threatening.
- A clot that blocks a blood vessel in the brain can cause a stroke. A clot in a blood vessel in the heart can cause a heart attack.
- Blood clots can cause some women to have miscarriages.

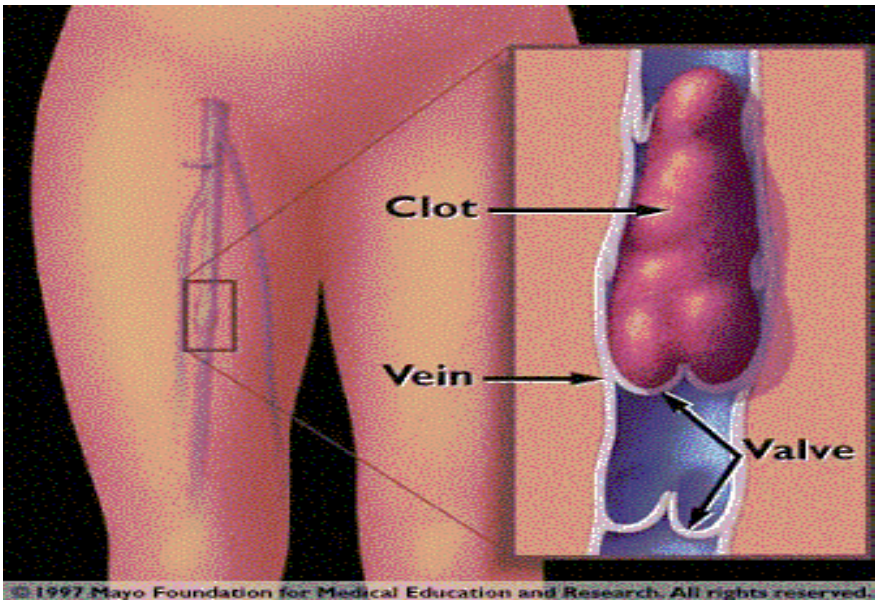


Figure2.4 Hyper coagulation Dangerous. [14]

Hyper coagulation causes: There are several causes in blood to clotting the blood too much like:

- Proteins in body that are supposed to keep blood from clotting too much. Some people don't make enough of these proteins. In other people, these proteins aren't doing their job properly. Or a person may have an extra protein in their blood that causes too much clotting like protein C deficiency or protein S deficiency.
- Cancer.
- Surgery.
- Prolonged bed rest several days.

Hyper coagulation treatment: There is some treatment like:

- Several medicines can thin the blood and make it less likely to clot which the doctor decides.
- The two most common blood thinners are called heparin and warfarin. Heparin must be injected with a small needle under the skin. Once the heparin starts working.
- Warfarin takes longer to begin working.

2.3.3 Bleeding ,Coagulation and Prothrombin Time

- **Bleeding Time:**

The bleeding time is the time required for a small cut to stop bleeding , the bleeding is usually performed by either the Duk method or the Ivy method[4] , the normal values for the Duk method are 1 to 3 minutes and normal valued for the Ivy method are 1 to 7 minutes.

The bleeding time is increased in those cases:

1. Scurvy, purpura hemorrhagica.
2. Symptomatic thrombocytopenic purpura, Clansman's disease.
3. Von Willebrand disease, plastic anemia, infection mononucleosis.

The bleeding time may increase or decease because of the following:

1. Shortage of platelets.
2. Inadequate function of platelets.
3. Poor retractability of capillaries.
4. Deficiency of plasma factors.

- **Coagulation Time:**

The coagulation time is the time required for blood to coagulate. The normal values for coagulation time vary with the method of determination. The most commonly used methods are:

- Capillary blood methods such as slide method, capillary tube method.
- Venous blood method such as lee and white method.

The difference between capillary and venous method is the normal value of coagulate. In capillary is short than venous because the substances in tissue juices, essentially thromboplastin, assist blood coagulation.

The coagulation time increases in some conditions like:

1. Hemophilia.
2. Vitamin K deficiency.
3. Heparin therapy.

The coagulation time is mainly used in the diagnosis and treatment of the hemorrhagic disease, this disease deals with abnormal bleeding.

- **Coagulation Factors:**

The factors that effect the coagulation of the blood and its function are given in the following table:

Table [2.1]: Coagulation Factors

Number	Name	Function
I	Fibrinogen	Forms clot (fibrin)
II	Prothrombin	It is activate protein C , platelets
III	Thromboplastin	The conversion prothrombin to thrombin is assist by thromboplastine
IV	Calcium	Required for coagulation factors to bind to phospholipids
V	Proaccelerin (Labile factor)	It forms the prothrombinase complex
VII	Proconvertin (Stable factor)	Activates IX, X
VIII	Antihemophilic factor	It forms the tenase complex
IX	Christmas factor	Activates X: forms tenase complex with Factor VIII
X	Stuart-Prower factor	Forms prothrombinase complex with factor V
XI	Plasma thromboplastin antecedent	Activates XII, IX and prekallikrein
XII	Hageman factor	Activates prekallikrein and fibrinolysis
XIII	Fibrin-stabilizing factor	Crosslinks fibrin

- **Prothrombin Time:**

Prothrombin is protein substances which are produced by liver. It is used in clotting the blood. During the clotting process, the prothrombin is converted to thrombin.

Prothrombin time is an important test because it checks if the five different blood clotting factors (I, II, V, VII, and X) are present. It is a blood test that measures how long it takes blood to clot. A prothrombin time test can be used to check for bleeding problems. Prothrombin time is also used to check whether medicine prevents blood clots from working. The prothrombin time increase by the following:

- Low levels of blood clotting factors.
- A change in the activity of any of the clotting factors.
- The absence of any of the clotting factors.
- Other substances, called inhibitors that affect the clotting factors.
- An increase in the use of the clotting factors.

- **Description of the Prothrombin time (test):**

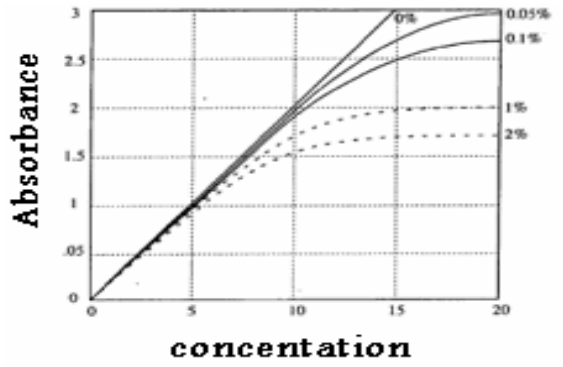
A sample of the patient's blood is obtained by venipuncture. The blood is collected in a tube that contains sodium citrate to prevent the clotting process from starting before the test. The blood cells are separated from plasma. The Prothrombin time test is performed by adding the patient's plasma to a protein in the blood (thromboplastin) that converts prothrombin to thrombin.

The mixture is then kept in a warm water bath at 37°C for one to two minutes. Calcium chloride is added to the mixture in order to counteract the sodium citrate and allow clotting to proceed. The test is timed from the addition of the calcium chloride until the plasma clots. This time is called the prothrombin time and the normal value is 11-15 seconds.

2.4 Project Theory:

The project depends on the main idea of the phenomenon of light absorption; which is described by Beer's law. In optics, the Beer-Lambert law, also known as Beer's law or the Lambert-Beer law or the Beer-Lambert-Bouguer law (in fact, most of the permutations of these three names appear somewhere in literature) is an empirical relationship that relates the absorption of light to the properties of the material through which the light is traveling.

- **Beers law**: states that the (concentration of a substance is directly proportional to the amount of light absorbed) or inversely proportional to the logarithm of the transmitted light; see **Fig. [2.5].**



Figuer2.5: Concentration vs. Absorbance [16]

The mathematical relationship between absorption of radiated energy & the concentration of a solution is shown by Beer's law:

$$A = \log(\%T) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2.1)$$

Where:

A: absorbance.

%T: Percent transmittance.

Transmittance (T) is defined as the ratio of transmitted light (I) to incident light (I_0).

$$T = \frac{I}{I_0} \quad \text{……..(2.2)}$$

$$A = \log \frac{V_0}{V} \quad \text{…… (2.3)}$$

Where:

A: absorbance

V_0: The output voltage from transmittance light through distilled water.

V: The output voltage from transmittance light through the solution.

2.5 Project Components:

This section provides a full explanation of each component and each part of this project.

The design consists of the following components:

1) DC power source.
2) Light parts.
3) PIC Microcontroller (16F84 PIC).

2.5.1 The Power Source:

The power supply is a system that supplies electrical energy to all project parts. It converts one form of electrical current and voltage to another desired

form. This typically involves converting 220 volt AC to a well-regulated lower DC voltage for electronic devices.

The circuit of power supply contains:

1. Transformer: To transform high AC voltage to lower AC voltage.
2. Rectifier: To convert the AC voltage to non-regulated DC voltage.
3. Filter: To reduce the variations of output voltage of rectifier.
4. Regulator: To produce well-regulated DC voltage.

2.5.2 Light Path Parts:

This design shows the light path which starts at the light source lamp until it reaches the detector; the components of this path are:

1. Light source.
2. Aperture.
3. LDR (light dependent resistors).

1. light Source :

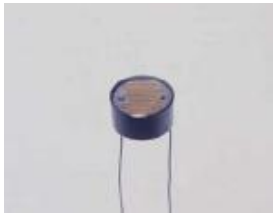
We will use the light source to get suitable wave length which is needed to pass through the Apert.

2. Cuvette (Sample handling):

It is used to put the blood sample inside. The design construction and material of the cuvette are all important to accurate measurements; so in our project we'll use tube which is covered by EDTA; to allow the blood clotting, but the EDTA does not affect the clotting unless shake the sample.

3. LDR (light dependent resistors):

LDRs or Light Dependent Resistors are very useful especially in light/dark sensor circuits. Normally the resistance of an LDR is very high.



Figer2.6: LDR [17]

2.5.3 PIC -Peripheral Interface Controller- Microcontroller :

As semiconductor fabrication technology became more advance, manufactures were able to place not only microprocessor but also memory and input/output interfacing circuit on single chip; this is known as a microcontroller or microcontroller unit (MCU).

The microcontroller may be including other additional device like, memory unit, Central Processing Unit, Bus, Input-output unit, Serial communication, Timer unit, Analog to Digital Converter. The Microcontroller is a brain of the digital device that operates in a close loop control process. It has I/O port to take in interrupt data and send out signal to control relay or just simply a motor or that type of mechanisms. We can differ between Microprocessor and Microcontroller by the following table:

Table [2.2]: Compare between microprocessor and microcontroller

Differ as	Microprocessor	Microcontroller
Speed	Can work in very high speed	Limited speed
Cost	Expensive	Cheap
Instruction set	Complex	Simple
Connection	Needs many external components	Ports ready and available
Usability	Can be used in any task	Depends on the task

The microcontroller is several families; every member of any family shares the same core architecture and instruction set. The families are identified primarily by the first two digits of the device code, the alphabetic character that follows gives some indication of the technology used (16C5XX/16F5XX).

The ‘C’ insert implies CMOS technology where CMOS stands for Complementary Metal Oxide Semiconductor, the leading semiconductor technology for implementing low- power logic systems.

The ‘F’ insert indicates incorporation of flash memory technology, ‘A’ after the number indicates technological up grade on the first issue device.

The ‘X’ indicates that a certain digit can take a number of values, the one taken being unimportant to the overall number quoted.

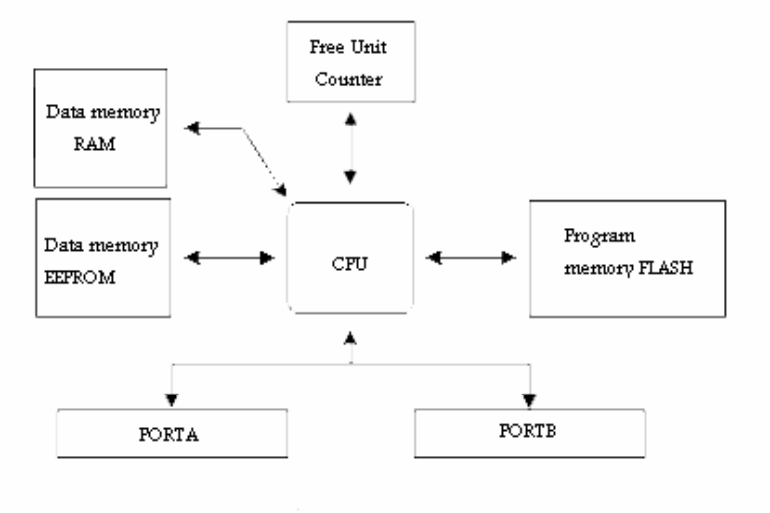


Figure2.7: PIC 16F84 structure [18]

The project uses the PIC 16F84 **fig [2.8]** with the following conditions:

1. Pins: 18; Speed: 4MHz.
2. 13 Input/Output pins.
3. Each pin can be programmed independently as input OR output.
4. I/O ports 0V to 5.5V.

The following diagram shows the pin-outs of the PIC 16F84

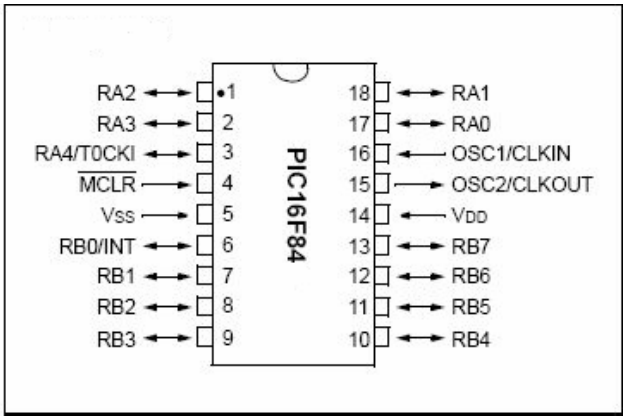


Figure 2.8: Pin of 16F84 Microcontroller [19]

- **RA0 to RA4**

RA is a bidirectional port. That is, it can be configured as an input or an output. The number follows RA is the bit number (0 to 4). So, we have one 5-bit directional port where each bit can be configured as Input or Output.

- **RB0 to RB7**

RB is a second bidirectional port. It behaves in exactly the same way as RA, except there are 8 - bits involved.

- **VSS and VDD**

These are the power supply pins. VDD is the positive supply, and VSS is the negative supply, or 0V. The maximum supply voltage that you can use is 6V, and the minimum is 2V.

- **OSC1/CLK IN and OSC2/CLKOUT**

These pins are where we connect an external clock, so that the microcontroller has some kind of timing. There are two types of oscillator circuit in common use in microcontrollers. The resistor–capacitor (RC) type and the crystal oscillator which depends on the piezo-electric properties of quartz crystal.

- **MCLR**

This pin is used to erase the memory locations inside the PIC (i.e. when we want to re-program it). In normal use it is connected to the positive supply rail. It is essential to recognize that this input must not be left unconnected .The simplest thing to do is to tie it to the supply rail and then forget it.

- **INT**

This is an input pin which can be monitored. If the pin goes high, we can cause the program to restart, stop or any other single function we desire. We shouldn't use this one many times

T0CK1

This is another clock input, which operates an internal timer. It operates in isolation to the main clock. Again, we shouldn't use this one many times either.

3

Project Conceptual Design

Chapter Three
Project conceptual design

This chapter describes the following:

- Main objectives of the project.
- The general block diagram.
- System work

3.1 Project Objectives:

This project supports many ideas and objectives that can be summarized as follows:

1 To design and implement clotting time meter by using light absorption property.
2 Using the microcontroller to read the system output and control the system and counting the time of the clotting and displaying the value into seven segments.
3 To be used as an instructional purpose in the biomedical laboratory in our university.

3.2 Design Options:

Here we will show the design options including light source and light detecting options, control unit options, temperature sensors options and programming language options.

3.2.1 Light Source and Detecting Options:

There are many types of light source:

1. Halogen lamp.
2. Photo LED with suitable wave length.

We will use photo LED source for the following reasons:

- Cheap.
- Don’t need filter and lenses.
- Give a suitable wave length which is needed in our project.
- Small size.

There are many types of light detectors:

1. Photo diode.
2. Photo transistor.
3. LDR "Light Dependent Resistance".

We will use the LDR for the following reasons:

- Sensitivity very good for all wavelengths.
- Good stability.
- Low cost.
- Small size.

3.2.2 Control Unit Options:

We can control the processes of this project using:

a. The Microprocessor.
b. The PIC controller.

We will use the PIC controller for the following reasons:

1) Cheap.
2) Simple instruction set.
3) Depends on the task.

Programming language options:

To program the microcontroller we can use:

1. The Assembly language.
2. The C language.

We used the first one.

3.3 General Block Diagram:

The following figure shows the block diagram of our project.

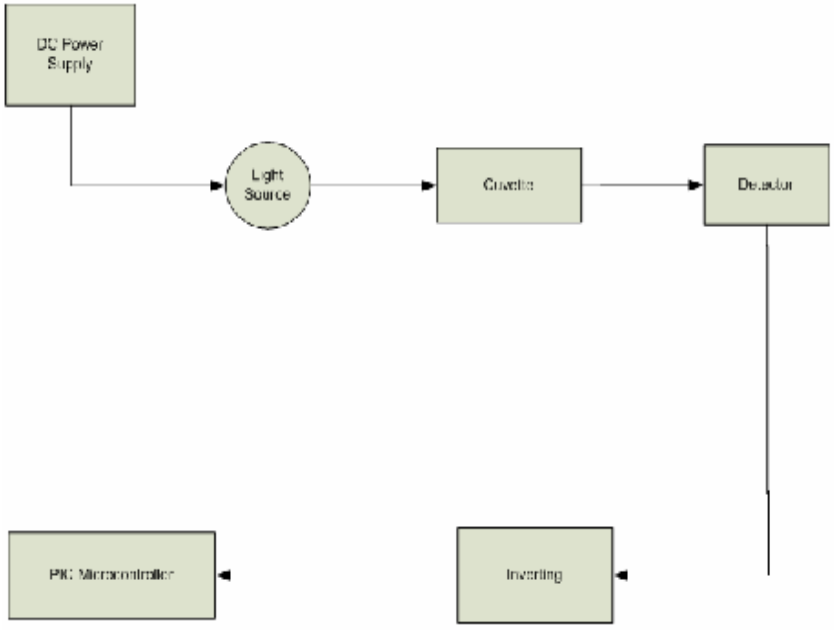


Figure 3.1: General block diagram

This block diagram consists of several units to be accomplished and integrated with each other to form the final clotting time meter, these units are:

1. **Power supply:**

    - All project parts supplies with suitable energy.
    - 220V, 50HZ.
    - Supplies DC voltage to feed the electrical circuit such as 5V, 12V, 18V, 24V for IC's.

2. **Light source:**

    - Expressed as LED which supplies the system with suitable wave length**.**

3. **Cuvette :**

    - We keep the sample in normal temperature value37Cº.
    - We use cuvette with covered by EDTA.

4. **LDR:**

    - It detects the intensity of light.

- It Gives the output as voltage change according to light intensity changes.
- The change in voltage occurs because the change in the light observance which effected into resistance.

5. **Switch transistor:**

- This is used as a switch.

6. **Inverter** :

- Using the inverter as interfacing circuit between the detecting circuit and PIC.
- It is used to change the logic (0) to logic (1).
- Logic (0) is sent as logic 1 to PIC.
- Logic (1) is sent as logic 0 to PIC.

7. **PIC Microcontroller:** we use the PIC in our project to

- Control to the operation when started and when finished.
- Counting the time of operation.
- Display the out put on seven segments.
- Display is the interface part that shows us the state and all

machine variables (time), which gives us feedback about the setting values.

3.4 How does the System Works?

These steps show how the design work & what is the tasks of operator to have at the end an accuracy value of clotting time.

- The operator takes the blood sample from the patient or if the sample in libratory it must be protected in the body temperature.

- After putting the blood sample in its holder the system work as follow:

  - The lamp (light) source gives light with suitable wavelengths the range. This wavelength is (400-700nm).
  - The light penetrates the cuvette which including the blood sample.
  - Then the light is detecting by suitable LDR.
  - The light absorbance is proportional inversely to LDR resistance.
  - At first the light is the max so the resistance of LDR is the min (before the blood clotting) so the voltage occurs in R is the approximation 5 v, after the blood clotting the voltage occurs is 0v.
  - This voltage value (zero voltage) is change in digital using the inverter which converts the logic zero to logic one and the inverter in this project work as interfacing circuit between the sensing circuit and PIC microcontroller circuit.

- When the value 5v the inverter is change it to 0 and the PIC start count, and When the value 0v the inverter is change it to 1 and the PIC stop account.
- The clotting of blood stay a few second ,after the clotting of blood complete the absorbance is limited and the voltage become zero this value translate to PIC which mean stop the operation and display the value of counter to the seven segment.
- The heating system is used for offers a stable temperature 37(C^o) around the blood sample.
- External crystal in the microcontroller to get the clock and in the 16F84 we use the 4 MHZ as frequency to clock the circuit.

4

Detailed Technical Project Design

4.1 Detailed Description of the Project Phases

4.2 Subsystem Design

Chapter Four
Detailed Technical Project Design

4.1 Detailed Description of the Project Phases:

The project design principle depends on the Beer's law, so our design will be built to satisfy this law by each component in the design.

The detailed description of the project phases can be summarized as follows:

- Light phase: we will use a specific light source and specific photo transistors. The light source gives a suitable wavelength to pass through the blood sample. The LDR is very sensitivity for the wave length.
- Processing phase: we are going to use the inverter circuit as interfacing circuit between the sensing circuit and PIC chip. We transfer the output values from the sensing circuit to the PIC as digital values. The PIC uses these values to stop the operation and display the value of counter into the seven segments.

4.2 Subsystem Design:

In this section we show the schematics, characteristics, feature, and the specifications of each component and subsystem which are divided into:

- Power supply system.
- Sensing system.
- PIC microcontroller.

4.2.1 Power Supply :

The power supply is a mean that provide electrical power to the project parts; it consists of many stages as shown is the following block diagrams**:**

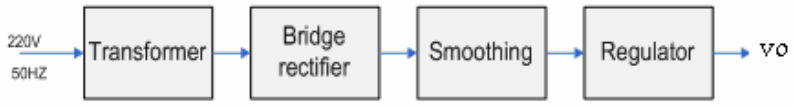


Figure 4.1: DC Power source block diagram

From the figure, the power supply includes:

- Transformer: provides the necessary voltage.
- Rectifier: the full wave rectifier to convert AC output from transformer to DC.
- Smoothing: to limit the voltage ripple.
- Regulator: to provide a constant voltage.

The power supply circuit is used to convert 220V AC / 50HZ to a suitable voltage (5, 12, 24) volt. The following circuit indicates the power supply circuit.

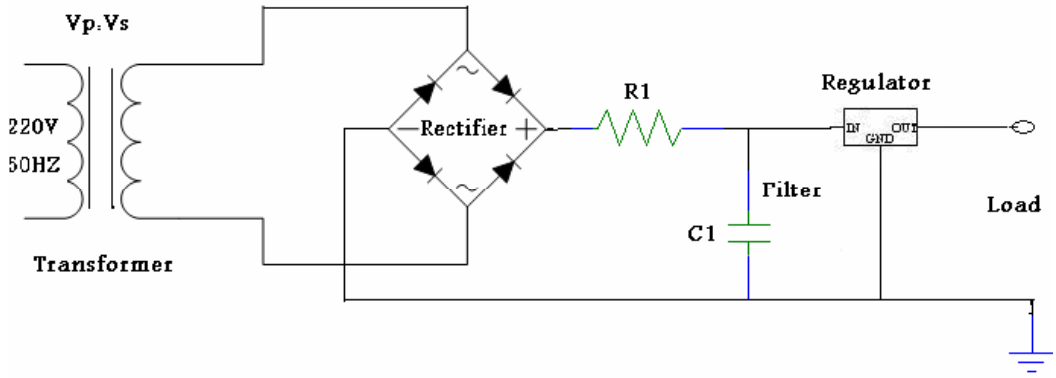


Figure 4.2: Power supply circuit

The mathematical relationship between the voltage and the turn ratio is:

$$\frac{Vp}{Vs} = \frac{Np}{Ns} \quad \textbf{……. (.4.1)}$$

The output voltage of the rectifier is given by:

$$Vo = V_s - 1.4 \quad \textbf{…….. (4.2)}$$

Vo …… rectifier output.
V_s **……** secondary voltage.

The output is given by:

$$Vdc = (1 - \frac{1}{2fR1C1})Vo \quad \textbf{……. (4.3)}$$

The ripple voltage is given by:

$$Vr = (1 - \frac{1}{fR1C1})Vo \quad \textbf{……... (4.4)}$$

$$Ripple - factor = \frac{Vr}{Vdc} \quad \textbf{…….. (4.5)}$$

4.2.2 Sensing System:

The light source is supplied from the DC power supply and the light take path from the light source to detector passes through the blood sample. The following block diagram shows the basic block that is connected with the light source:

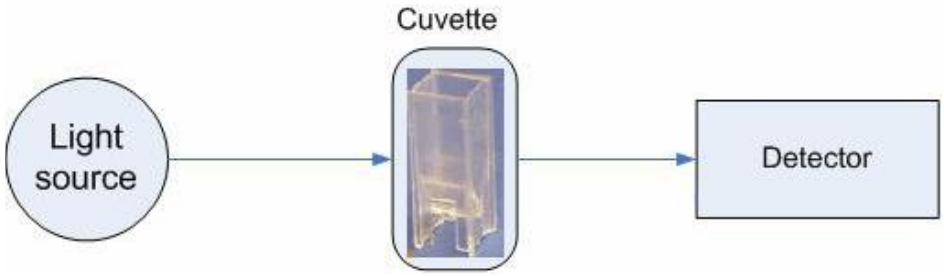


Figure 4.3: Light Source block diagram

The block diagram includes:

- Light source: use the photo LED.
- Cuvette: includes blood sample.
- Detector: detecting the light from the light source.

The following circuit shows a light that passes through a blood sample and is detected by the LDR. The light absorbance affects the LDR resistance. When the blood is clotted, the LDR resistance will be very high so the voltage to R3 approximately equals zero which means the sample is clot.

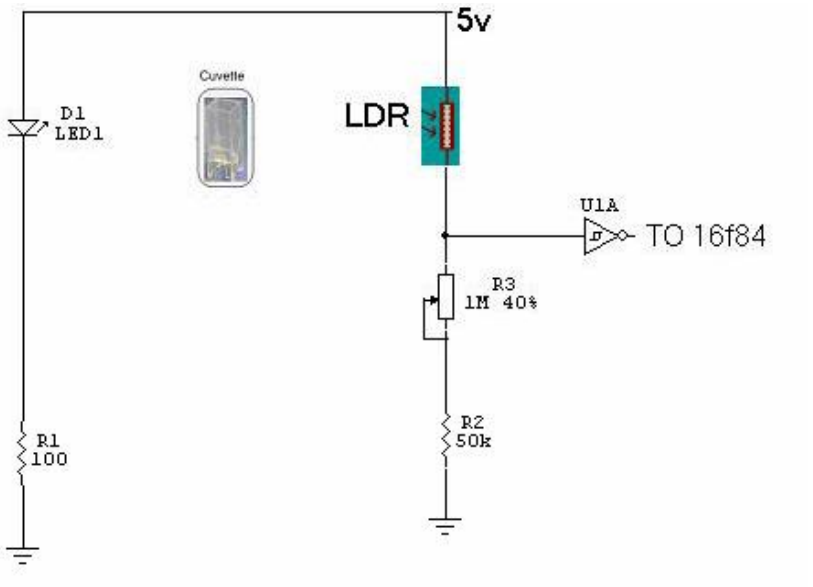


Figure 4.4: Sensing system schematic

4.2.3 PIC Microcontroller :

The schematic below shows the data that passes from the sensing circuit to the PIC microcontroller:

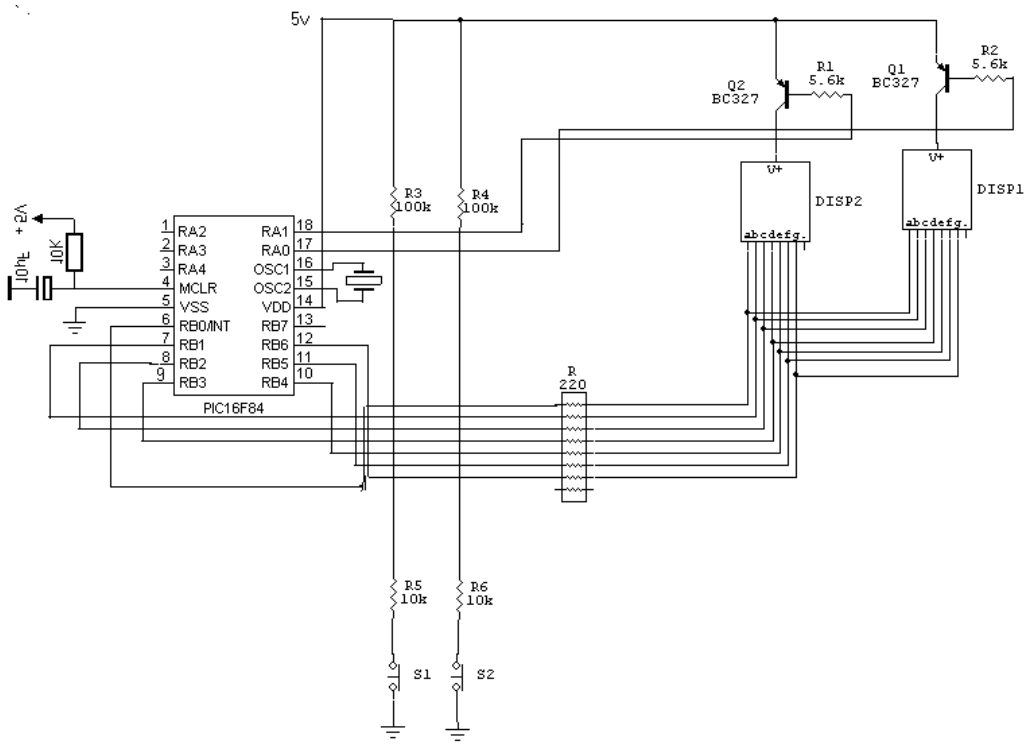
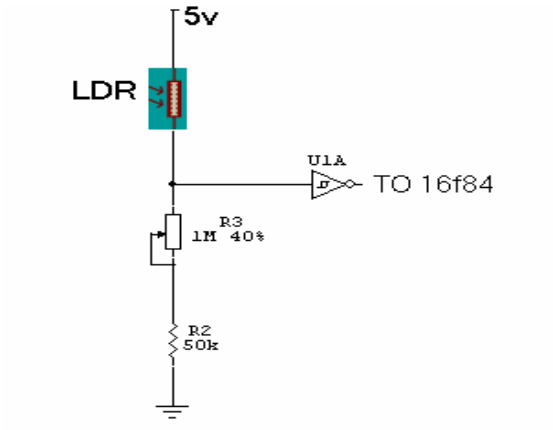


Figure 4.5: The PIC circuit

- **Interfacing circuit:** it interfaces between the sensing part and the microcontroller part, and tells the PIC when stops the counting and finishes the operation and displays the output of counting on the seven segments. This circuit is an inverter that changes the logic from logic (0) to logic (1).



Figuer 4.6: Interfacing Circiut

- **PIC microcontroller :** it performs the following tasks :

  - When the system starts sensing and observing the light, the PIC starts counting.
  - When the interfacing circuit sends the logic one to the PIC microcontroller, the PIC understands this value as stopping the counting of time and displays the result on the LCD and finishes the operation**.**

5

Software

Chapter Five
Software

5.1 Software Needed for the Project:

In this project as mentioned before, we will use a PIC microcontroller: to process the output value and to count the clotting time. We use the assembly language for programming the chip to do the following steps:

- Use the PIC to control the system when start, and when stops and this case depends on the programming of the chip.
- Use the assembly language to build counter in the PIC to count the time that the blood needs to clot completely.
- Use the language to program the PIC at fished the count displaying the result on seven segments displays.

5.2 Flowchart:

This flowchart must be follow by the operator to success the procedure for measuring hemoglobin concentration.

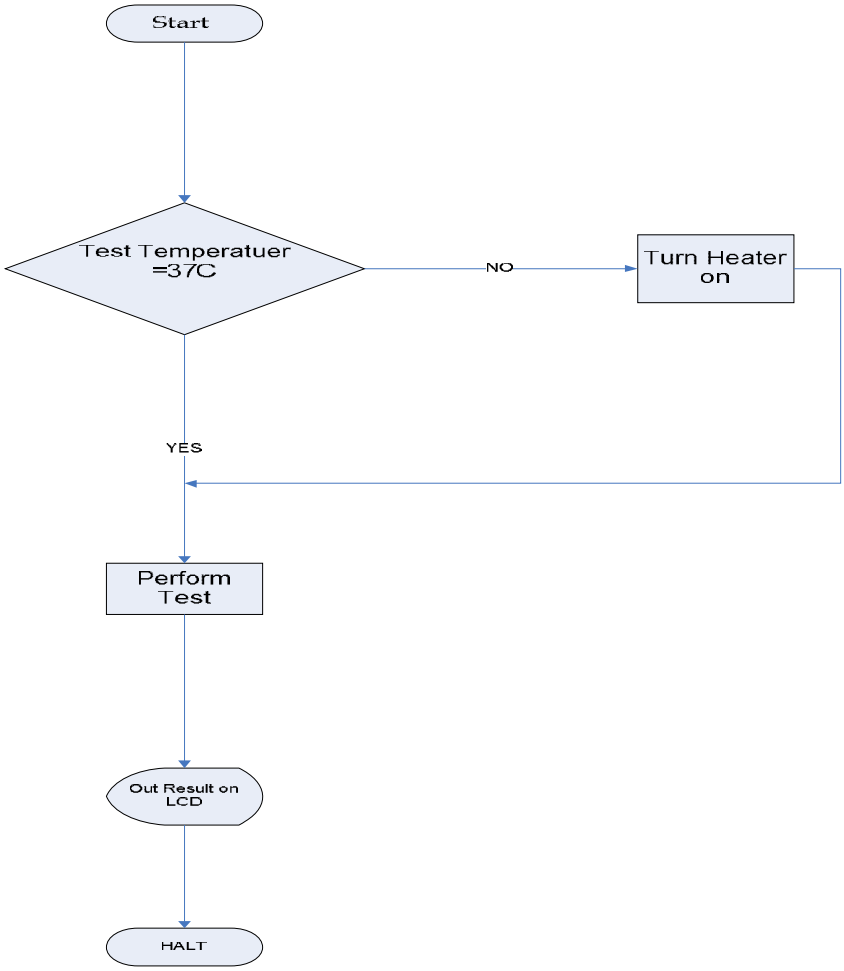


Figure 5.2: Flowchart.

5.3 Main Program:

```
                *** PROGRAM EQUATES ***
PC              EQU     2
STATUS          EQU     3
PORTA           EQU     5
PORTB           EQU     6
TRISA           EQU     5
TRISB           EQU     6
R0              EQU     H'C'
R1              EQU     H'D'
TIMER           EQU     H'E'
TIM01S          EQU     H'F'
C               EQU     0
RP0             EQU     5
DAT5mSH         EQU     10
DAT5mSL         EQU     167



                *** MAIN PROGRAM ***

                ORG             0
                BSF             STATUS, RP0
                MOVLW           0
                MOVWF           TRISB
                BCF             STATUS, RP0
CLEAR           MOVLW           H'FF'
                MOVWF           PORTB
                CLRF            TIMER
BEGIN           BSF             STATUS, RP0
                MOVLW           H'FF'
```

```
                MOVWF     TRISA
                BCF       STATUS, RP0
                NOP
                NOP
                BTFSS     PORTA, 1
                GOTO      CLEAR
                BTFSC     PORTA, 0
                GOTO      DISPLAY
                INCF      TIMER
                CALL      DAA
DISPLAY         BSF       STATUS, RP0
                CLRF      TRISA
                BCF       STATUS, RP0
                MOVLW     3
                MOVWF     PORTA
                MOVLW     100
                MOVWF     TIM01S
;
DISPLAY1        MOVFW     TIMER
                ANDLW     H'F'
                CALL      TABLE
                MOVWF     PORTB
                BCF       PORTA, 1
                CALL      DLY5mS
                MOVLW     H'FF'
                MOVWF     PORTB
                BSF       PORTA, 1
                SWAPF     TIMER, W


                ANDLW     H'F'
                CALL      TABLE
                ANDLW     B'11111111'
```

```
                MOVWF     PORTB
                BCF       PORTA, 0
                CALL      DLY5mS
                MOVLW     H'FF'
                MOVWF     PORTB
                BSF       PORTA,0
                DECFSZ    TIM01S
                GOTO      DISPLAY1
                GOTO      BEGIN

                  *** DECIMAL ADJUSTMENT ***
DAA             MOVF      TIMER, W
                ANDLW     H'F'
                SUBLW     9
                BTFSC     STATUS, C
                GOTO      DAA1
                MOVLW     6
                ADDWF     TIMER
DAA1            SWAPF     TIMER, W


                ANDLW     H'F'
                SUBLW     9
                BTFSC     STATUS,C
                GOTO      DAA2
                MOVLW     H'60'
                ADDWF     TIMER
DAA2            RETURN
```

```
                    *** 5ms DELAY ***
DLY5mS              MOVLW       DAT5mSH
                    MOVWF       R0
DLY5mS1             MOVLW       DAT5mSL
                    MOVWF       R1
DLY5mS2
                    DECFSZ      R1
                    GOTO        DLY5mS2
                    DECFSZ      R0
                    GOTO        DLY5mS1
                    RETLW 0
        *** LOOK-UP TABLE ***
   TABLE            ADDWF       PC
                RETLW H'C0'             ;0
                RETLW H'F9'             ;1
                RETLW H'A4'             ;2
                RETLW H'B0'             ;3
                RETLW H'99'             ;4
                RETLW H'92'             ;5
                RETLW H'82'             ;8
                RETLW H'F8'             ;7
                RETLW H'80'             ;8
                RETLW H'90'             ;9
   END
```

6

System Implementation and Testing

Chapter Six

System Implementation and Testing

This chapter demonstrates the methods and procedures used to implement, test, and examine the system operation and behavior. System testing is an important and crucial step in implementing the system. It measures the effectiveness of the system just before introducing it to its users.

6.1 Procedure:

To do the test we must follow the next steps:

Take the blood sample from the patient

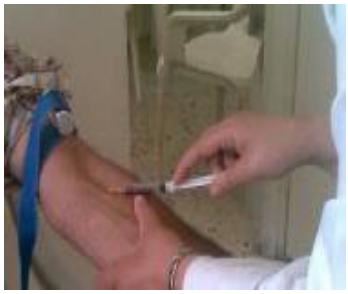


Figure 6.1: Blood Sample

1. Shaking the blood slowly.

Figure 6.2: Shaking the blood

Center fugue the blood to separate the plasma from blood.

Figure 6.3: Center Fugue the blood

2. After separating the plasma from blood we do the test

6.2 Test and Result:

After finishing from built our design project, we test some blood Sample on it.

First sample; Yousef Ahmed sample; at laboratory test the time value Was 11s; at our design the time value was 10s as show in **Figure [6.4]**

Figure 6.4: Test {1}

Second sample; Mouna Hadad sample; at laboratory test the time value Was 13s; at our design the time value was 14s as show in **Figure [6.5]**

Figure 6.5: Test {2}

Third sample; Mousa sample; at laboratory test the time value was 12s; at our design the time value was 11s as show in **Figure [6.6]**

Figure 6.6: Test {3}

Error calculations:

At the end of our test for blood samples we are going to calculate the error. Percentage as following equations:

$$erorr\{1\} = \left|\frac{truevalue - measuredvalue}{truevalu}\right| * 100\% = \frac{11-10}{11} * 100\% = 9\%$$

$$erorr\{2\} = \left|\frac{truevalue - measuredvalue}{truevalu}\right| * 100\% = \left|\frac{13-14}{13}\right| * 100\% = 7.5\%$$

$$erorr\{3\} = \left|\frac{truevalue - measuredvalue}{truevalu}\right| * 100\% = \frac{12-11}{12} * 100\% = 8.33\%$$

→ Average error (E):

$$\overline{E}\{\%\} = (\sum_{1}^{3} E) / 4 = (9 + 7.5 + 8.33) / 4 = 6.2\%$$

6.3 Project Maintenance:

This project needs maintenance as any medical instrumentation; the main points to maintain the integrity of the work are:

1. Always check the LED voltage; prevent it to be less than 5v.
2. Always check the wires connection

3. Change the cuvette when needed; keep it clean after every test.

4. Always check the PIC connection.

7

Conclusion and Future Work

Chapter Seven
Conclusion and Future work

7.1 Conclusion:

Our project conclusions consist of:

1. The project measure the value of time taken by the blood to completely clot; using suitable photo LED for the desired wave length (400-500 nm) which we need.

2. The project uses the PIC microcontroller to process and control the data and display the result; we choose it for the following reasons:

- The PIC is signal chip and contains some device like CPU, memory, ADC… and other devices.
- The PIC microcontroller is cheaper and simple.
- High performance.

3. the designed clotting time meter has the following properties:

- Feasible.
- Flexible.
- Easy to use.

7.2 Recommendation:

1. Our project used seven segment display to show the time of clotting but in future we can use the LCD with some programming to LCD.
2. In future we can build the heating system with use heater to save the blood sample in degree $37C^0$.
3. In future, Use LED and phototransistor with the same wave length Instead of LDR and.

Reference

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[10]http://talking-electronics.netfirms.com/index.html

[11]http://www.rentron.com/contact.htm

[12] http://familydoctor.org/online/famdocen/home/common/blood/244.html

[13] http://www.weitzlux.com/celebrex/deepveinthrombosis_2467.html

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[19] http://sixthsense.osfc.ac.uk/electronics/microprocessors/pic_chip.asp

Appendices

- Appendix A: Definitions
- Appendix B: Datasheets of Project Components

Appendix: A

Definitions

FEATURES

- Applications:
  - Wave and pulse shapers
  - Astable multivibrators
  - Monostable multivibrators.
- Complies with JEDEC standard no. 7A
- ESD protection:
  HBM EIA/JESD22-A114-A exceeds 2000 V
  MM EIA/JESD22-A115-A exceeds 200 V.
- Specified from –40 to +85 °C and –40 to +125 °C.

DESCRIPTION

The 74HC14 and 74HCT14 are high-speed Si-gate CMOS devices and are pin compatible with low power Schottky TTL (LSTTL). They are specified in compliance with JEDEC standard no. 7A.

The 74HC14 and 74HCT14 provide six inverting buffers with Schmitt-trigger action. They are capable of transforming slowly changing input signals into sharply defined, jitter-free output signals.

QUICK REFERENCE DATA

GND = 0 V; T_{amb} = 25 °C; $t_r = t_f$ = 6 ns

SYMBOL	PARAMETER	CONDITIONS	TYPICAL		UNIT
			HC	HCT	
t_{PHL}/t_{PLH}	propagation delay nA to nY	C_L = 15 pF; V_{CC} = 5 V	12	17	ns
C_I	input capacitance		3.5	3.5	pF
C_{PD}	power dissipation capacitance per gate	notes 1 and 2	7	8	pF

Notes

1. C_{PD} is used to determine the dynamic power dissipation (P_D in μW):
   $P_D = C_{PD} \times V_{CC}^2 \times f_i \times N + \Sigma(C_L \times V_{CC}^2 \times f_o)$ where:
   f_i = input frequency in MHz;
   f_o = output frequency in MHz;
   C_L = output load capacitance in pF;
   V_{CC} = supply voltage in Volts;
   N = total load switching outputs;
   $\Sigma(C_L \times V_{CC}^2 \times f_o)$ = sum of the outputs.
2. For type 74HC14 the condition is V_I = GND to V_{CC}.
   For type 74HCT14 the condition is V_I = GND to V_{CC} – 1.5 V.

FUNCTION TABLE

INPUT	OUTPUT
nA	nY
L	H
H	L

Note

1. H = HIGH voltage level;
   L = LOW voltage level.

ORDERING INFORMATION

TYPE NUMBER	PACKAGE				
	TEMPERATURE RANGE	PINS	PACKAGE	MATERIAL	CODE
74HC14D	−40 to +125 °C	14	SO14	plastic	SOT108-1
74HCT14D	−40 to +125 °C	14	SO14	plastic	SOT108-1
74HC14DB	−40 to +125 °C	14	SSOP14	plastic	SOT337-1
74HCT14DB	−40 to +125 °C	14	SSOP14	plastic	SOT337-1
74HC14N	−40 to +125 °C	14	DIP14	plastic	SOT27-1
74HCT14N	−40 to +125 °C	14	DIP14	plastic	SOT27-1
74HC14PW	−40 to +125 °C	14	TSSOP14	plastic	SOT402-1
74HCT14PW	−40 to +125 °C	14	TSSOP14	plastic	SOT402-1
74HC14BQ	−40 to +125 °C	14	DHVQFN14	plastic	SOT762-1
74HCT14BQ	−40 to +125 °C	14	DHVQFN14	plastic	SOT762-1

PINNING

PIN	SYMBOL	DESCRIPTION
1	1A	data input
2	1Y	data output
3	2A	data input
4	2Y	data output
5	3A	data input
6	3Y	data output
7	GND	ground (0 V)
8	4Y	data output
9	4A	data input
10	5Y	data output
11	5A	data input
12	6Y	data output
13	6A	data input
14	V_{CC}	supply voltage

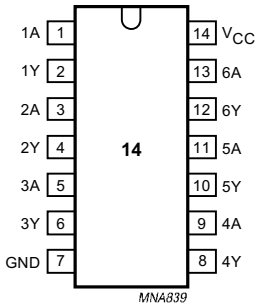
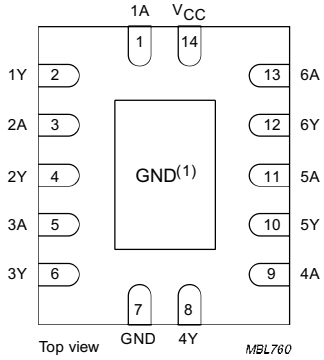


Fig.1 Pin configuration.



(1) The die substrate is attached to this pad using conductive die attach material. It can not be used as a supply pin or input.

Fig.2 Pin configuration DHVQFN14.

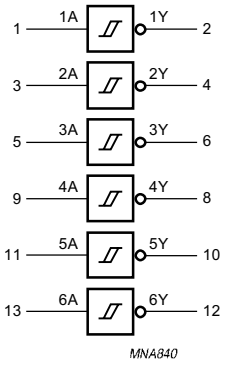


Fig.3 Logic symbol.

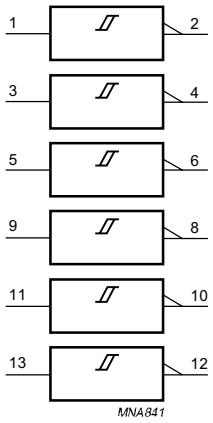


Fig.4 IEC logic symbol.

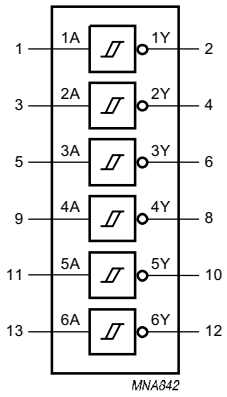


Fig.5 Functional diagram.

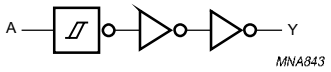


Fig.6 Logic diagram (one Schmitt trigger).

RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	CONDITIONS	74HC14			74HCT14			UNIT
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
V_{CC}	supply voltage		2.0	5.0	6.0	4.5	5.0	5.5	V
V_I	input voltage		0	–	V_{CC}	0	–	V_{CC}	V
V_O	output voltage		0	–	V_{CC}	0	–	V_{CC}	V
T_{amb}	operating ambient temperature	see DC and AC characteristics per device	–40	+25	+85	–40	+25	+85	°C
			–40	–	+125	–40	–	+125	°C

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 60134); voltages are referenced to GND (ground = 0 V).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CC}	supply voltage		–0.5	+7	V
I_{IK}	input diode current	$V_I < -0.5$ V or $V_I > V_{CC} + 0.5$ V	–	±20	mA
I_{OK}	output diode current	$V_O < -0.5$ V or $V_O > V_{CC} + 0.5$ V	–	±20	mA
I_O	output source or sink current	-0.5 V $< V_O < V_{CC} + 0.5$ V	–	±25	mA
I_{CC}; I_{GND}	V_{CC} or GND current		–	50	mA
T_{stg}	storage temperature		–65	+150	°C
P_{tot}	power dissipation	T_{amb} = –40 to +125 °C			
		DIP14 packages; note 1	–	750	mW
		Other packages; note 2	–	500	mW

Notes

1. For DIP14 packages: above 70 °C the value of P_D derates linearly with 12 mW/K.
2. For SO14 packages: above 70 °C the value of P_D derates linearly with 8 mW/K.
   For (T)SSOP14 packages: above 60 °C the value of P_D derates linearly with 5.5 mW/K.
   For DHVQFN14 packages: above 60 °C the value of P_D derates linearly with 4.5 mW/K.

DC CHARACTERISTICS

Type 74HC14

At recommended operating conditions; voltages are referenced to GND (ground = 0 V).

SYMBOL	PARAMETER	TEST CONDITIONS		MIN.	TYP.(1)	MAX.	UNIT
		OTHER	V_{CC} (V)				
T_{amb} = 25 °C							
V_{OH}	HIGH-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = –20 µA	2.0	1.9	2.0	–	V
		I_O = –20 µA	4.5	4.4	4.5	–	V
		I_O = –20 µA	6.0	5.9	6.0	–	V
		I_O = –4.0 mA	4.5	3.98	4.32	–	V
		I_O = –5.2 mA	6.0	5.48	5.81	–	V
V_{OL}	LOW-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = 20 µA	2.0	–	0	0.1	V
		I_O = 20 µA	4.5	–	0	0.1	V
		I_O = 20 µA	6.0	–	0	0.1	V
		I_O = 4.0 mA	4.5	–	0.15	0.26	V
		I_O = 5.2 mA	6.0	–	0.16	0.26	V
I_{LI}	input leakage current	$V_I = V_{CC}$ or GND	6.0	–	–	0.1	µA
I_{CC}	quiescent supply current	$V_I = V_{CC}$ or GND; I_O = 0	6.0	–	–	2.0	µA
T_{amb} = –40 to +85 °C							
V_{OH}	HIGH-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = –20 µA	2.0	1.9	–	–	V
		I_O = –20 µA	4.5	4.4	–	–	V
		I_O = –20 µA	6.0	5.9	–	–	V
		I_O = –4.0 mA	4.5	3.84	–	–	V
		I_O = –5.2 mA	6.0	5.34	–	–	V
V_{OL}	LOW-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = 20 µA	2.0	–	–	0.1	V
		I_O = 20 µA	4.5	–	–	0.1	V
		I_O = 20 µA	6.0	–	–	0.1	V
		I_O = 4.0 mA	4.5	–	–	0.33	V
		I_O = 5.2 mA	6.0	–	–	0.33	V
I_{LI}	input leakage current	$V_I = V_{CC}$ or GND	6.0	–	–	1.0	µA
I_{CC}	quiescent supply current	$V_I = V_{CC}$ or GND; I_O = 0	6.0	–	–	20	µA

SYMBOL	PARAMETER	TEST CONDITIONS		MIN.	TYP.(1)	MAX.	UNIT
		OTHER	V_{CC} (V)				
T_{amb} = –40 to +125 °C							
V_{OH}	HIGH-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = –20 μA	2.0	1.9	–	–	V
		I_O = –20 μA	4.5	4.4	–	–	V
		I_O = –20 μA	6.0	5.9	–	–	V
		I_O = –4.0 mA	4.5	3.7	–	–	V
		I_O = –5.2 mA	6.0	5.2	–	–	V
V_{OL}	LOW-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = 20 μA	2.0	–	–	0.1	V
		I_O = 20 μA	4.5	–	–	0.1	V
		I_O = 20 μA	6.0	–	–	0.1	V
		I_O = 4.0 mA	4.5	–	–	0.4	V
		I_O = 5.2 mA	6.0	–	–	0.4	V
I_{LI}	input leakage current	$V_I = V_{CC}$ or GND	6.0	–	–	1.0	μA
I_{CC}	quiescent supply current	$V_I = V_{CC}$ or GND; I_O = 0	6.0	–	–	40	μA

Note

1. All typical values are measured at T_{amb} = 25 °C.

PIC16F84A
Data Sheet

18-pin Enhanced FLASH/EEPROM
8-bit Microcontroller

Note the following details of the code protection feature on PICmicro® MCUs.

- The PICmicro family meets the specifications contained in the Microchip Data Sheet.
- Microchip believes that its family of PICmicro microcontrollers is one of the most secure products of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the PICmicro microcontroller in a manner outside the operating specifications contained in the data sheet. The person doing so may be engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable".
- Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our product.

If you have any further questions about this matter, please contact the local sales office nearest to you.

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Microchip received QS-9000 quality system certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona in July 1999. The Company's quality system processes and procedures are QS-9000 compliant for its PICmicro® 8-bit MCUs, KEELOQ® code hopping devices, Serial EEPROMs and microperipheral products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001 certified.

PIC16F84A

18-pin *Enhanced* FLASH/EEPROM 8-Bit Microcontroller

High Performance RISC CPU Features:

- Only 35 single word instructions to learn
- All instructions single-cycle except for program branches which are two-cycle
- Operating speed: DC - 20 MHz clock input
  DC - 200 ns instruction cycle
- 1024 words of program memory
- 68 bytes of Data RAM
- 64 bytes of Data EEPROM
- 14-bit wide instruction words
- 8-bit wide data bytes
- 15 Special Function Hardware registers
- Eight-level deep hardware stack
- Direct, indirect and relative addressing modes
- Four interrupt sources:
  - External RB0/INT pin
  - TMR0 timer overflow
  - PORTB<7:4> interrupt-on-change
  - Data EEPROM write complete

Peripheral Features:

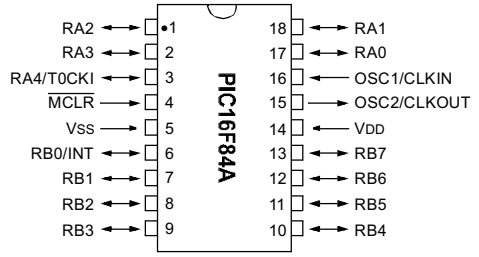
- 13 I/O pins with individual direction control
- High current sink/source for direct LED drive
  - 25 mA sink max. per pin
  - 25 mA source max. per pin
- TMR0: 8-bit timer/counter with 8-bit programmable prescaler

Special Microcontroller Features:

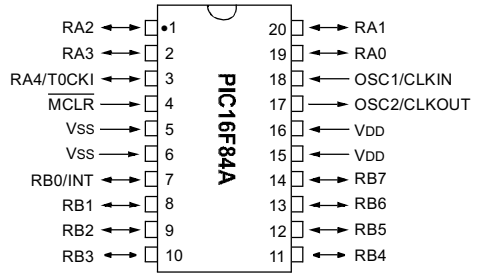
- 10,000 erase/write cycles *Enhanced* FLASH Program memory typical
- 10,000,000 typical erase/write cycles EEPROM Data memory typical
- EEPROM Data Retention > 40 years
- In-Circuit Serial Programming™ (ICSP™) - via two pins
- Power-on Reset (POR), Power-up Timer (PWRT), Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own On-Chip RC Oscillator for reliable operation
- Code protection
- Power saving SLEEP mode
- Selectable oscillator options

Pin Diagrams

PDIP, SOIC



SSOP



CMOS Enhanced FLASH/EEPROM Technology:

- Low power, high speed technology
- Fully static design
- Wide operating voltage range:
  - Commercial: 2.0V to 5.5V
  - Industrial: 2.0V to 5.5V
- Low power consumption:
  - < 2 mA typical @ 5V, 4 MHz
  - 15 µA typical @ 2V, 32 kHz
  - < 0.5 µA typical standby current @ 2V

PIC16F84A

Table of Contents

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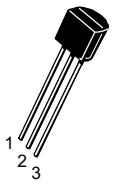
PNP Silicon

BC327,
BC327-16,
BC327-25,
BC327-40



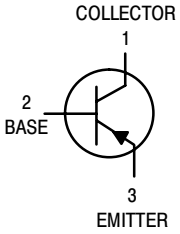
CASE 29–11, STYLE 17
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	BC327	Unit
Collector–Emitter Voltage	V_{CEO}	–45	Vdc
Collector–Base Voltage	V_{CBO}	–50	Vdc
Emitter–Base Voltage	V_{EBO}	–5.0	Vdc
Collector Current – Continuous	I_C	–800	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = –10 mA, I_B = 0)	$V_{(BR)CEO}$	–45	–	–	Vdc
Collector–Emitter Breakdown Voltage (I_C = –100 μA, I_E = 0)	$V_{(BR)CES}$	–50	–	–	Vdc
Emitter–Base Breakdown Voltage (I_E = –10 μA, I_C = 0)	$V_{(BR)EBO}$	–5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = –30 V, I_E = 0)	I_{CBO}	–	–	–100	nAdc
Collector Cutoff Current (V_{CE} = –45 V, V_{BE} = 0)	I_{CES}	–	–	–100	nAdc
Emitter Cutoff Current (V_{EB} = –4.0 V, I_C = 0)	I_{EBO}	–	–	–100	nAdc

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Continued)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = –100 mA, V_{CE} = –1.0 V)	BC327		100	–	630	
	BC327–16		100	–	250	
	BC327–25		160	–	400	
	BC327–40		250	–	630	
(I_C = –300 mA, V_{CE} = –1.0 V)			40	–	–	
Base–Emitter On Voltage (I_C = –300 mA, V_{CE} = –1.0 V)		$V_{BE(on)}$	–	–	–1.2	Vdc
Collector–Emitter Saturation Voltage (I_C = –500 mA, I_B = –50 mA)		$V_{CE(sat)}$	–	–	–0.7	Vdc
SMALL–SIGNAL CHARACTERISTICS						
Output Capacitance (V_{CB} = –10 V, I_E = 0, f = 1.0 MHz)		C_{ob}	–	11	–	pF
Current–Gain – Bandwidth Product (I_C = –10 mA, V_{CE} = –5.0 V, f = 100 MHz)		f_T	–	260	–	MHz

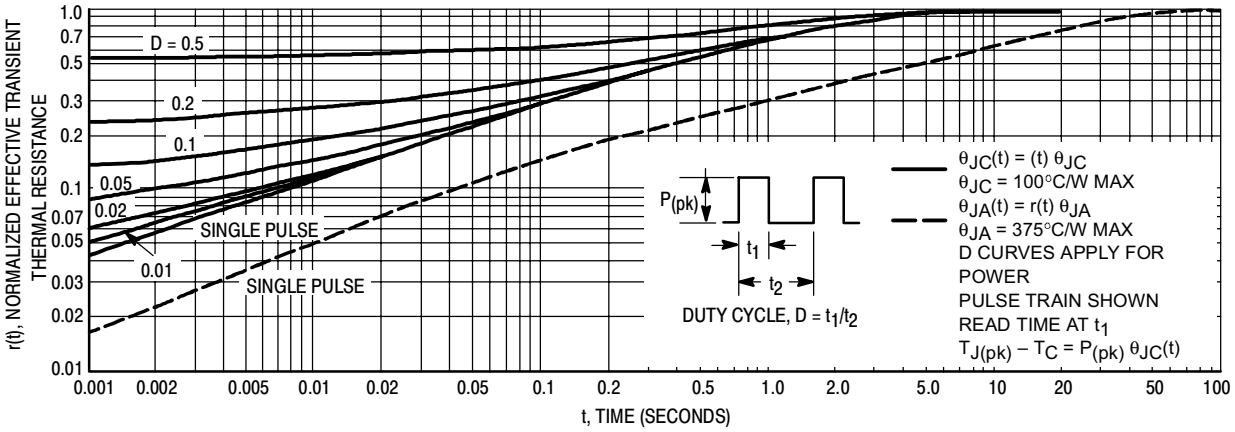


Figure 1. Thermal Response

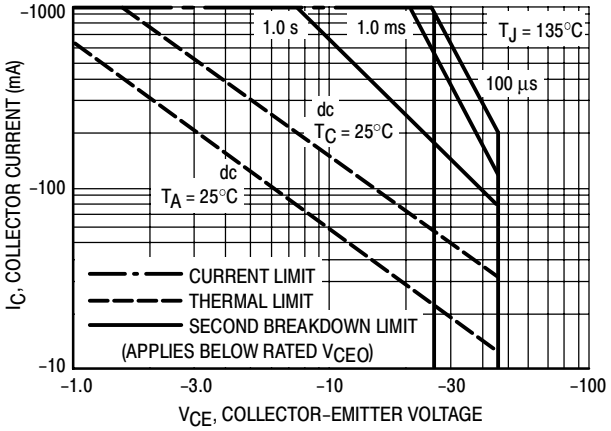


Figure 2. Active Region – Safe Operating Area

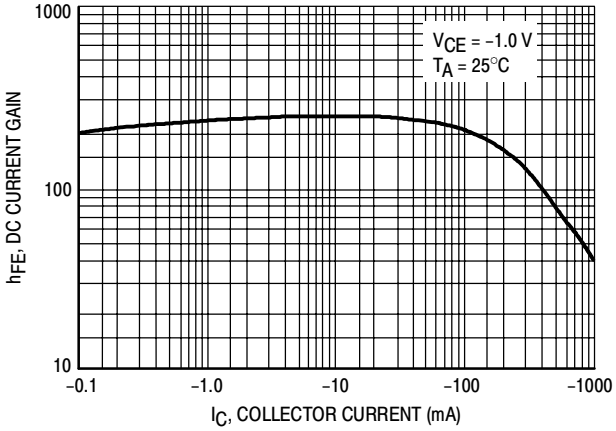


Figure 3. DC Current Gain

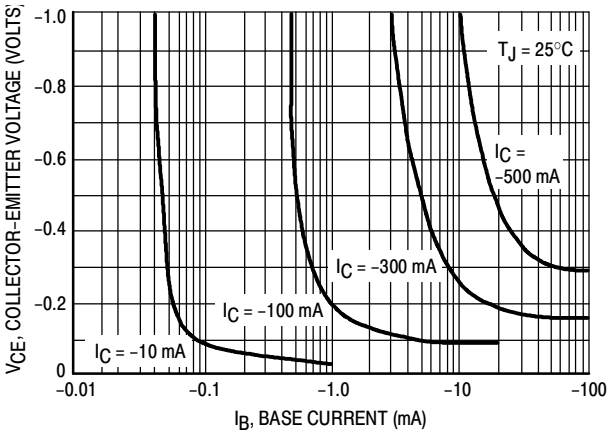


Figure 4. Saturation Region

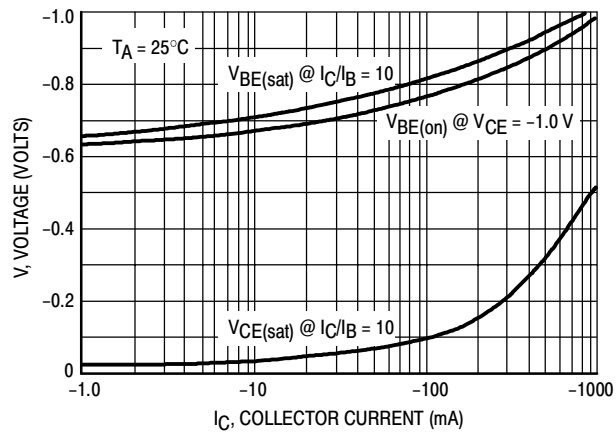


Figure 5. “On” Voltages

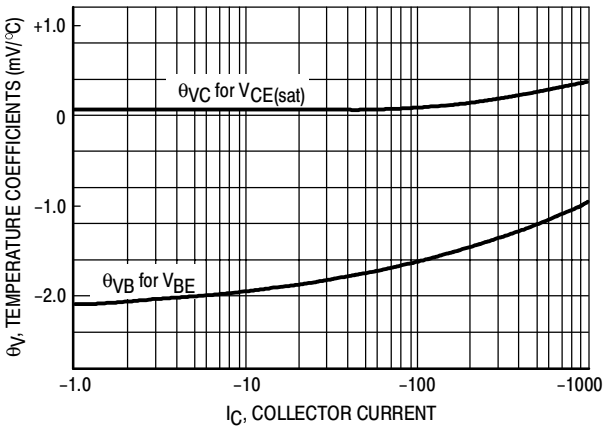


Figure 6. Temperature Coefficients

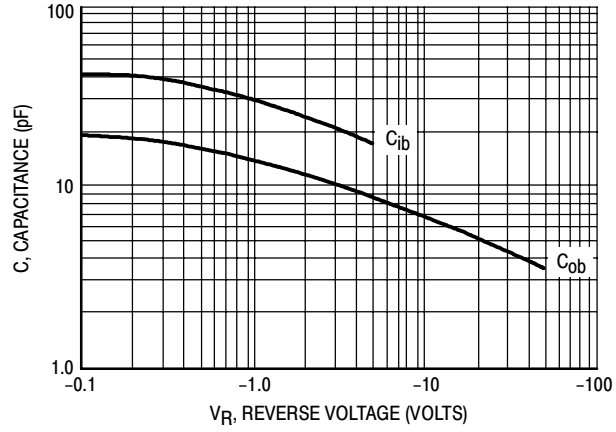
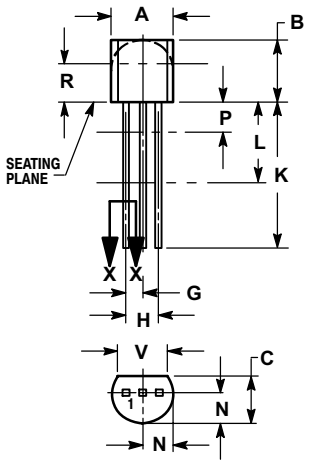
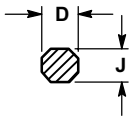


Figure 7. Capacitances

PACKAGE DIMENSIONS

TO–92 (TO–226)
CASE 29–11
ISSUE AL





SECTION X–X

STYLE 17:
PIN 1. COLLECTOR
2. BASE
3. EMITTER

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. CONTOUR OF PACKAGE BEYOND DIMENSION R IS UNCONTROLLED.
4. LEAD DIMENSION IS UNCONTROLLED IN P AND BEYOND DIMENSION K MINIMUM.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.175	0.205	4.45	5.20
B	0.170	0.210	4.32	5.33
C	0.125	0.165	3.18	4.19
D	0.016	0.021	0.407	0.533
G	0.045	0.055	1.15	1.39
H	0.095	0.105	2.42	2.66
J	0.015	0.020	0.39	0.50
K	0.500	---	12.70	---
L	0.250	---	6.35	---
N	0.080	0.105	2.04	2.66
P	---	0.100	---	2.54
R	0.115	---	2.93	---
V	0.135	---	3.43	---

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