DESIGN AND CONSTRUCTION OF A PULSE-RATE MEASURING DEVICE

BY

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DEDICATION

I dedicate this project to God Almighty who grants wisdom, and to my entire family for all their support, care and understanding. To my very dear friends who have always been there for me through thick and thin. To my Lovely Mother I say thank you. I love you all.

DECLARATION

I OBAITAN ANNE-MARIE declare that this work was done by me and has never been presented elsewhere for the award of a degree. I hereby relinquish the copyright to the Federal University of Technology, Minna.

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ABSTRACT

The pulse rate measuring device is an electronic device that observes or monitors the heartbeat or pulse rate of the heart, and gives an output in form of a visible signal. It consists of input, a two stage gain amplifier, a comparator and a microcontroller. The output is displayed or observed through the liquid crystal display (LCD).The pulse rate monitor has a light source for illuminating the skin tissue. The infra-red sensor and transmitter used for signal detection and transmission, functions via the changes in the arterial blood flow as a result of expansion and contraction of the heart during pumping of blood in the body, on exposure to the ambient light. The output of the infra-red device is amplified, and then compared with a reference voltage by the comparator. The output from the comparator is then fed into the microcontroller which in turn feeds the liquid crystal display unit as the output. The output shows the number of heartbeats measured normally in beats per second (BPM).

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CHAPTER ONE

GENERAL INTRODUCTION

1.1 INTRODUCTION

The human system comprises of vital signs that indicate fitness and orderliness in the body when closely monitored. These are body temperature, blood pressure, respiratory rate and pulse rate all of which are dependent on one organ of the body THE HEART.

The heart is the circulatory system's power supply; it beats continuously because the body's tissue, especially the brain depends on a constant supply of oxygen and nutrients delivered when blood flows through the heart. In an event where the heart stops pumping blood for more than a few minutes, death could occur.

This project is designed to monitor one of these vital signs mentioned above; the heart/ pulse rate. The heart/pulse rate monitor is a device that allows a user to measure his or her heartbeat rate in a real time.

Medical officials use an instrument called a stethoscope to detect internal body sounds of which the sound produced by the heart is one. The sounds of the heart are as a result of actions in the valves of the heart, not by the contractions of the heart muscle itself. In the heart beat generation, unlike most muscles, which rely on nerve impulse to cause them to contract, heart muscles can contract of its own accord. Certain heart muscle cells have the ability to contract spontaneously and these cells generates electrical signals that spreads to the rest of the heart and causes it to contract with a steady but regular beat. The heart begins with a small group of specialized muscle cells located in the upper right corner of the right atrium. This atrium is known as the sinoatrial node (SA); it generates electrical signals more frequently than cells elsewhere in the heart, for this reason, the SA node is also known as the heart's pacemaker.

Impulses generated by the SA node spread rapidly throughout the atria, so that all the muscle cells of the atria contract virtually in unison. Pulses of electrical nature cannot be conducted through the partition between the atria and the ventricles, which is primarily made of fibrous connective tissue rather than muscle cells. The impulses from the SA node are carried across this connective tissue partitioned by a small bridge of muscles called the atrioventricle node (AV). Cells in the AV node conduct impulses relatively slow, introducing a delay of about 0.2 seconds before an impulse reaches the ventricles. This delay allows time for the blood in the atria to empty into the ventricles before the ventricles begins to contract. The impulse spreads rapidly among the cell that makes up the ventricles. Although this complicated circuit has many steps, an electrical impulse spreads from the SA node throughout the heart beat in less than one second. The journey of an electrical impulse around the heart can be traced by a machine called the electrocardiogram (ECG) consisting of a recording device attached to the electrodes that are placed at various points on a person's skin. The recording device measures different phases of the heart's ratio of contraction register on the electrocardiogram helping medical officials diagnose heart problems or identify damage from heart attack.

For an adult, the normal heart rate is about 72 beats a minute. However when a person is exercising, the heart beats faster. In conclusion, young people have faster resting heart rate than adults do. Although the SA node generates the heart beat, nerves and certain chemical in the blood slow down almost simultaneously. Small mammals have more rapid heart rate than large mammals because they have the highest energy needs. The resting heart rate of a mouse is from 500 to 600 beats per minutes, while that of an elephant is 30 beats per minutes

1.2 Definition of Project.

The heart beat rate monitor is an electronic device that observes (monitor) the pulse rate of the heart, giving an output in form of a visible signal. It consists of an input, different amplifiers performing different functions and active circuit components and also an output display.

1.3 Aims/objectives of the project

a) To develop a relatively cheap device for the measuring of the heart rates that will ease the problems of effective cardiac arrests, as number of people can afford.

b) To improve and promote the professional ability to give the right diagnosis that is based on heart in cases where an emergency first aid is needed

c) To allow for and encourage domestic and individual monitoring and observation of pulse rates

d) To introduce to the public the importance of periodic pulse rate monitoring during rest times or during exercises especially athletes.

1.4 Methodology

The input signal is a non- electrical form of energy taken from any of the palpated sites enumerated below and converted into electrical signal via the infra-red sensor transmitter and an infra-red sensor photo transistor. The signal is amplified and filtered for removal of excess noise and sound from other sources. The amplified signal is then fed into the comparator to be compared with a reference voltage. The output from the comparator is fed into a microcontroller which in turn feeds the LCD (LIQUID CRYSTAL DISPLAY) and then a visible output is seen. The output is displayed in digital form.

The palpated sites from which the input signal originates at which the input transducers are placed are as follows;

- The chest (aoria)
- The neck region (aortic artery)
- In the armpit
- Behind the knee
- Over the abdomen (abdominal artery)
- The side of the thumb (radial artery)
- The side of the elbow or under the bicep muscle (radial artery)

But in this case the site being taken into consideration is the thumb.

1.5 Project Synopsis

Chapter one gives an introduction, brief definition, aims or objectives of the project including the design methodology. Chapter two gives the literature review and theories of the design and construction of the project. Chapter three contains the complete design, its implementation, specification and construction. Chapter four contains construction procedures, general workability, result and discussion while chapter five gives the conclusion on the project and recommendation.

CHAPTER TWO

LITERATURE REVIEW

2.1 Historical Background

Scientific and Engineering contribution to the development and protection of heart rate technique date back in history. The discussion below gives an insight into these recorded histories. When blood is pumped from the heart to other parts of the body, there is expansion and contraction of the heart. Pulses are therefore produced during contraction and noticed at different parts (palpated sites) of the body. As far back as 2600BC, Imhotep, an Egyptian physician, discovered pulses made by the heart during contraction. Aristotle, a Greek philosopher (384-322BC) also gave a description of chick embryo 2200 years later [12].

In 1628AD, an English physician named William Harvey discovered blood circulation round the body and first realized what was responsible for blood movement through the body vessels, and that this moving blood provides the body with required nourishment. Due to these discoveries of pulses generated through contraction, different kinds of pulse detection and measuring device came into existence [3].

The stethoscope was invented by Rene Laennee in 1816AD and has been in use especially by medical personnel. Carlo Matheucci, an Italian physicist, 26 years later proved that there is a corresponding amount of electrical current for every heart beat. A French physicist, Gabriel Lippmann in 1872 invented a capillary electrometer which consists of a thin glass tube with a column of mercury beneath sulphuric acid. This was improved on in 1891 by British psychologists William Baylios and Startling Edwards of the University College London, where the mercury meniscus was seen to move varying electrical potential observed through the microscope [3].

The 20th century witnessed extraordinary advances in the diagnosis of heart beat and other changes. Many doctors had become interested in measuring the pulses and abnormal heart beat. In 1920, a Dutch physiologist William Einthoven invented the Electrocardiography (ECG) equipment used for monitoring heart beat. The heart beat rate monitor in form of a heart detective was discovered by Helen Brand in October 1976. In February 1981 the method for measuring heartbeat rate and the circuit for the same purpose was discovered by charmilski etal [10].

Pulses monitoring devices especially those that relate to the heart pulses vary from type to type. The wrist type or wrist worn/fitted pulses monitor was invented in 1981 by Walbeoffe Wilson. The method and apparatus used for measuring heartbeat rate was discovered by Bailey in December 1983.Other inventions are Perivo measuring system in1984 by Hirano, heart rate detector in October 1985 by Dyek et al [9]. Also in May 1986, methods and apparatus for ECG signal rhythm analysis was discovered by Adams and in 1988 Sadah found an equipment for measuring ECG signals. These discoveries made the pulse rate monitors available in different forms ranging from the small wrist worn type, knee strap monitors worn just above the knee for exercises, the chest strap monitors worn over the chest and the finger strap worn like a ring over the thumb etc. All these different types of pulse rate monitors have different media of application and operation principles [4].

2.2 The measuring Device (Infra-red device).

The device that senses and transmits the pulse from the thumb is an infra-red device which consists of an infra-red transmitter that is the LED and an infra-red sensor. With the infra-red as the input transducer, a light source provides illumination to aid right functioning of the device. This senses the pulses generated during heart contraction when the device is placed under or at the side of the thumb where we have the radial artery. Ordinarily the signal is noticeable with the naked eye when a source of illumination is provided with the thumb over the light source, especially in a dark environment as the blood flow responds to the heart contraction. This signal is then transformed or converted into electrical signal and sent to the amplifier.

2.3 Amplification of signal

The generated signal is amplified by the use of the general purpose operational amplifier. This is the LM358 series of op-amp. The diagram below gives the general models of amplifier without feedback and an amplifier with a feedback network. A feedback amplifier is one in which a fraction of the amplifier output is feed back to the input circuit. There are basically two types of feed back;

1. The positive feedback
2. The negative feedback

A.

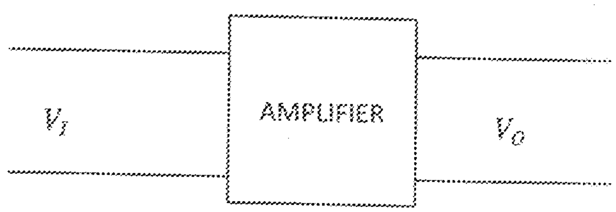


Figure 2.2a An Amplifier without feedback

B.

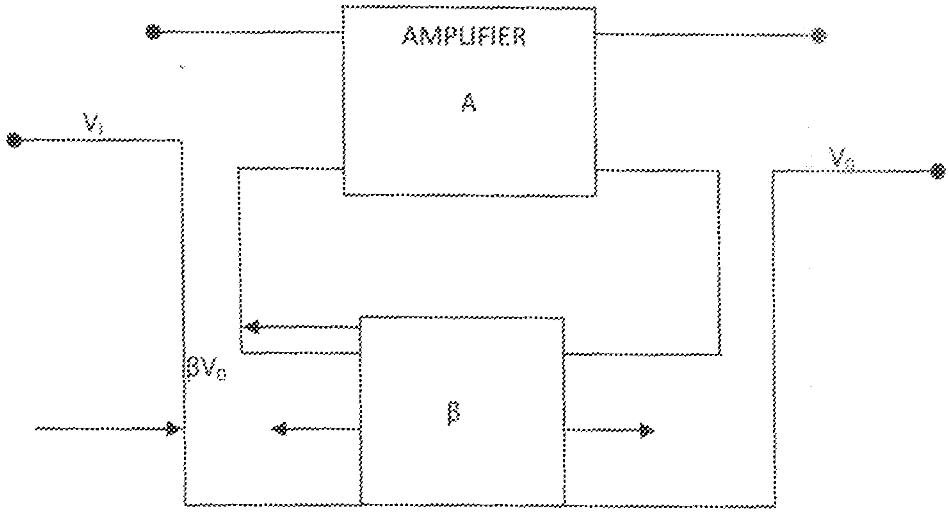


Figure 2.2b An Amplifier with feedback

However, an operational amplifier is the amplifier used for the accomplishment of amplification of the pulse or signal used. It is a high gain amplifier that amplifies signals having frequency ranging from 0Hz to a little beyond 1Mz. It is an IC package with label LM358 integrated on a silicon wafer. They are so named because of the intention of their original design; performance of mathematical operations like summation, subtraction, multiplication, differentiation, integration etc. in analogue computers, but are now used sign changing, scale changing, pulse changing, voltage regulating etc. Operational amplifiers can be applied as inverting and non-inverting constant gain amplifiers, comparators, etc. Focus is hereby on the inverting and non inverting amplifier with constant gain.

2.4 Pulse Detection.

The amplified signal which comes out of the output of the op-amp is detected by the flashing of a light emitting diode which corresponds to the contraction of heartbeat, and dims or goes off as the heart expands during blood pumping. The comparator compares the signal that is already amplified or voltage level from the amplifying op-ampV_1, with the other voltageV_2. If V_1 and $V_2$are equal, then $V_O$should ideally be zero (0). Even if V_1 differs from V_2 by a very small amount, V_0 is large because of high voltage gain. Since the comparator used is also the operational amplifier (LM358) being used as comparator. The amplified and compared signal is passed through a microcontroller

2.5 Limitations.

The difficulties which limit the performance of this project is the irregularities of the display signal which consists of the problem of wrong data display by the LCD (LIQUID CRYSTAL DISPLAY). These inaccuracies could be caused by sensitivity to several factors which are mostly external factors like pulses from other sources other than pulses emanating from the human body and also light from the environment.

CHAPTER THREE

DESIGN AND IMPLEMENTATION

3.1 Hardware and Software Design Considerations

Certain specifications, parameters, and methods of implementation must be considered in system design and construction in order to give the expected result. The implementation of the design involves segmenting the overall system design into subsystems/modules/units, which are individually designed and tested before the integration of the various subsystems. The system design is divided into:

Hardware Design

This consists of various units as shown in the block diagram below:

- Power Supply Unit
- Sensor Unit
- Comparator Unit
- Micro-controller Unit
- Display Unit

The design of the project can be represented by the block diagram in figure 3.1.

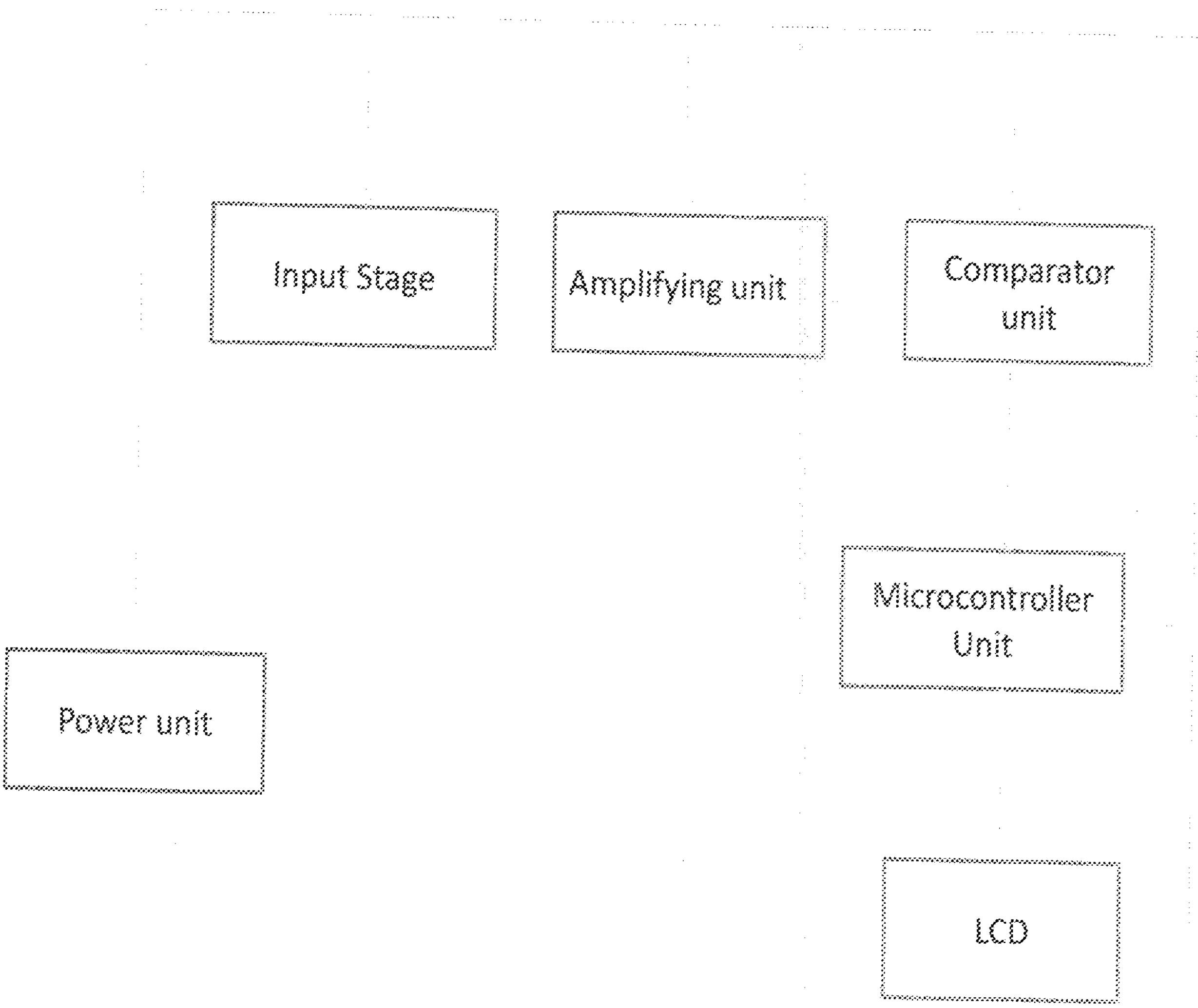


Fig. 3.1 Block Diagram of the pulse-rate Measuring device.

The Block diagram of the heartbeat rate monitor in fig 3.1 gives the stages of signal transformation and transmission right from the input stage to the output stage. The non-electrical signal is obtained by a sensor which in this case is the infra-red transmitter and receiver. The signal received is a weak one, so it is amplified for adequate strengthening and increase in signal amplitude. This is taken to the comparator for voltage comparison then to the microprocessor which is in turn wired to the LCD (LIQUID CRYSTAL DISPLAY) through which the output is visualized in Beats per minute (Bpm).

3.2 Power Supply Unit

A microcontroller based system design has to be activated with a regulated power supply. A transient on the power line could make the microcontroller malfunction, resulting in system failure. The system operates on a voltage $V_{CC} = 5V \pm 10\%$ and as a result of this; the power supply unit designed is 5V DC and is not affected by variation in the AC voltage serving as input to the transformer. The components used in the power supply include:

TRANSFORMER

A 220/12V AC transformer is used with output voltage of 12V AC.

RECTIFYING DIODES

This converts the AC current to DC and satisfies charging current demands of the filter capacitor. The arrangement of the diodes is called a bridge rectifier. Rectification is done by the PN junction diodes. In order to reduce ripple voltage to a very small value, the DC voltage needs to be filtered.

FILTER CAPACITOR

Filter capacitors were chosen to be large enough to reduce the ripple voltage contained in a rectified voltage, to a relatively filtered voltage which resembles a smooth DC voltage as much as possible. The power supply circuit for the different stages in the signal transmission of the monitor is given in figure 3.2.

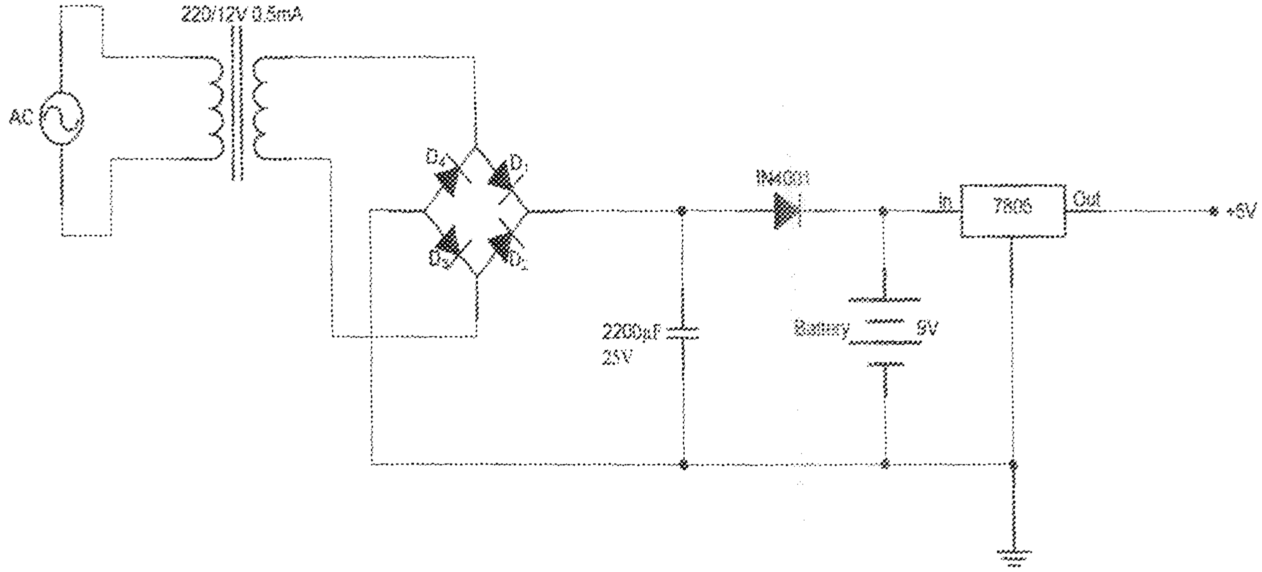


Figure 3.2 Power Supply Unit

Capacitors of low values were used at the output of the regulator in order to give the power supply low AC output impedance. To determine the proper value of capacitors used, the equation given below is employed:

$$V_{DC} = V_m - \frac{(4.7\times10^{-3} I_{DC})}{C} \qquad 3.1$$

Where V_m is the peak rectified voltage in volts

I_{DC} is the load current in mA

V_{DC} is the dc voltage

C is the filter capacitor in μF

REGULATOR (7805)

The regulator receives the input of a fairly constant DC voltage and supplies, as output, a somewhat lower value of DC voltage, which it maintains fixed or regulated over a wide range of load current or input variation. The 7805 regulator maintains a 5V DC supply voltage to the system.

Mathematical reasons for selecting the value of the capacitor used

Peak voltage from the supply $= \sqrt{2} \times Vrms$ 3.2

$Vrms = 12$

$Vp = \sqrt{2} \times 12 = 16.97v$

But $It = Cdv$ 3.3

$C = \frac{It}{dV}$ 3.4

$dv = 15\% \; of \; Vpeak.$

$\frac{15}{100} \times 16.97 = 2.5v$

$dv = \frac{1}{4Cf}$ 3.5

Where $f = 50Hz$

$2.5 = \frac{1}{(4 \times C \times 50)}$

$C = \frac{1}{2.5 \times 4 \times 50} = 2000\mu F$ Source: [1]

3.3 Input Stage

The input stage of this heartbeat rate monitor consists of a fluorescent Light Emitting Diode (LED) as the infra-red transmitter. The LED which is connected to a 5v supply illuminates the finger for effective signal detection or sensation by the infra-red sensor which is a photo transistor. This is aided via the variation of the light intensity of the LED due to expansion and contraction of the muscles.

The variation in luminance or light intensity, which corresponds to the contraction and relaxation of the muscle especially at the palpated sites (thumb), is sensed by the infra-red sensor which is connected in series with a fixed resistor as shown in fig 3.3

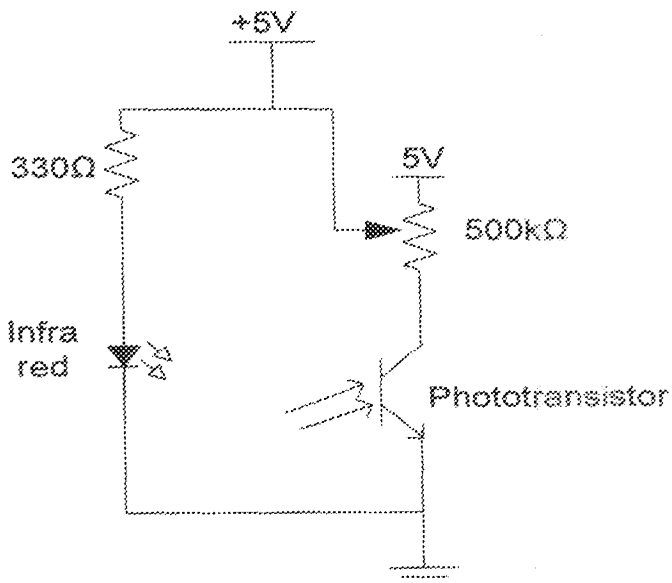


Fig 3.3 The Infra-red transmitter and sensor

The network in fig 3.3 is governed by the mathematical expression given by the voltage divider network theorem

$$V1 = \frac{R1}{(R2+R1)} . Vt \quad 3.6$$

Here, $Vt = 5v$

The value of V1 is not constant as a result of variation in the value of R2 due to the variation of the light intensity. The value of R2 varies from o-10 MΩ. Therefore V1 varies from 5v $for(R_2 = 0)$ to 10v $for\ (R_2 = 10M\Omega)$

3.4 Amplification Stage

Amplification of the signal from the sensor for increase in amplitude and signal strength is done at this stage. This is due to the fact that the signal gotten from the sensor is weak

Amplifiers are often required to increase the voltage and power levels of the signals by a certain factor.

A non-inverting amplifier is used in this case, it provides an amplified output that is in phase with the input. This is achieved via the use of the LM358 operational amplifier Integrated circuit. The LM358 consists of two independent, high gains, internal frequency operational amplifiers which are designed specifically to operate from a single power supply over a range of voltage. The LM358 IC package is shown in figure 3.4a

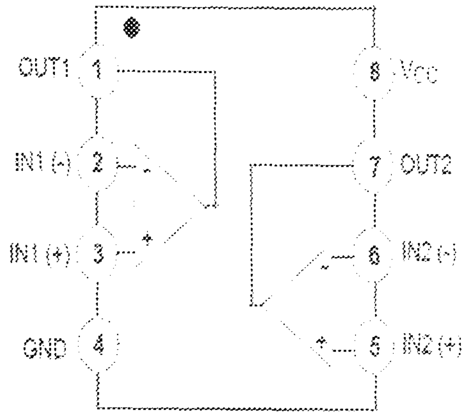


Fig 3.4a LM358 pin out diagram

The amplifier used in this project is one with feedback to help maintain its gain. For an amplifier without feedback, the voltage gain is given by the ratio of the output voltage V_o, to the input voltage V_i

$$A = \frac{OUTPUT\ VOLTAGE}{INPUT\ VOLTAGE} = \frac{V_O}{V_i} \qquad 3.7$$

For positive feedback

$$V_O = AV_S + A\beta V_O \qquad 3.8$$

And for negative feedback

$$V_O = AV_S - A\beta V_O \qquad 3.9$$

$$\frac{V_O}{V_S} = \frac{V_O}{V_i} = \frac{A}{(1+\beta A)} = A \qquad 3.10$$

From (3.9), it shows that if β is negative A reduces, since $(1-\beta A) > 1$ and if β is positive, A increases because$(1-\beta A) < 1$.

Feedback in an amplifier always helps to control its output, increase its gain, decrease its output impedance and stabilize its gain.

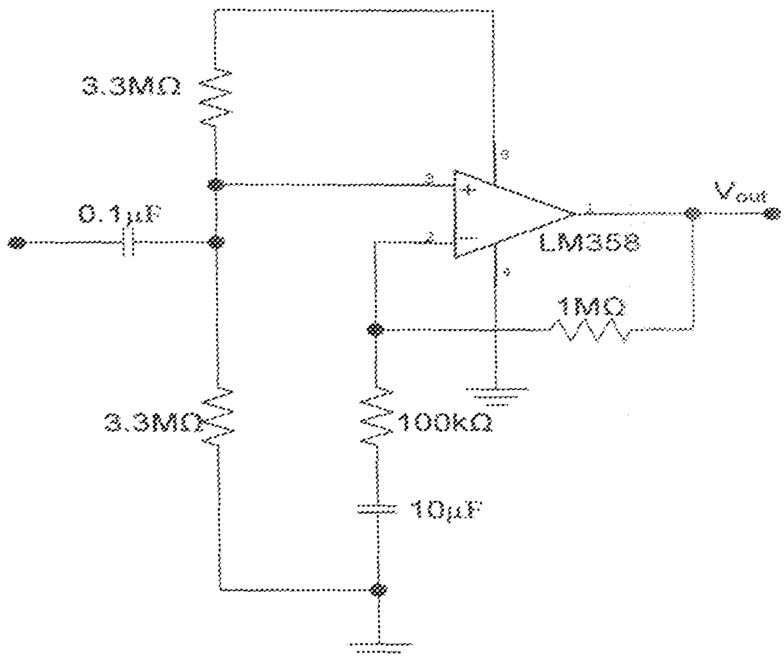


Fig 3.4b op-amp in its inverted input mode.

From fig 3.4b, the capacitor is a coupling capacitor, whose function is to block all the DC signals and allows AC signals only to pass. This signal is amplified by a chosen amplification

If $R_{in} = R_a$, $R_f = R_b$ then A (Gain of the amplifier) is given by the expression

$$A = 1 + \frac{R_b}{R_a} \qquad 3.11$$

$$A = 1 + \frac{1M\Omega}{100K\Omega} = 101$$

$$A = 101$$

V_{in} Depends on the intensity of light or the level of luminance. When the intensity is high, the value of V_{in} is high, and it is low when at low intensity of light. Changes in one of the values of the resistances used in R_{in} and R_f automatically alters the amplification factor A, thereby affecting the output voltage from the amplifier V_{out}.

3.5 Comparator Stage

A voltage comparator is a component device used to compare the magnitude of two signals and develop a logic output. Due to the variation of the light intensity from the input stage, there is the need for signal and voltage comparison. The outputs of the amplifier with the preset reference voltage level are therefore compared by the comparator. If the two voltage levels are equal the output voltage of the comparator reads zero ideally, but if they differ in value, a large value is seen from the comparator output due to the high gain of the amplifier.

The input voltage to the comparator, V_{in} is the voltage from the amplifier while the reference voltage of the comparator is preset using the variable resistor. The comparator circuit is shown in figure 3.5

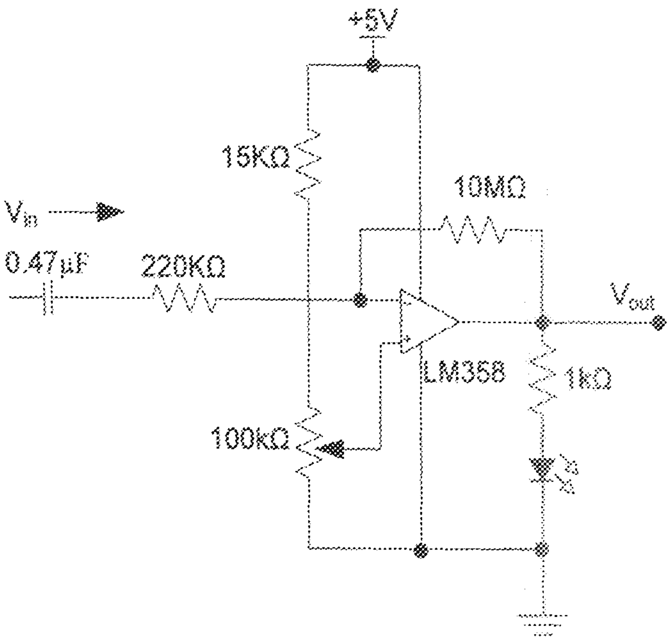


Fig 3.5 Comparator Circuit

As seen from the diagram in fig. 3.6, the capacitor is used as a decoupling capacitor, whose function is to block all AC signals and allows only DC signals to pass. After the comparison, if there is an appreciable difference in the two voltages, the pulse detector which is the LED gives a flashing indication, implying that a pulse has been seen. The resistor in series with the LED used for signal detection plays the role of limiting the current flowing in the LED.

3.6 The Microcontroller Unit

In this stage the signal gotten from the comparator is sent to the microcontroller for further analysis and programming. It programs the pulse and converts it to a digital signal which is in turn shown on the LCD.

A microcontroller is a general purpose computer, but one which is meant to fetch data, perform limited calculations on the data and control its environment based on those calculations. Onboard all computers have several things in common namely,

1. A central processing unit (CPU) that executes programs
2. Some random access memory (RAM) where it can store data that is variable.
3. Some read only memory (ROM) where programs to be executed can be stored
4. Input and output (I/O) devices that enables communication to be established with the outside world i.e. connection devices such as mouse keyboard monitors e.t.c.

If a computer matches majority of these characteristics then it is classified as a microcontroller. Microcontrollers may be;

- Embedded inside some other device (often a consumer product) so that they can control the features or actions of the product. Another name for a microcontroller is therefore an embedded controller.
- Dedicated to one task and run one specific program. The program stored in the ROM and generally does not change.
- A low price device, a battery operated microcontroller might consume as little as 50 milli watts.

A microcontroller may take input from the device it is controlling and controls the device by sending signals to different components in the device. The microcontroller comes in different types but PIC16F84 was the model used for the programming of this device. Below is a diagram showing the internal architecture of a microcontroller. The microcontroller has an oscillating frequency of 4MHz.

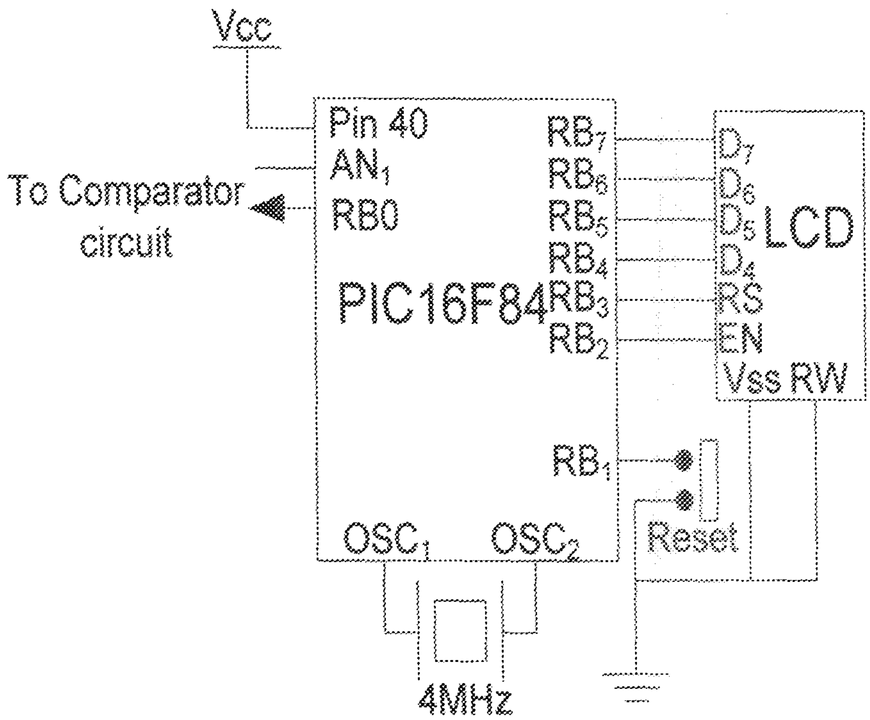


Figure 3.6 the PIC16F84 microcontroller

The reset button is also connected to pin RB1 of the microcontroller and the input from the comparator is connected to RB0.

3.7 The Display Unit

After the programming and analysis of the microcontroller, the output which is the pulse rate is displayed on the LCD. The most commonly used Character based LCDs are based on Hitachi's HD44780 controller or others which are compatible with HD44580. The most commonly used LCDs found in the market today are 1 Line, 2 Line or 4 Line LCDs which have only 1 controller and support at most 80 characters, whereas LCDs supporting more than 80 characters make use of 2 HD44780 controller.

Most LCDs with 1 controller have 14 Pins and LCDs with 2 controller have 16 Pins (two pins are extra in both for back-light LED connections). Pin description is shown in the table below.

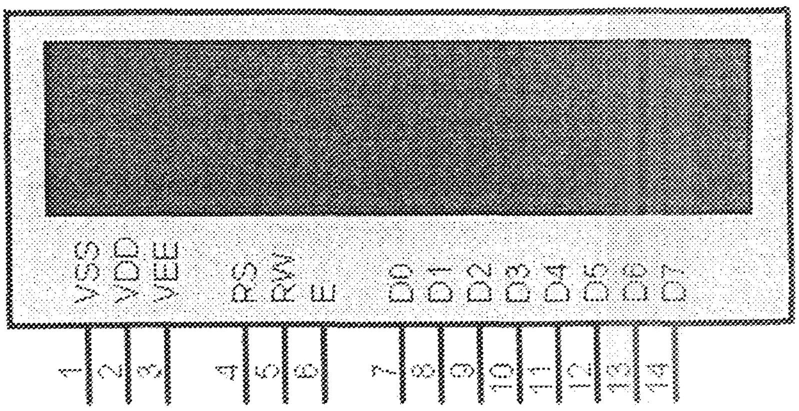


Figure 3.7: Character LCD type HD44780 Pin diagram

Pin No.	Name	Description
Pin no. 1	VSS	Power supply (GND)

Pin no. 2	**VCC**	Power supply (+5V)
Pin no. 3	**VEE**	Contrast adjust
Pin no. 4	**RS**	0 = Instruction input 1 = Data input
Pin no. 5	**R/W**	0 = Write to LCD module 1 = Read from LCD module
Pin no. 6	**EN**	Enable signal
Pin no. 7	**D0**	Data bus line 0 (LSB)
Pin no. 8	**D1**	Data bus line 1
Pin no. 9	**D2**	Data bus line 2
Pin no. 10	**D3**	Data bus line 3
Pin no. 11	**D4**	Data bus line 4
Pin no. 12	**D5**	Data bus line 5
Pin no. 13	**D6**	Data bus line 6
Pin no. 14	**D7**	Data bus line 7 (MSB)

Table 1: Character LCD pins with 1 Controller

Pin No.	Name	Description
Pin no. 1	**D7**	Data bus line 7 (MSB)
Pin no. 2	**D6**	Data bus line 6

Pin no. 3	**D5**	Data bus line 5
Pin no. 4	**D4**	Data bus line 4
Pin no. 5	**D3**	Data bus line 3
Pin no. 6	**D2**	Data bus line 2
Pin no. 7	**D1**	Data bus line 1
Pin no. 8	**D0**	Data bus line 0 (LSB)
Pin no. 9	**EN1**	Enable signal for row 0 and 1 (1st controller)
Pin no. 10	**R/W**	0 = Write to LCD module 1 = Read from LCD module
Pin no. 11	**RS**	0 = Instruction input 1 = Data input
Pin no. 12	**VEE**	Contrast adjust
Pin no. 13	**VSS**	Power supply (GND)
Pin no. 14	**VCC**	Power supply (+5V)
Pin no. 15	**EN2**	Enable signal for row 2 and 3 (2nd controller)
Pin no. 16	**NC**	Not Connected

Table 2: Character LCD pins with 2 Controller

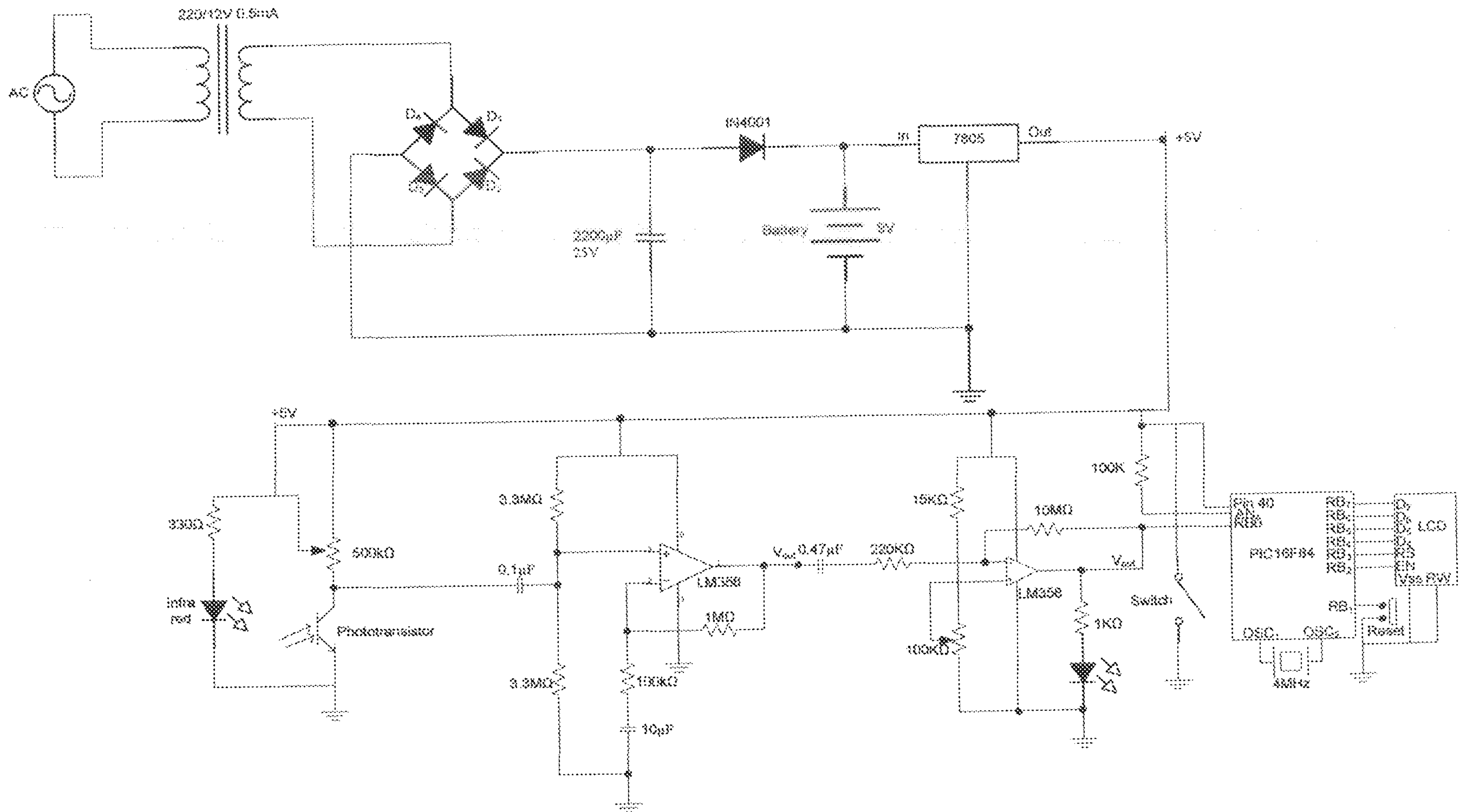
Pins 13, 12, 11, 10, 9, 8 of the microcontroller are connected to pins 14, 13, 12, 11, 4, 6 of the LCD respectively.

The microcontroller sends the pulse rate to the LCD and it stores the information in display data

RAM (DDRAM). It display data represented in 8-bit character codes. Its extended capacity is 80 X 8 bits, or 80 characters. The area in display data RAM (DDRAM) that is not used for display can be used as general data RAM. So whatever you send on the DDRAM is actually displayed on the LCD.

3.8 The implementation.

The modules explained from the input to the output stages coupled together give the implementation of the pulse rate measuring device. This is shown in the overall circuit diagram.



THE CIRCUIT DIAGRAM OF A PULSE RATE MEASURING DEVICE

CHAPTER FOUR

CONSTRUCTION AND TESTING

4.1 Construction.

The realization of the pulse rate measuring device which is a stage by stage process started with the implementation of the circuit on the bread board. This involves the right connections of all the components that make up the circuit together on the bread board to see how it operates as a system.

After the realization of the system at the bread board stage, the second stage which is soldering is carried out. This involves the permanent placement of the components on a Vero board. But in this case a printed circuit board was use for extra precaution. A printed circuit board is a board that is mapped with the circuit diagram of the device to be constructed. It is better than the normal Vero board in the sense that there is no looping involved and all the components have their specified place already mapped out. The components are soldered to the PCB (Printed Circuit Board) carefully using a soldering iron and lead.

The final stage of the realization is the casing which houses or encloses the whole implemented circuit. The casing was done in such a way that it can be easily opened in case of any malfunctioning. Below is the layout of the printed circuit board.

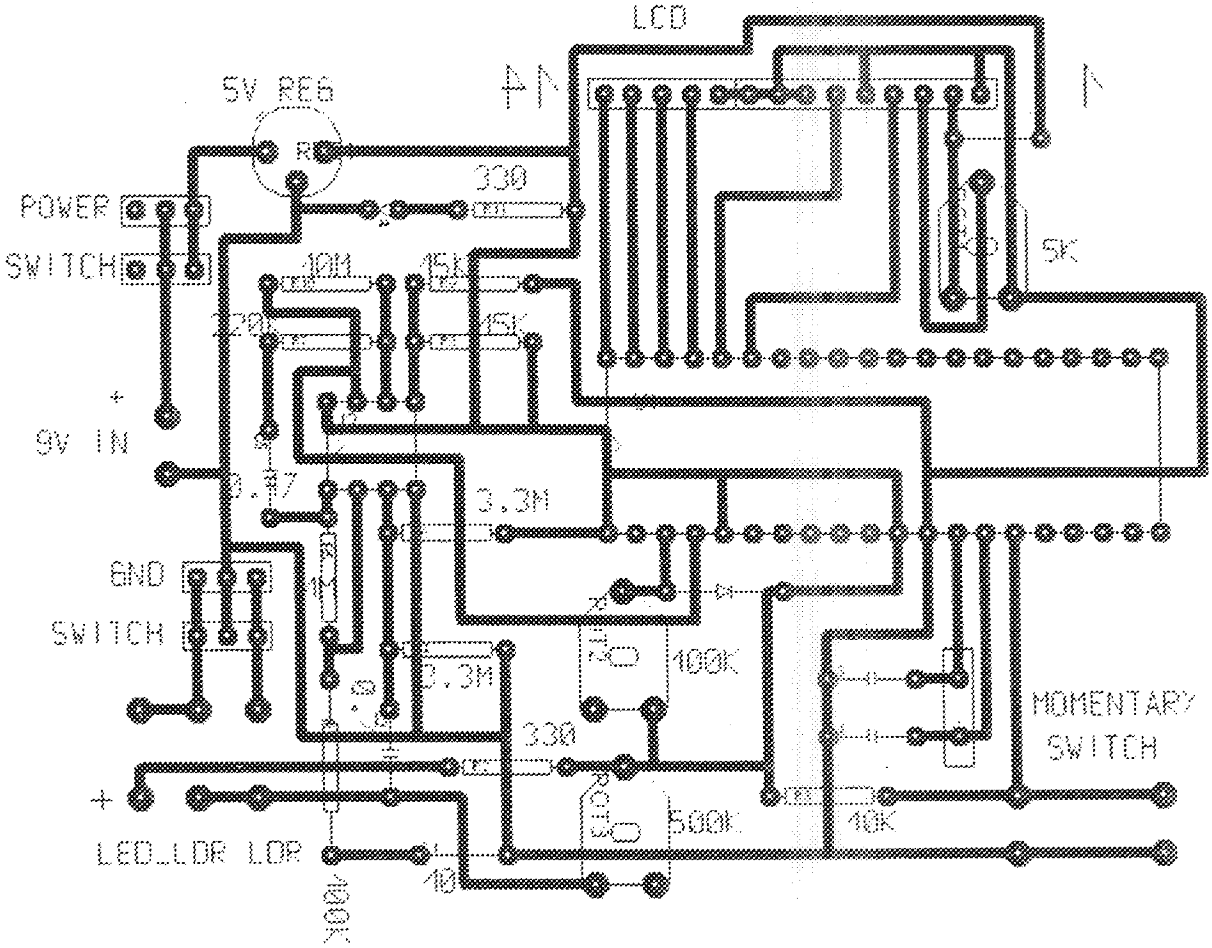


Figure 4.1 the printed circuit board layout.

4.2 Testing.

The stage-by-stage assembling of the components involves testing at every stage, in order to access the continuity of these components. In fact, the different modules right from the sensing stage, the amplifying stage, the comparator stage, microcontroller unit and display unit, were all tested to ensure that they give the right output which is required as an input into the next stage.

4.3 Result.

The result or the outcome of the project is a visual display of the pulse rate which is displayed on the LCD, after the various stages of signal transformation and signal transmission and the LED flashes which signifies pulsation in accordance with the pulse rate.

A recording of the results gotten after testing the pulse rate measuring device four times on an individual is shown in the table below.

ATTEMPTS	PULSE RATE MEASURED PER MINUTE
1	60
2	74
3	63
4	65

Table 3. A table showing the results of the test done on an individual with the pulse rate monitor

4.4 Problems Encountered

Several challenges were encountered in the process of actualization of the project (pulse-rate measuring device). Some of these challenges are enumerated below;

- Some of the circuit component were not readily available, especially the microcontroller PIC16F84.
- An LDR was originally supposed to be used instead of the infra-red device but it was found out that its signal detection was really low hence the use of an infra-red device.
- The infra-red takes time before it begins to respond to variation of the pulses and signal level, but when it begins to sense, it senses and transmits well; and so it was as the input device.

4.5 Precautions

- The LED needed for illumination of the thumb was ensured to be put close to the infra-red sensor for effective working, since the resistance of the photo transistor (infra-red sensor) becomes low when light in form of the photons is delivered to it by a source (fluorescent LED).
- The values of the resistors and other components were rightly used to avoid change of parameters like the amplification factor A, of the amplifier.
- Right and tight connections were ensured during the bread boarding phase for good flow of parameters and effective monitoring.
- During soldering, it was ensured that there is no short-circuiting either by drops of lead or by other unknown wrong connections.
- The configurations and operating principles of components like the PIC16F84 and the LM358 op-amp IC was known before the commencement of the project.
- An IC socket should be used during the soldering of the IC packages to prevent unnecessary destructions of components.

4.6 Casing

The casing of the pulse-rate measuring device was done that it could accommodate the whole of the PCB which contains all the components. It was made of plastic, giving space for its visual displays and a little allowance for easy removal in case of future adjustment or repair.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The fact that there are so many ways to solving a particular problem such as monitoring of the pulse should not be overemphasized. The system procedures all depend on the energy conversions process, with respect to the desired form of output.

The pulse-rate measuring device here, which was realized through energy conversion and transmission processes explained in previous chapters, aims at an achievement of better amplifications of signal emanating from the body, due to cardiac function. With the required amplification and voltage comparison, the non-electrical signal which was converted to electrical signal by the input device, received more strength and amplitude, making it acceptable by the microcontroller and the LCD.

Pulse-rate measuring device is used for diagnosis in hospitals. where there is a need for patients to visualize the output Bpm, gives no room for secret deceit, since the display is visible, unlike the normal stethoscope where only the doctors knows the output.

The Infra-red device used as the input sensor, provided there is adequate illumination from the light source, responded certainly within a little time, giving a satiable response as output which is required for other subsequent stages.

All the processes were seen to function in accordance with the system design and design specifications. Though several eventualities arose, such as the ones due to system imperfection, detection of other signals etc, it is a realizable and achievable project.

5.2 Recommendation

Good things are made better with better thoughts reasoning and better analysis of processes involved in getting a better output. The input sensor, the processor and the receiver or output device which finally gives out the output signal should be highly evaluated with respect to their sensitivities, operation principles, etc.

It is recommended that an alternate power source should be provided to supplement the original A.C supply just in case of power failure. A rechargeable battery is therefore advised to be used ith further research.

o as part of the recommendation, the choice of input device should depend on the signal gth or amplitude from the palpated site in view. This implies that the device should be ately sensitive to pick the signal from such locations. The use of an infra-red device instead R (Light Dependent Resistor) is encouraged due to poor signal detection by the LDR.

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APPENDIX

The codes used for programming the microcontroller is given below

```
program Hbeat

dim text as char[20]

dim i as byte

dim adc_value, adc_max, adc_low, times, count as word

main:

TRISB = 0                    ' PORTB is output

Lcd_Init(PORTB)              ' Initialize LCD on PORTB

'Lcd_Cmd(Lcd_CURSOR_OFF)      ' Turn off cursor

' text = "H.beat Monitor"

' Lcd_Out(1, 1, text)

' text = "project 2009"

' Lcd_Out(2, 1, text)



r i = 0 to 10
```

```
adc_value = adc_read(1)

if adc_value < adc_max then inc(adc_low) else inc(adc_max) end if

next i

text = "Please Press switch"

Lcd_Out(1, 1, text)

text = "to get the H.beat "

Lcd_Out(1, 1, text)

do loop until portc.0 = 0

do

do loop until (adc_value < adc_max) and (adc_value < adc_low)

loop until times  = 15

text = "Please wait .. "

Lcd_Out(1, 1, text)

text = "system busy... "

Lcd_Out(1, 1, text)
```

```
count = 4 * count
text = "your heart rate"
Lcd_Out(1, 1, text)
text = "value is"
WordToStr(count, text)
Lcd_Out(1, 1, text)
end.
```