



Sudan University of Science and Technology



College of Engineering

Department of Biomedical Engineering

A project submitted in partial fulfillment for the Degree of B.Sc.
in Biomedical Engineering

Project title:

Design of Digital Heart Rate Meter

تصميم دائرة إلكترونية لقياس معدل نبضات القلب

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الآية

قال تعالى :

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

﴿الَّذِينَ آمَنُوا وَتَطْمَئِنُّ قُلُوبُهُمْ بِذِكْرِ اللَّهِ أَلَا بِذِكْرِ اللَّهِ

تَطْمَئِنُّ الْقُلُوبُ﴾

صدق الله العظيم

سورة الرعد ﴿28﴾

DEDICATION

TO OUR PARENTS...

TO OUR BROTHERS AND SISTERS..

WITH MORE WARM HAPPINESS..

FEELING AND WONDERFUL MEMORIES

WE WOULD LIKE TO DEDICATED THIS RESEARCH

TO OUR FAMILIES, AND FRIENDS...

TEACHERS AND COLLEAGUE...

ACKNOELEGMENT

Our greater thanks to ALLAH for giving us hopes and determination to carry on light our way and blessed our steps.

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Abstract

The heart rate meter is medical device used to measuring the number of heartbeats per unit of time, usually expressed as beats per minute (bpm). .heart related diseases are increasing day by day, the need for an accurate and affordable heart rate measuring device or heart monitor is essential to ensure quality of health. However, most heart rate measuring tools and environments are expensive and do not follow comfortable.

This project has been a new integrated, simple and portable device to provide a monitoring heart rate at the fingertip by using optical sensor .the implementation of the heart monitor involves low cost amplifier and filter components coupled with a microcontroller to count the heart for duration of fifteen seconds and displays the information"HR" on digital display unit.

The circuit is tested by simulation program then designed practically and Result is obtained.

المستخلص

جهاز قياس معدل ضربات القلب هو جهاز طبي يستخدم لقياس عدد نبضات القلب في وحدة الزمن .

أمراض القلب في زيادة يومية فالحاجة إلى جهاز لقياس النبضات القلبية مهم لضمان الصحة .

هذا المشروع مصمم ليكون متكامل وبسيط وسهل النقل لقياس النقل لقياس معدل ضربات القلب من خلال أصابع اليد عبر حساس ضوئي , تصميم الجهاز يعتمد على مكبرات ومرشحات أقل تكلفة مرتبطة بمتحكم دقيق (ميكروكنترولر) لقياس النبضات في 15 ثانية وعرض النتيجة في شاشة عرض رقمية.

تم اختبار الدائرة باستخدام برنامج محاكاة وصممت عمليا و تم عرض النتائج.

Abbreviations:

AC: alternative current

Bpm: beat per minuets

C: capacitor

DC: direct current

ECG: electrocardiogram

F: frequency

HRM: heart rate meter

Hz: hertz

IIRx: infrared receiver

IR: infrared

IRTx: infrared transimeter

K Ω : killo-ohm

LCD: liquid crystal display

LED: light emitting diode

μ F: micro farad

Mv: milli volt

nf: nano farad

OP-Amps: operation amplifiers

OTP:one time programble

PCG: Phonocardiogra

R: resistance

RAM: random access memory

RF: radio frequency

ROM: read only memory

UK: united Kingdom

V: volt

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Chapter One

Introduction

1.1 General reviews:

Heart rate is the number of heartbeats per unit of time, typically expressed as beats per minute (bpm). Heart rate can vary as the body's need to absorb oxygen and excrete carbon dioxide changes during exercise or sleep. The measurement of heart rate is used by medical professionals to assist in the diagnosis and tracking of medical conditions. It is also used by individuals, such as athletes, who are interested in monitoring their heart rate to acquire maximum efficiency.

Changes in lifestyle and unhealthy eating habits have resulted in a dramatic increase in incidents of heart and vascular diseases. The heart rate rises gradually during exercises and returns slowly to the rest value after exercise. The rate when the pulse returns to normal is an indication of the fitness of the person. Lower than normal heart rates are usually an indication of a condition known as bradycardia, while higher than normal heart rates are known as tachycardia.

Furthermore, heart problems are being increasingly diagnosed on younger patients. Worldwide, Coronary heart disease is now the leading cause of death. Thus, any improvements in the diagnosis and treatment tools are welcomed by the medical community. In a clinical environment, heart rate is measured under controlled conditions like blood measurement heart beat measurement and Electrocardiogram.

However there is a great need that patients are able to measure the heart rate in the home environment as well [1]

A heart rate monitor is a simple device that takes a sample of the heartbeat signal and computes the bpm so that the information can easily be used to track heart conditions. The HRM devices employ electrical and

optical methods as means of detecting and acquiring heart signals. Heartbeat rate is one of the very important parameters of the cardiovascular system. Normal heart rate of a resting person is about 70 bpm for adult males and 75 bpm for adult females.

Athletes normally have lower heart rates than less active people. Babies have a much higher heart rate at around 120 bpm, while older children have heart rates at around 90 bpm [2].

1.2 Significant of study:

The design of heart rate meter will provide fast and accurate reading about heart status; because of its portable size our design can be used at home or the clinic or any desired location to monitor heart rate. Under the time constraints we will only be able to produce prototype meeting the general constrains above.

Many features could be added such as wireless monitoring ECG technology and alarm features.

Monitoring one's heart rate is useful not only for patient but also for normal persons including athletes in order to observe the heart rate variations due to stress, exercise and concentration.

For persons with illness of course the heart rate gives a good indication of the intensity and the stress on the heart as well.

1.3 Problem statement:

Heart rate measurement is one of the very important parameters of the human cardiovascular system. Heart rate is simply and traditionally measured by placing the thumb over the subject's arterial pulsation and feeling timing and counting the pulses usually in a 15 second period. This method although simple, is not accurate and can give errors when the rate is high. More sophisticated methods to measure the heart rate utilize

electronic techniques include with designed to measure the heart rate, blood pressure, and temperature of the subject “patient monitor”.

1.4 Objective:

The objectives of this research are divided into general objective and specific objectives.

1.4.1 General objective:

The main purpose of this research is to design a heart rate meter that measure heart rate in real time with high accuracy which support healthcare physicians in decision making.

1.4.2 Specific objective:

1. Design sensor circuit that pick up signal.
2. Design processing circuit to boost the weak signal coming from sensor unit and convert it into a pulse.
3. Design control circuit.
4. Display unit.

1.5 Methodology:

Heart rate measurement indicates the heart beats of the human cardiovascular system. This project demonstrates technique to measure the heart rate by sensing the change in blood volume in finger artery while the heart is pumping the blood.

It consists of an infrared LED that transmits an IR signal through the fingertip of the subject a part of which is reflected by the blood cells. The reflected signal is detected by a photodiode sensor. The changing blood volume with heart beat results in a train of pulses at the output of the photodiode the magnitude of which is too small to be detected directly by microcontroller; therefore a multi-stages high gain active low pass filter is designed using two Operational Amplifiers (Op Amps) to filter and

amplify the signal to appropriate voltage levels that the pulses can be counted by the microcontroller (PIC16F877A). Finally the detected heart rate was displayed on LCD.

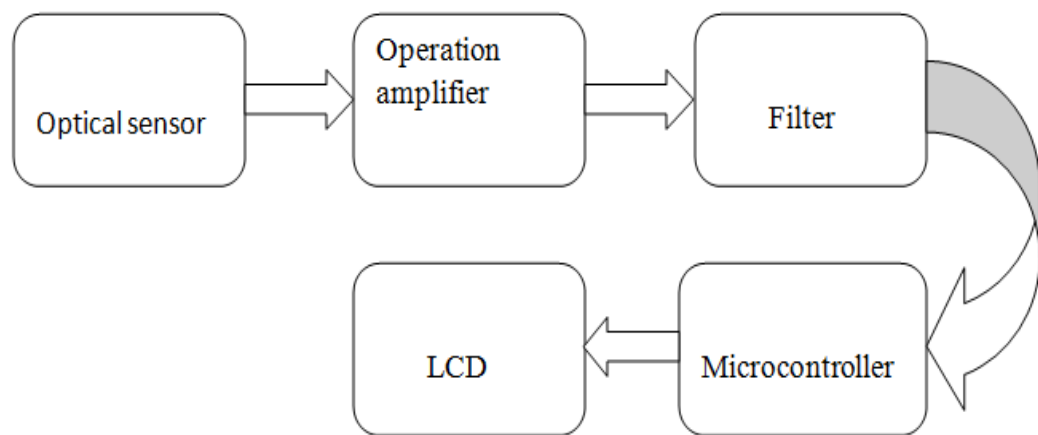


Figure1.1:general block diagram of digital heart rate meter

1.6 Thesis Layout:

This research consists of five chapters:

Chapter one is an introduction, Chapter two deals of theoretical background and discusses the related literature reviews, chapter three include the methodology, the design and implementation of digital heart rate meter was explained in chapter four. The results and discussion were illustrated in chapter five.

Finally Conclusions and recommendations presented in chapter six.

Chapter Two

Literature review

Heart rate is simply and traditional indicates the soundness of our heart and helps assessing the condition of cardiovascular system that measured by placing the thumb over the subject's arterial pulsation (typically on the wrist or the neck), and feeling or listening; to heartbeats using a stethoscope, timing and counting the pulses usually in a 30 second period. Heart rate (bpm) of the subject is then found by multiplying the obtained number by 2. This method although simple, is not accurate and can give errors when the rate is high. More sophisticated methods to measure the heart rate utilize electronic techniques. Electro-cardiogram (ECG) is one of frequently used and accurate methods for measuring the heart rate. ECG is an expensive device and its use for the measurement of the heart rate only is not economical. Low-cost devices in the form of wrist watches are also available for the instantaneous measurement of the heart rate. Such devices can give accurate measurements but their cost is usually in excess of several hundred dollars, making them uneconomical. Most hospitals and clinics in the UK use integrated devices designed to measure the heart rate, blood pressure, and temperature of the subject. Although such devices are useful their cost is usually high and beyond the reach of individuals [1].

2.1 Design and implementation of ECG monitoring and heart rate measurement system :

This paper describes the design of a simple 3-lead Electrocardiogram (ECG) monitoring and heart rate measurement system with LCD output. The system takes the physical pulse input using Ag/Cl sticking electrodes stuck to the arms and right leg of the patient under observation. The model encompasses of instrumentation amplifier and filter circuits etc, which are used for signal conditioning of the pulse input from the

patient's body and displayed on CRO as the ECG waveform. Thus conditioned signal is also processed by the microcontroller AT89S52 to count the heart for duration of one minute and displays the information on LCD display[3].

2.2 Development of a device for remote monitoring of heart rate and body temperature :

this paper was presented a new integrated, portable device to provide a convenient solution for remote monitoring heart rate at the fingertip and body temperature using Ethernet technology and widely spreading internet. Now a day, heart related disease is rising. Most of the times in these cases, patients may not realize their actual conditions and even it is a common fact that there are no doctors by their side, especially in rural areas, but now a day's most of the diseases are curable if detected in time. We have tried to make a system which may give information about one's physical condition and help him/her to detect these deadly but curable diseases. The system gives information of heart rate and body temperature simultaneously acquired on the portable side in real-time and transmits results to web. In this system, the condition of heart and body temperature can be monitored from remote places. Eventually, this device provides a low-cost, easily accessible human health monitor solution bridging the gaps between patients and doctors[2].

2.3 Heart rate monitor :

The aim of this project is to implement an ECG and Digital Heart Rate counter. The main challenges include amplifying the desired weak signal in the presence of noise from other muscles and electrical sources. A display of the heart rate will be obtained by measuring the time between signal peaks and then calculating the frequency of the peaks in units of beats per minute.

The device is most useful if it is portable. This requires a battery to be able to power all of the necessary components as well as the power output of the battery to be regulated.

The implementation of the heart monitor involves low cost amplifier and filter components coupled with a sophisticated microcontroller and LCD screen.

Results were successful for the amplifier filter stage of the implementation with an ECG successfully detected and recorded but variability of the voltage points complicated the calculation and display of the actual rate.[4]

2.4 Heart rate measurement from the finger using a low-cost microcontroller :

This paper describes the design of a simple, low-cost microcontroller based heart rate measuring device with LCD output. Heart rate of the subject is measured from the finger using optical sensors and the rate is then averaged and displayed on a text based LCD.(using pic16f84 microcontroller)[1].

2.5 Design and development of a heart rate measuring device using fingertip:

In this paper, we presented the design and development of a new integrated device for measuring heart rate using fingertip to improve estimating the heart rate. As heart related diseases are increasing day by day, the need for an accurate and affordable heart rate measuring device or heart monitor is essential to ensure quality of health. However, most heart rate measuring tools and environments are expensive and do not follow ergonomics. Our proposed Heart Rate Measuring (HRM) device is economical and user friendly and uses optical technology to detect the flow of blood through index finger. Three phases are used to detect pulses on the fingertip that include pulse detection, signal extraction, and pulse amplification. Qualitative and quantitative performance evaluation of the device on real signals shows accuracy in heart rate estimation, even under intense of physical activity. We compared the performance of HRM device with Electrocardiogram reports and manual pulse measurement of heartbeat of 90 human subjects of different ages. The results showed that the error rate of the device is negligible.(using LDR detector)[5].

2.6 Microcontroller based heart rate monitor:

This paper describes the development of a heart rate monitor system based on a microcontroller. It offers the advantage of portability over tape-based recording systems. The paper explains how a single-chip

microcontroller can be used to analyse heart beat rate signals in real-time. In addition, it allows doctors to get the heart beat rate file of the patient by e- mail every twenty four hours. It can also be used to control patients or athletic person over a long period. The system reads, stores and analyses the heart beat rate signals repetitively in real-time. The hardware and software design are oriented towards a single-chip microcontroller-based system, hence minimizing the size. The important feature of this paper is use of zero crossing algorithm to compute heart rate. It then processes on real-time the information to determine some heart diseases[6].

Chapter Three

Theoretical Background

3.1 The human heart:-

The heart is a muscular organ that acts like a pump to continuously send blood throughout your body. The heart is at the centre of the circulatory system this system consists of a network of blood vessels such as arteries, veins, and Capillaries. These blood vessels carry blood to and from all areas of the body.

An electrical system regulates the heart and uses electrical signals to contract the Heart's walls. When the walls contract blood is pumped into the circulatory system. A system of inlet and outlet valves in the heart chambers work to ensure that blood flows in the right direction.

The heart is vital to your health and nearly everything that goes on in the body without the heart's pumping action, blood can't circulate within the body.

Blood carries the oxygen and nutrients that your organs need to work normally. Blood also carries Carbon dioxide, a waste product to your lungs to be passed out of the body and into the air. Healthy heart supplies the areas of the body with the right amount of blood at the rate needed to work normally. If disease or injury weakens the heart the body's organs won't receive enough blood to work normally.

3.2 The chambers of the hearts:

The heart is made up of four chambers. The superior chamber consists of the right atrium and the left atrium, which lie primarily on the posterior side of the heart. Extending interiorly from each thin walled atrium is a small, ear-shaped appendage called auricle that expands the volume of the chamber.

Blood drains into the atria from the pulmonary and systemic circulatory system, composing the lower chambers are the right ventricle and left ventricle; which are much larger than the atria. The right ventricle pumps blood through the pulmonary circulatory system and the thicker walled left ventricle pumps blood through the longer systemic circulatory system. Internally the two ventricles are separated by a thick myocardial wall called the inter ventricular septum. On the anterior surface of the heart, the inter ventricular septum is marked by a shallow diagonal groove known as the anterior inter ventricular sulcus (or groove) which is occupied the anterior inter ventricular artery great cardiac vein and adipose tissue. On the posterior surface of the heart, the ventricles are separated by the posterior inter ventricular sulcus which contains the posterior interior artery, middle cardiac vein and adipose tissue.

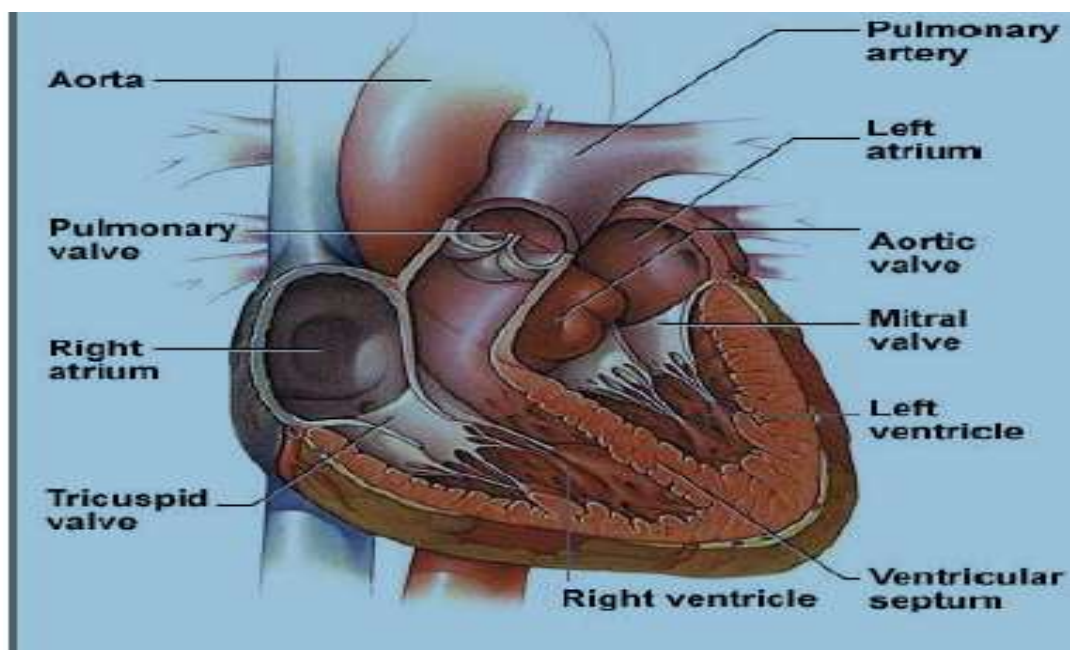


Figure3.1 Anatomy of the heart and associated valve

3.3 Pumping Mechanism of the Heart:

The heart muscle has two stages, diastole and systole. Diastole is the state of relaxation and systole is the state of contraction. Blood from the body enters the right atrium through the inferior and superior vena cava. Blood from the lungs enter the left atrium through the pulmonary vein. The heart beat is initiated and maintained by special muscle cells known collectively as the pace maker or senatorial node. The pace maker is ideally placed in the muscle of the right atrium. The pacemaker sends a wave of excitation through the muscles of the right atrium and to the muscles of the left atrium. The excitation results in the contraction of both atria (plural for atrium) at the same time resulting in blood rushing across the tricuspid and bicuspid valves into the right and left ventricles. The wave of excitation travels across the bundle of his in the septum. The wave of excitation then reaches the ventricles which cause contraction at the same time. The tricuspid and bicuspid valves are both closed during contraction of the ventricles causing blood having reached the ventricles, to be forced into the aorta from the left ventricle, and into the pulmonary artery from the right ventricle [7].

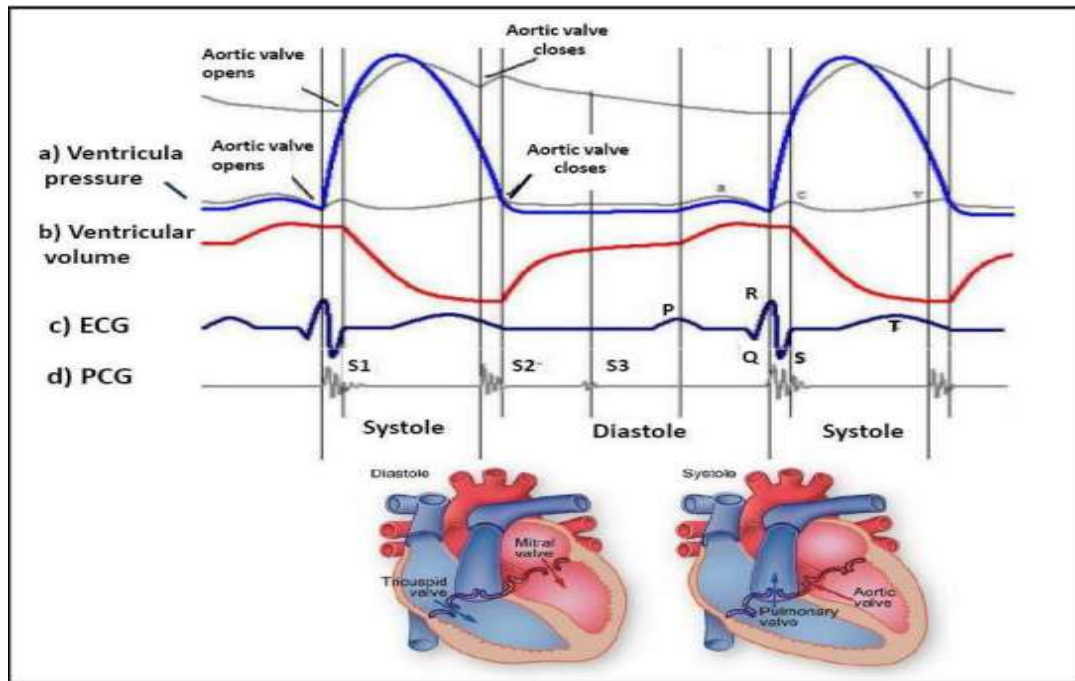


Figure 3.2 Signals of Cardiac Cycle (A) Ventricular Pressure (B) Ventricular Volume (C) ECG and (D) PCG (Heart Sounds)

3.4 The heart rate:

Heart rate or heart pulse is the speed of the heartbeat measured by the number of poundings of the heart per unit of time — typically beats per minute (bpm). The heart rate can vary according to the body's physical needs, including the need to absorb oxygen and excrete carbon dioxide. Activities that can provoke change include physical exercise, sleep, anxiety, stress, illness, ingesting, and drugs.

The normal resting adult human heart rate ranges from 60–100 bpm. Tachycardia is a fast heart rate, defined as above 100 bpm at rest. Bradycardia is a slow heart rate, defined as below 60 bpm at rest. During sleep a slow heartbeat with rates around 40–50 BPM is common and is considered normal. When the heart is not beating in a regular

pattern, this is referred to as an arrhythmia. These abnormalities of heart rate sometimes indicate disease.

3.5 Behavior of blood flow during a heart beat:

The contraction and relaxation of cardiac muscles causes blood to flow in and out of the heart. During each cardiac cycle, a group of tissues in the heart called the sinoatrial node generates electrical impulses that spread through the heart and cause rhythmic contraction and relaxation of heart muscles. During each cardiac cycle, the blood vessels pulsate in order to carry blood to/from different parts of the human body.

The general places used to measure heart rate are inside the elbow, ventral part of wrist, neck, behind the knee “popliteal artery” and chest “where a stethoscope is usually used”.

Heart rate monitoring machines are designed so as to measure the heart beat at these spots. However, these machines turn out to be bulky and difficult to carry as the methodology used to monitor the heart rate at these spots involves complex process [8].

Chapter Four

Methodology

4.1 Introduction:

This chapter discusses the design of heart rate meter used to measure heart beats and display the measuring results on LCD.

4.2 Elements of system design:

The designed system used to measure heart beats is basically consisting of:

1. Optical Sensor
2. Operation amplifier
3. Filter
4. Microcontroller
5. LCD

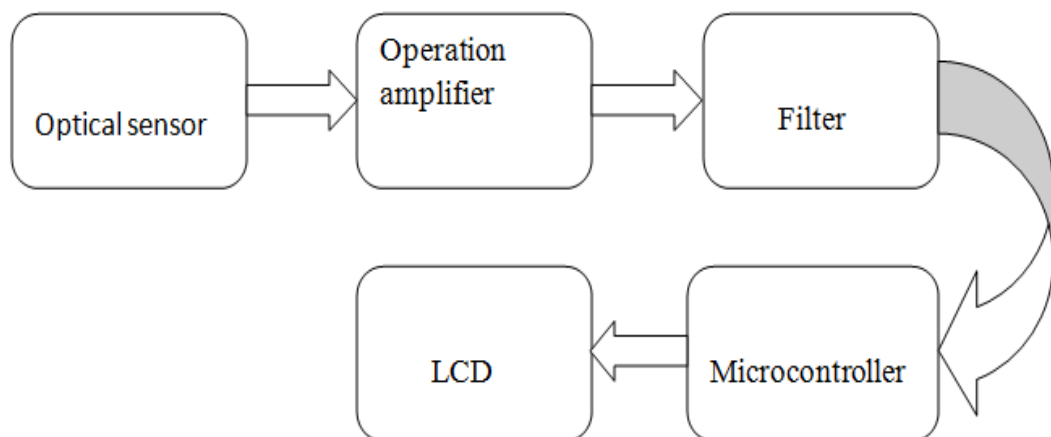


Figure4.1 : general block diagram of digital heart rate meter

4.2.1 Optical sensor:

Is a device use to measure the heart beats and convert them to an electrical signals the monitoring system uses an optical sensor to measure the alteration in blood volume at the fingertip with each heart beat. The sensor unit consists of an infrared light-emitting-diode (IR. LED) and a photodiode placed side by side as shown below.

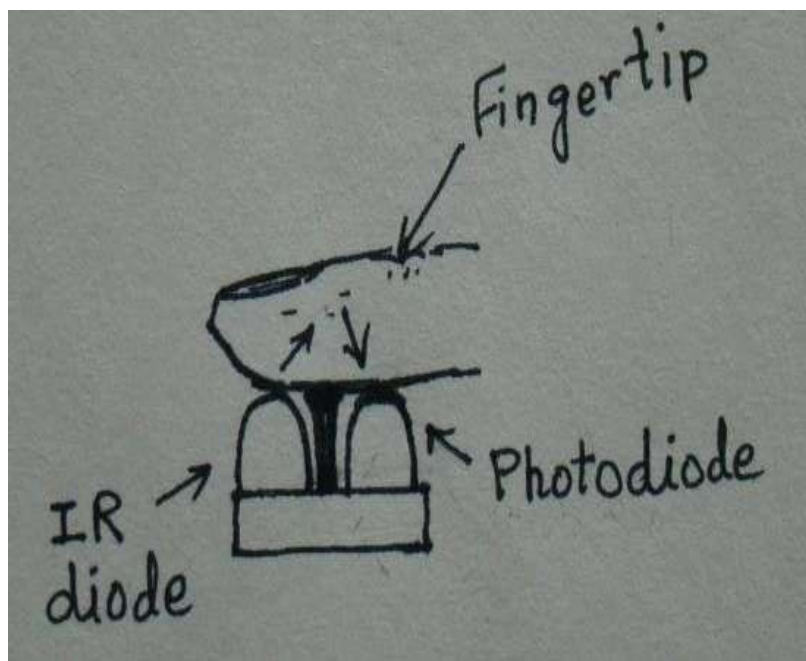


Figure 4.2: Electric Optical Sensor

4.2.2 Operational amplifier:

Operational amplifier is an electronic piece have high impedance at the input terminals (ideally infinite) and low output impedance (ideally zero) [9]. Operation amplifiers mostly used in signal conditioning stages to amplify and filter signal from noise.

Since heart beats are very week in amplitude and low in frequency, operation amplifier is used to amplify and filter heart beats.

The op-amp (LM358) was selected to amplify and filter heart rate signal due to the following specification.

LM358N has Internally Frequency Compensated for Unity Gain, Large DC Voltage Gain about 100dB, Wide Power Supply Range 3V~32V (or $\pm 1.5\text{V} \sim 16\text{V}$), Input Common Mode Voltage Range Includes Ground, Large Output Voltage Swing: 0V DC to $V_{cc} - 1.5\text{V}$ DC and Power Drain Suitable for Battery Operation.

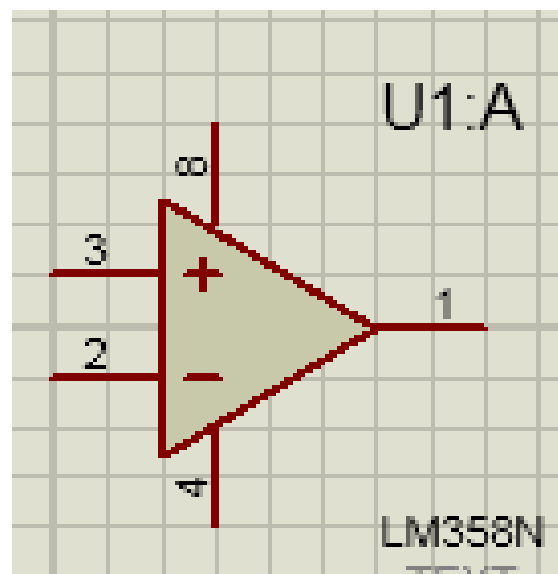


Figure 4.3: LM358 circuit diagram

4.2.3 Filter:

Electronic or active filters are electronic circuits which perform signal processing functions, specifically to remove unwanted frequency component from the signal [9].

The used filters are Low Pass that passes low-frequency signals and blocks high-frequency ones [10].

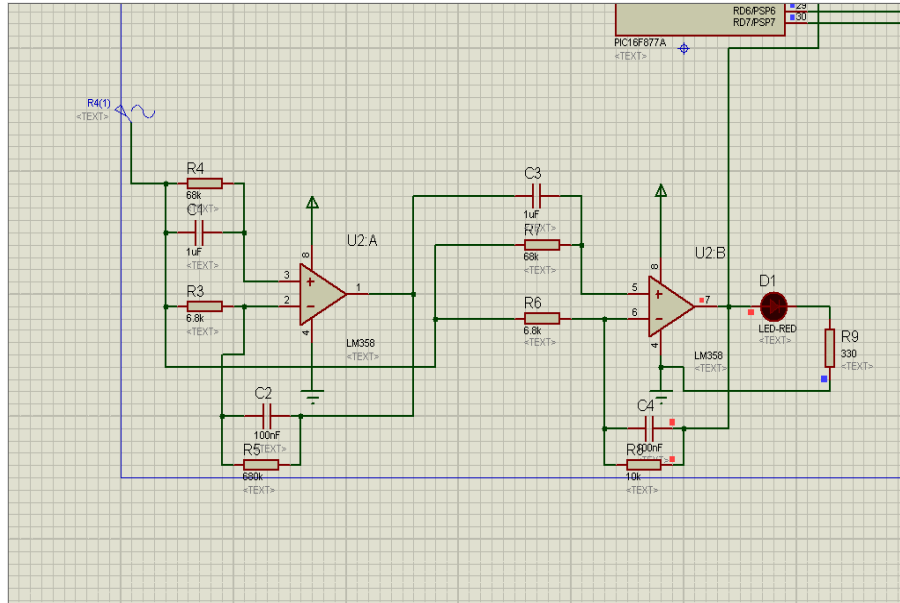


Figure 4.4: low pass filter with cut off frequency (2.34Hz).

4.2.4 Microcontroller:

Is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of ferroelectric RAM, NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications [11].

The used microcontroller is PIC16f877A it has 40 pins make it easier to use the peripherals as the functions are spread out over the pins. This makes it easier to decide what external devices to attach without worrying too much if there are enough pins to do the jobs.

One of the main advantages is that each pin is only shared between two or three functions so it's easier to decide what the pin function [12].

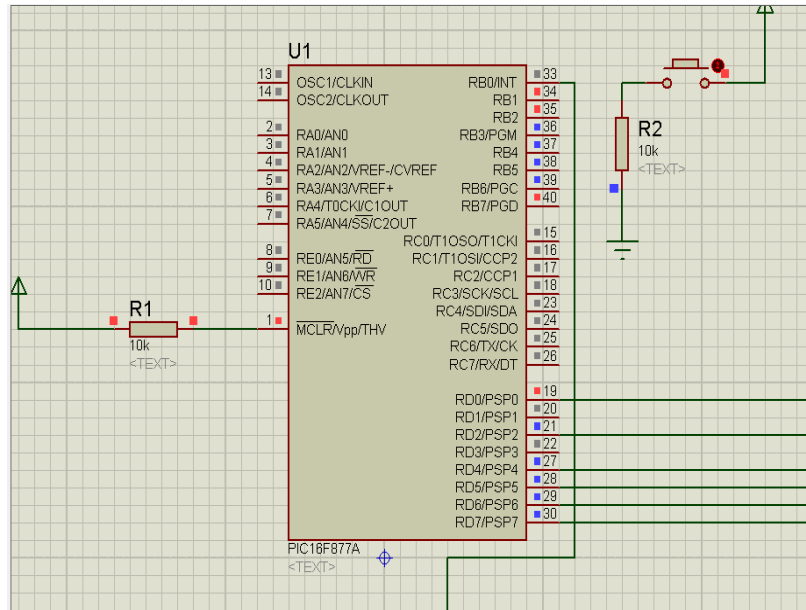


Figure 4.5: PIC 16F877A Microcontroller

4.2.5 LCD:

LCD screen is an electronic display module and find a wide range of application.

A 16x2 LCD display is very basic module and is very commonly used in various devices and circuit .these modules preferred over seven segments and other multi segment LEDs. The reasons being LCDs are economical; easily programmable, Have no limitation of displaying special & even custom characters (unlike in seven segment) animation and so on.

A 16x2 LCD mean it can display 16 characters per line and there are 2such lines.

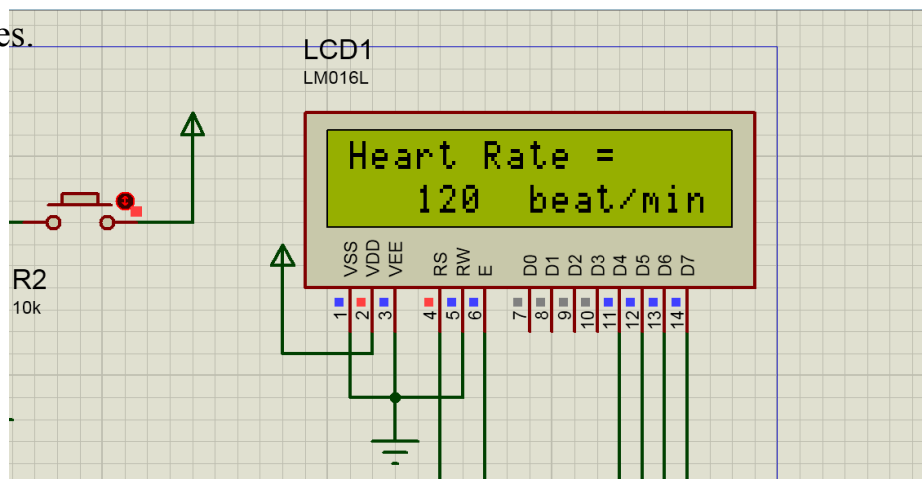


Figure 4.6: 16x2 LCD

4.3 The system design using simulation program:

The electrical output signal of the pulse generator connected to signal conditioning circuit .these signals are weak and noisy for that we used two operation amplifiers to amplify and filter the signals (cut off frequency 2.34Hz).

The amplified and filtered signals are connected to the microcontroller through RB0/INT which counts the pulse rate per minute and displaying it as digital values on LCD.

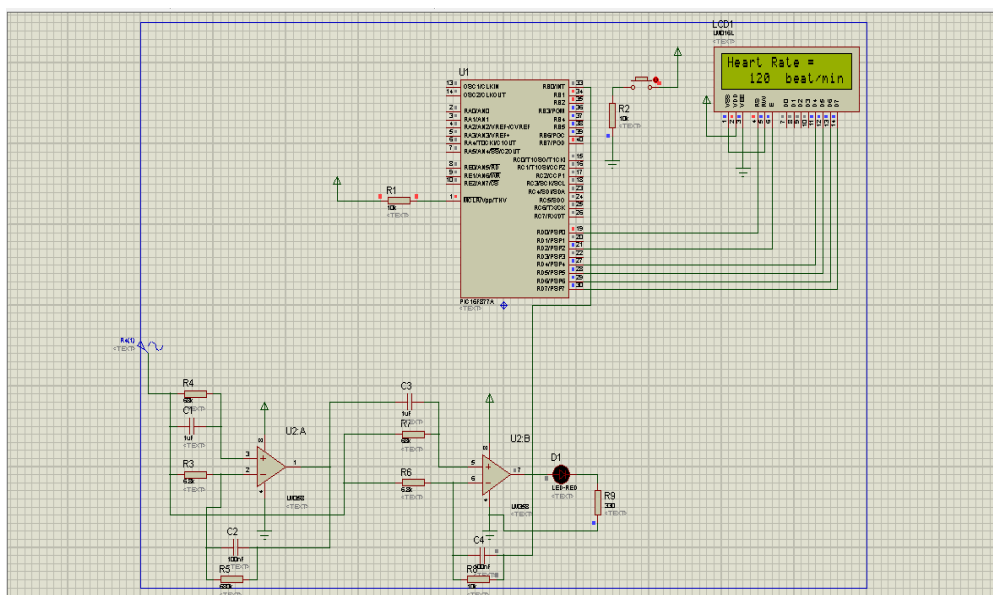


Figure 4.7: simulation circuit diagram of digital heart rate meter

Chapter Five

DESIGN AND IMPLEMENTATION

5.1 Introduction :

This chapter discusses the design and implement of a Digital heart rate meter circuit, which integrated into three phases (pick up the signal, signal conditioning and Display phase).

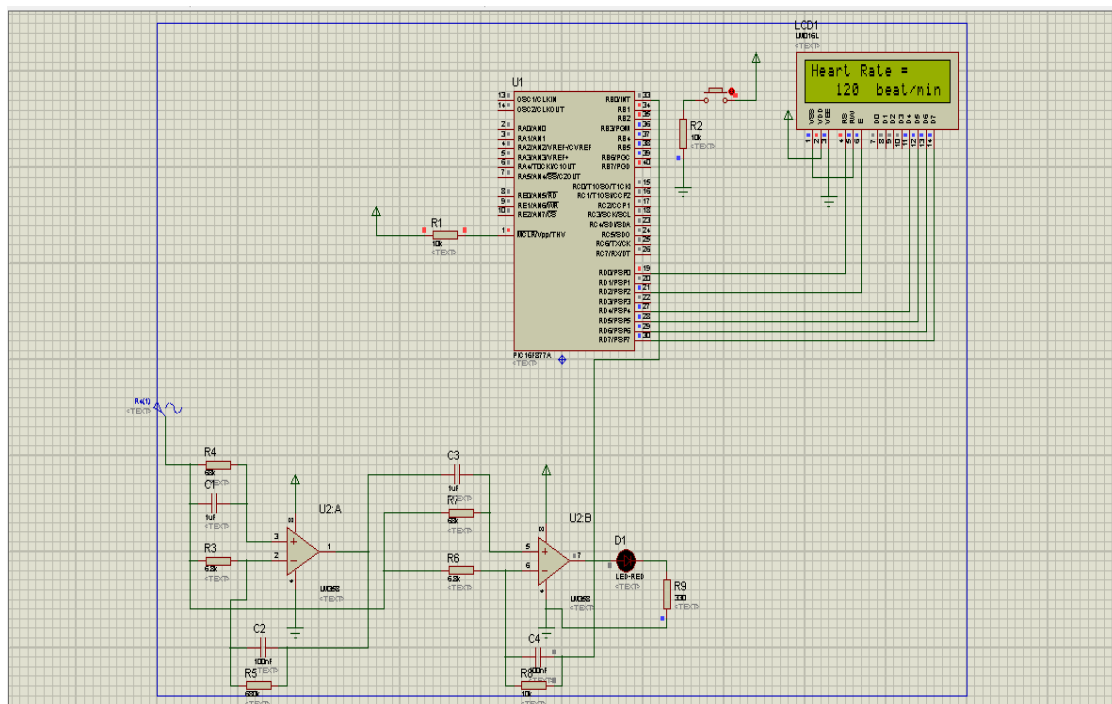


Figure 5.1: simulation circuit diagram of digital heart rate meter

5.2 pulse detection circuit:

Optical sensors have been used to measure the alteration in blood volume at fingertip with each heart beat. The sensor unit consists of an IRTx and IRRx placed side by. The IRTx transmits an infrared light into the fingertip (placed over the sensor unit). IRRx senses the portion of the light that is reflected back. The intensity of reflected light depends upon the blood volume inside the fingertip. So each heart beat slightly alters the amount of reflected infrared light that can be detected by the IRRx. With

a proper signal conditioning this little change in the amplitude of the reflected light can be converted into pulse. The more infrared light is received the less the voltage of the input point from the sensor part is produced. The IRRx picks an AC signal with some DC components; the DC components come up from non-pulsative tissues. Direct crosstalk between the IR transmitter and receiver is avoided though they are placed closely. A Resistor is connected to the Infrared receiver (IRRx) to reduce the current drawn by the detection system. If the intensity of IR light is too high then the reflected infrared light from the tissue will be sufficient enough to saturate the photo detecting diode all the time and no signal will exist. So the value of the resistance connected in series with the Infrared transmitter (IRTx) is chosen to limit the current and hence the intensity of the transmitted infrared light [13].

5.2.1 IRLED (transmitter) :

A light-emitting diode (LED) is a semiconductor device that emits visible light when an electric current passes through it. The light is not particularly bright but in most LEDs it is monochromatic occurring at a single wavelength [14].

Features of IRLEDs:

1. Low power requirement consume 0.33 watts: Most types can be operated with battery power supplies.
2. High efficiency; Most of the power supplied to an LED or IRED is converted into radiation in the desired form with minimal heat production.
3. Long life; when properly installed, an LED or IRED can function for decades.
4. Cannot break easily, don't like other lamp.
5. Low cost.

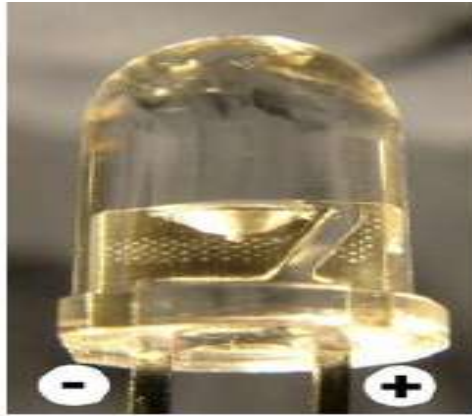


Figure 5.2: IR LED

5.2.2 Photodiode (receiver):

Photodiodes are semiconductor light sensors that generate a current or voltage when the P-N junction in the semiconductor is illuminated by light. The term photodiode can be broadly defined to include even solar batteries but it usually refers to sensors used to detect the intensity of light.

Features of photodiode; Excellent linearity with respect to incident light, Low noise, Wide spectral response, mechanically rugged, Compact and lightweight and Long life [15].

5.3 Signal conditioning circuit:

The signal conditioning circuit consists of two identical active low pass filters with a cut-off frequency of about 2.34 Hz. This means the maximum measurable heart rate is about 140 bpm. LM358 dual Opamp chip has been used in this circuit which operates at a single power supply. The filter blocks any higher frequency noises present in the signal. The two stage filter and amplifier converts weak signal coming from the photo sensor unit into a pulse. An LED connected at the output blinks every time indicating a heart beat is detected.

A small movement of finger causes high frequency noise. The pulse rate signal filtering is necessary to block any higher frequency noises present in the signal. The desired signal can be extracted from the noisy signal using a low pass filter. The equation for cut off frequency of the low pass filter is given below:

$$\text{cut off frequency} = 1 / 2\pi RC \dots\dots\dots (1)$$

Cut off frequency of the filter designed is 2.34 Hz. If not amplified the signal found from the filter circuit is found having amplitude in mV level. The signal must be amplified for understanding and counting pulse rate by the microcontroller. A two stage signal filter and amplifier circuit using LM358 OpAmp can be designed for this. This OpAmp is operated with 5 volts. The equation for gain of each stage of the low pass filter is given below:

$$\text{gain of each stage} = 1 + R_f / R_i \dots\dots\dots (2)$$

In the designed circuit, total gain is 10201. Values of R_F and R_I are 680 K Ω and 6.8 K Ω . The 1 μ F capacitors, which are connected in series to the inputs of each filter blocks the undesired DC components of the signal. The two 1 μ F capacitors must be able to stand some reverse bias, so they should be non polarized.

5.3.1 Filter calculation:

Using this equation to calculate the resistor and capacitor of the filter due to the cut off frequency of (2.34Hz)

$$F = 1/2\pi RC \dots\dots\dots (3)$$

Assume: R=680K-ohm

$$C = 1/2\pi * 680 * 10^3 * 2.34$$

$$C = 0.100007 \mu F$$

The available capacitor 100 nF that is used in the circuit.

5.4 Display circuit:

The following two images are port names taken from the datasheets of the

Microcontroller and LCD used. The table details the corresponding pin connections between these two elements. The order in which these were connected was chosen to preserve the bit order of the microprocessor.

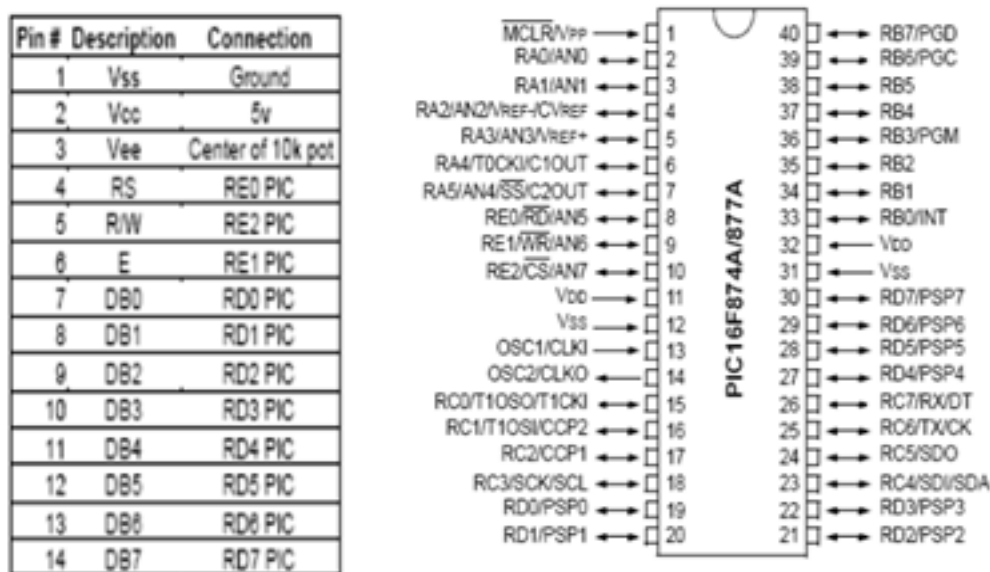


Figure5.3: Pins connections of LCD & Microcontroller

Table 5.1: Pins connections of LCD & Microcontroller:

Microcontroller pin#	LCD pin#
19	4
21	6
27	11
28	12
29	13
30	14

Pin 15 on the LCD is a contrast adjustment and will require a potentiometer attachment. Note that a 5V is required to power both the LCD and microcontroller, so a voltage regulator was added before the node where the tracks split off to power, the LCD pin 2 and the microcontroller pin 1,3,5 connected to ground and pin 33 was realized part way through the implementation stage that the output signal waveform from the amplification.

As a direct result of this, complete implementation of the display unit became

A real challenge as this relied on finding a variable voltage point.

The expected output of the LCD is "HEART RATE=-1 beat/min". This will update frequently as new calculations are made. A complete photographic view of the system can be seen in the appendix section.

5.5 Power supply unit:

The power supply unit is a regulated 5v supply powered from a 9 volts battery. The battery "cycle" is one complete discharge and recharge cycle. The battery powers the project through an LM7805 DC voltage regulator,

which keeps the output voltage supply constant. A voltage regulator has only three legs as shown below:

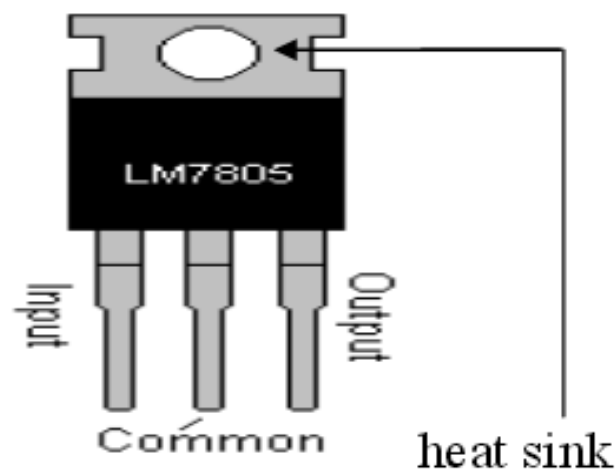


Figure 5.4: LM7805

This device appears to be comparatively simple device but it is actually a very complex integrated circuit. A regulator converts varying input voltage and produces a constant “Regulated” output voltage. Voltage regulators are available in a variety of output, typically 5 volts, 9 volts and 12 volts.

Chapter Six

Result and discussion

6.1 Results:

Electronic digital heart rate meter has been designed, implemented and successfully tested for measuring heart rate and display in digital form.

Measuring the pulse rate for four cases by digital heart rate meter.



Figure 6.1: the pulse rate displaying for the first case



Figure 6.2: the pulse rate displaying for the second case



Figure 6.3: the pulse rate displaying for the third case



Figure 6.4: the pulse rate displaying for the fourth case

Measuring the heart rate by practical circuit and compared it with the pulse Oximeter:

Case one:

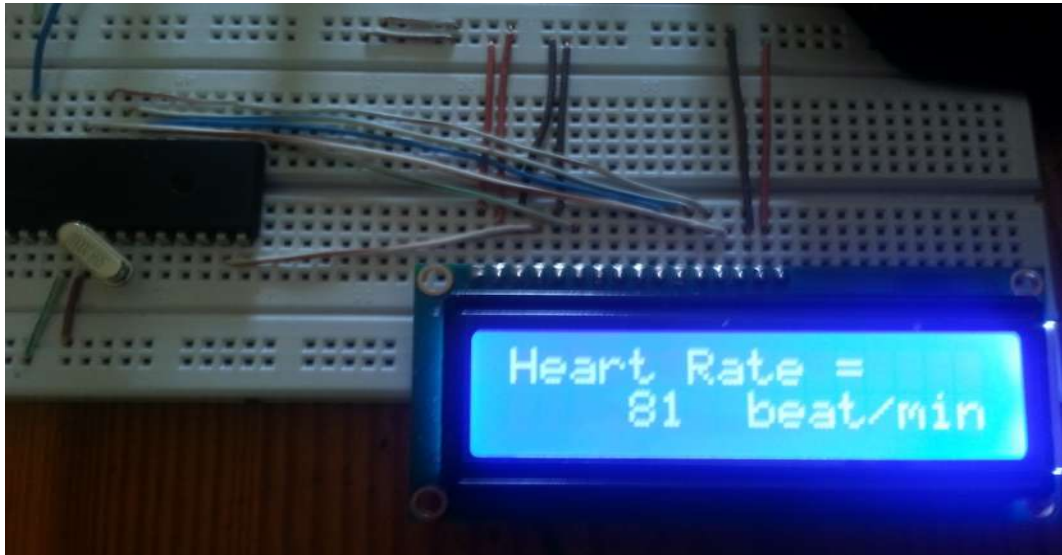


Figure 6.5: the pulse rate in practical circuit



Figure 6.6: the pulse rate in pulse Oximeter

Case two:



Figure 6.7: the pulse rate in practical circuit



Figure 6.8: the pulse rate in pulse Oximeter

6.2 Implementation circuit:

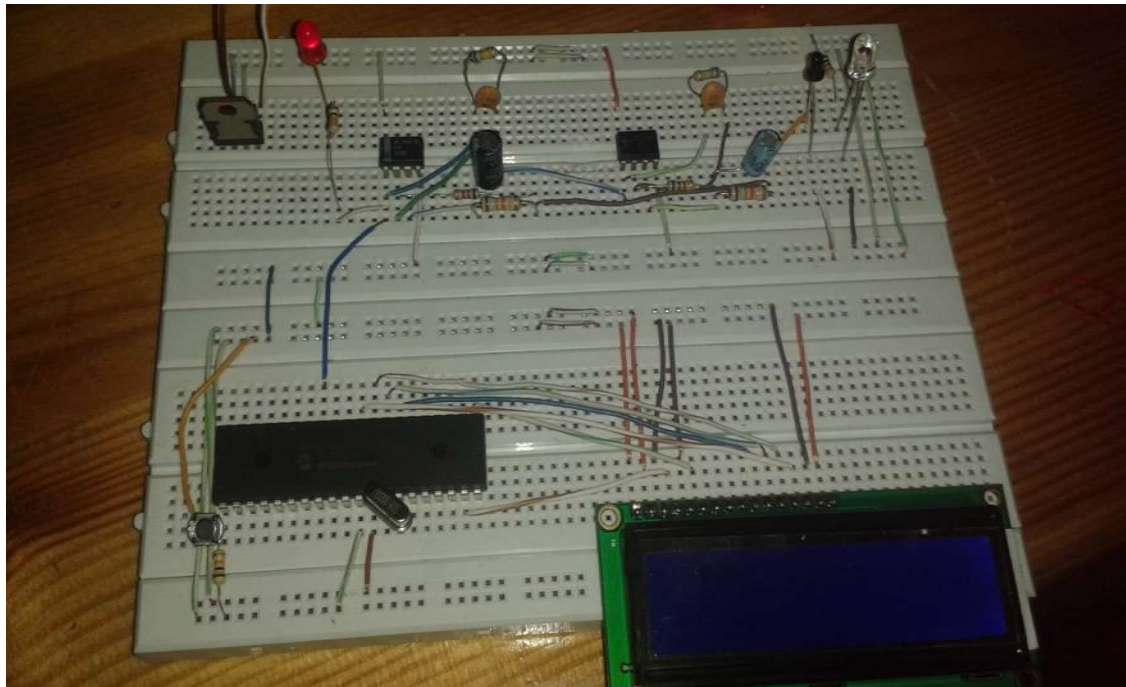


Figure 6.9: the hardware circuit of digital heart rate meter

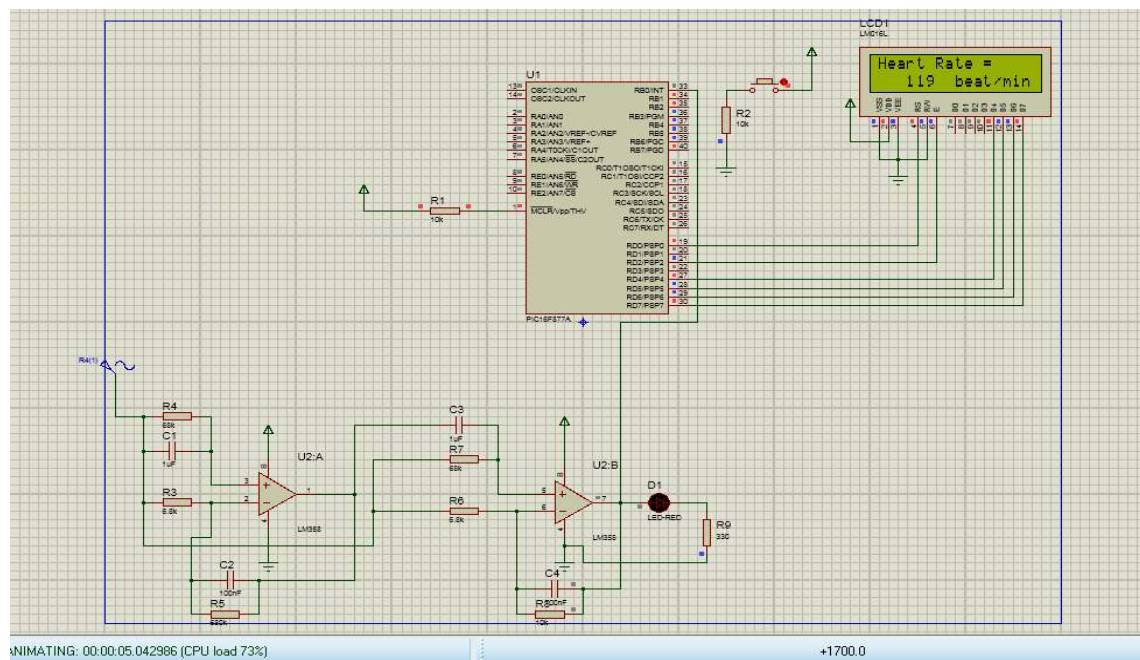


Figure 6.10: simulation circuit diagram of digital heart rate meter[16]

6.3 Discussion:

In this project the reading of heart beat in practical circuit not identical to the reading from pulse Oximeter because the output signal from practical circuit had large losses in information due to the wires used to connect each point in circuit to another, educational board have no protection from environment condition and the sensor covering is not appropriate .

Chapter Seven

CONCLUSIONS AND RECOMMENDATION

7.1 Conclusions:

A portable and simple heart rate measuring device has been designed, that measures the heart rate efficiently in a short time and with less expense without using time consuming and expensive clinical pulse detection systems. The measured parameter has been displayed in digital form, this make it easy and practical in normal and emergency situations.

7.2 Recommendation:

- Use of good cover for the optical sensor gives more and better result and help in analysis of heart beats.
- Use alarm to indicate abnormal heart beats.
- Built data for different heart beats including normal and abnormal states could be used for student training and simulation of different heart beats.
- Heart beat calculation near perfect by using more complex algorithm, the heart beat rate calculation can be more accurate.
- For further improvement the design can be wireless electronic heart rate meter which allow data to be transferred to computer or handled device for storage and retrieval a later time.

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heart pulse received on the skin by electrodes is a result of traveling electrical activity from the heart. At the skin
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<http://www.livestrong.com/article/134189-heart-ratevariability-during-sleep>

[14] <http://whatis.techtarget.com/definition/light-emitting-diode-LED> copyright
1999-2014

[15] http://www.physics.ucc.ie/fpetersweb/FrankWeb/courses/PY3108/Labs/PD_Info.pdf

'photodiode_technical_information pdf'(secured) (15\09\2015)

[16]'Heart rate measurement from fingertip' ,<http://embedded-lab.com/blog/?p=1671> January 29, 2012

Appendix

Dual Low Power Operational Amplifiers

Utilizing the circuit designs perfected for recently introduced Quad Operational Amplifiers, these dual operational amplifiers feature 1) low power drain, 2) a common mode input voltage range extending to ground/V_{EE}, 3) single supply or split supply operation and 4) pinouts compatible with the popular MC1558 dual operational amplifier. The LM158 series is equivalent to one-half of an LM124.

These amplifiers have several distinct advantages over standard operational amplifier types in single supply applications. They can operate at supply voltages as low as 3.0 V or as high as 32 V, with quiescent currents about one-fifth of those associated with the MC1741 (on a per amplifier basis). The common mode input range includes the negative supply, thereby eliminating the necessity for external biasing components in many applications. The output voltage range also includes the negative power supply voltage.

- ① Short Circuit Protected Outputs
- ② True Differential Input Stage
- ③ Single Supply Operation: 3.0 V to 32 V
- ④ Low Input Bias Currents
- ⑤ Internally Compensated
- ⑥ Common Mode Range Extends to Negative Supply
- ⑦ Single and Split Supply Operation
- ⑧ Similar Performance to the Popular MC1558
- ⑨ ESD Clamps on the Inputs Increase Ruggedness of the Device without Affecting Operation

DUAL DIFFERENTIAL INPUT OPERATIONAL AMPLIFIERS

SEMICONDUCTOR
TECHNICAL DATA



N SUFFIX
PLASTIC PACKAGE
CASE 628



D SUFFIX
PLASTIC PACKAGE
CASE 751
(S0-8)

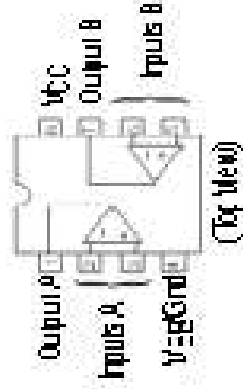
MAXIMUM RATINGS ($T_A = +25^\circ\text{C}$, unless otherwise noted.)

Rating	Symbol	LM258 LM358	LM2904 LM2904V	Unit
Power Supply Voltages Single Supply Split Supplies	V_{CC} V_{CC}, V_{EE}	32 +16	26 +13	Vdc
Input Differential Voltage Range (Note 1)	V_{IDR}	+32	+26	Vdc
Input Common-Mode Voltage Range (Note 2)	V_{ICR}	-0.3 to 32	-0.3 to 26	Vdc
Output Short-Circuit Duration	T_{SC}	Continuous		
Junction Temperature	T_J	150		$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +125		$^\circ\text{C}$
Operating Ambient Temperature Range	T_A	-25 to +85 0 to +70 - -	- - -40 to +105 -40 to +125	$^\circ\text{C}$

NOTES: 1. Split Power Supplies.

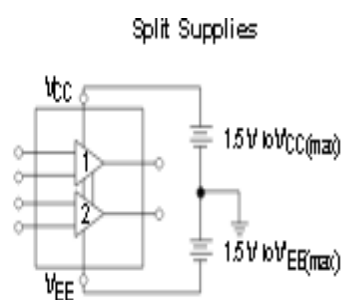
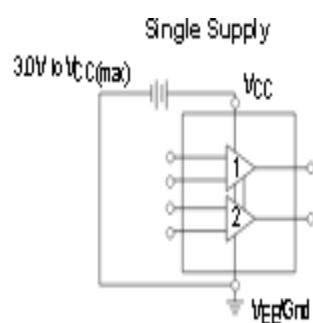
2. For Supply Voltage stress: less than 32 V for the LM258/358 and 26 V for the LM2904, the absolute maximum input voltage is equal to the supply voltage.

PIN CONNECTIONS

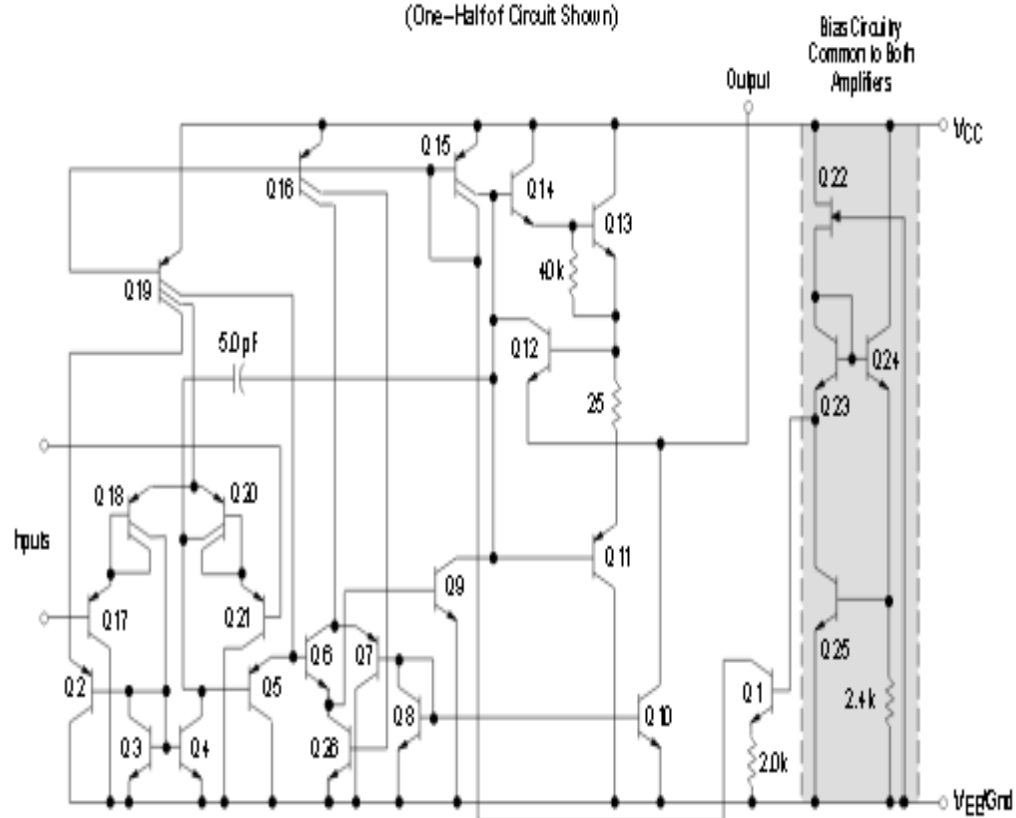


ORDERING INFORMATION

Device	Operating Temperature Range	Package
LM2904D	$T_A = -40^\circ\text{C to } +105^\circ\text{C}$	SO-8
LM2904N		Plastic DIP
LM2904VD	$T_A = -40^\circ\text{C to } +125^\circ\text{C}$	SO-8
LM2904VN		Plastic DIP
LM258D	$T_A = -25^\circ\text{C to } +85^\circ\text{C}$	SO-8
LM258N		Plastic DIP
LM358D	$T_A = 0^\circ\text{C to } +70^\circ\text{C}$	SO-8
LM358N		Plastic DIP



Representative Schematic Diagram
(One-Half of Circuit Shown)



Devices Included in this Data Sheet:

- PIC16F873A
- PIC16F876A
- PIC16F874A
- PIC16F877A

High-Performance RISC CPU:

- Only 35 single-word instructions to learn
- All single-cycle instructions except for program branches, which are two-cycle
- Operating speed: DC – 20 MHz clock input
DC – 200 ns instruction cycle
- Up to 8K x 14 words of Flash Program Memory, Up to 368 x 8 bytes of Data Memory (RAM), Up to 256 x 8 bytes of EEPROM Data Memory
- Pinout compatible to other 28-pin or 40/44-pin PIC16CXXX and PIC16FXXX microcontrollers

Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during Sleep via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
 - Capture is 16-bit, max. resolution is 12.5 ns
 - Compare is 16-bit, max. resolution is 200 ns
 - PWM max. resolution is 10-bit
- Synchronous Serial Port (SSP) with SPI™ (Master mode) and I²C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) – 8 bits wide with external $\overline{RD}$, $\overline{WR}$ and $\overline{CS}$ controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

Analog Features:

- 10-bit, up to 8-channel Analog-to-Digital Converter (A/D)
- Brown-out Reset (BOR)
- Analog Comparator module with:
 - Two analog comparators
 - Programmable on-chip voltage reference (VREF) module
 - Programmable input multiplexing from device inputs and internal voltage reference
 - Comparator outputs are externally accessible

Special Microcontroller Features:

- 100,000 erase/write cycle Enhanced Flash program memory typical
- 1,000,000 erase/write cycle Data EEPROM memory typical
- Data EEPROM Retention > 40 years
- Self-reprogrammable under software control
- In-Circuit Serial Programming™ (ICSP™) via two pins
- Single-supply 5V In-Circuit Serial Programming
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving Sleep mode
- Selectable oscillator options
- In-Circuit Debug (ICD) via two pins

CMOS Technology:

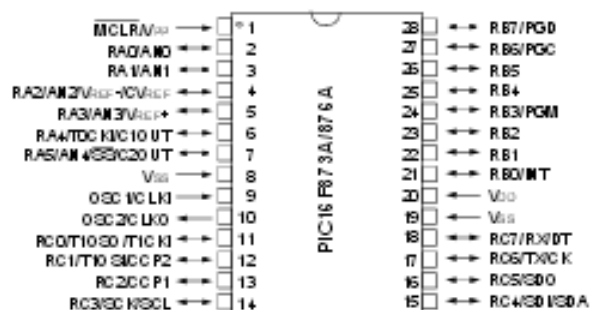
- Low-power, high-speed Flash/EEPROM technology
- Fully static design
- Wide operating voltage range (2.0V to 5.5V)
- Commercial and Industrial temperature ranges
- Low-power consumption

Case	Performance		Case Study Index	Expected Index	Cost			BET	Trans & Sub	Comparisons
	Lines	#Single Instructions			Cost of FC	Cost of FC	Cost of FC			
FC 0.375	124	400	10	10	10	10	10	10	10	10
FC 0.375	124	400	10	10	10	10	10	10	10	10
FC 0.375	124	400	10	10	10	10	10	10	10	10
FC 0.375	124	400	10	10	10	10	10	10	10	10

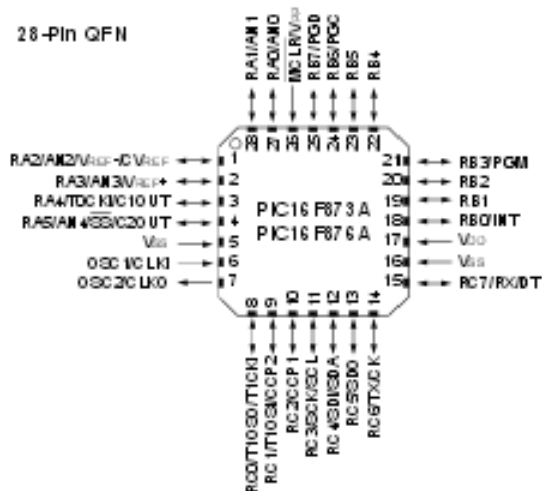


Pin Diagrams

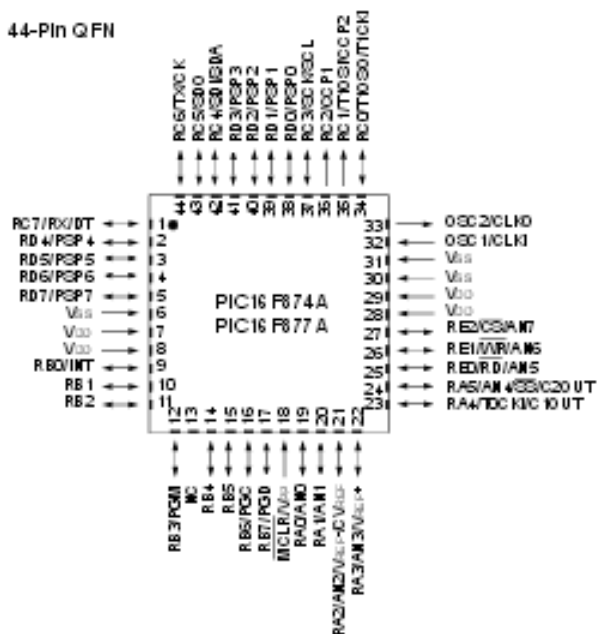
28-Pin PDIP, SOIC, SOP



28-Pin QFN

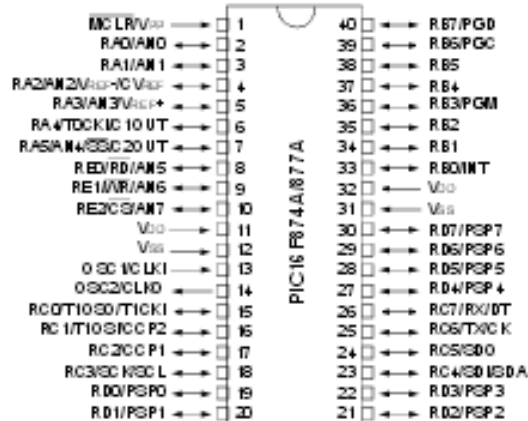


44-Pin QFN

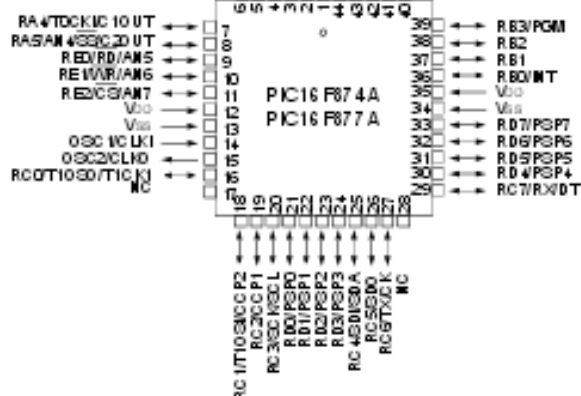


Pin Diagrams (Continued)

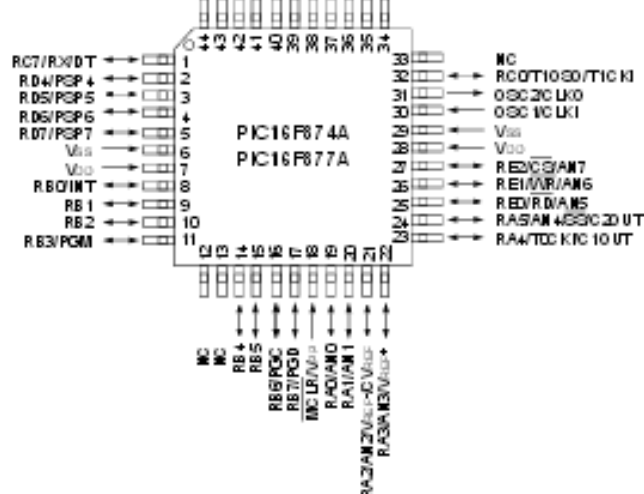
40-Pin PDIP



44-Pin PLOC



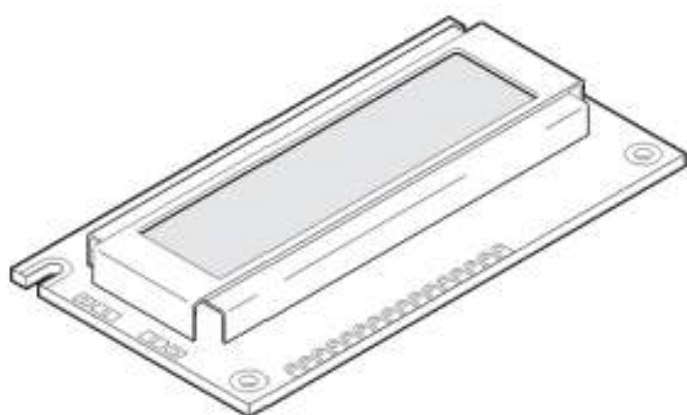
44-Pin TQFP



ALPHANUMERIC LCD DISPLAY (16 x 2)

Order Code

LED008 16 x 2 Alphanumeric Display
FRM010 Serial LCD Firmware (optional)



Contents

1 x 16x2 Alphanumeric Display
1 x data booklet

Introduction

Alphanumeric displays are used in a wide range of applications, including palmtop computers, word processors, photo copiers, point of sale terminals, medical instruments, cellular phones, etc. The 16 x 2 intelligent alphanumeric dot matrix display is capable of displaying 224 different characters and symbols. A full list of the characters and symbols is printed on pages 7/8 (note these symbols can vary between brand of LCD used). This booklet provides all the technical specifications for connecting the unit, which requires a single power supply (+5V).

Further Information

Available as an option is the **Serial LCD Firmware**, which allows serial control of the display. This option provides much easier connection and use of the LCD module. The firmware enables microcontrollers (and microcontroller-based systems such as the PICAXE) to visibly output user instructions or readings onto an LCD module. All LCD commands are transmitted serially via a single microcontroller pin. The firmware can also be connected to the serial port of a computer.

An example PICAXE instruction to print the text

Hello using the `serout` command is as follows:

```
serout 7,T2400,"Hello"
```

