Real-time Heart Rate Monitoring and BPM Display

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Abstract

This project focuses on the design and implementation of an electronic heartbeat reader utilizing commonly available components. The circuit diagram involves a straightforward arrangement, comprising a microphone, amplifier, and low-pass filter to capture and refine the heart signal. The system aims to display the heart rate on a 7-segment display while measuring the Beats Per Minute (BPM). Overall, this project provides a foundation for a practical and accessible heart rate monitoring system.

Contents

1 Introduction

Heart rate monitoring is essential for healthcare, offering insights into cardiovascular well-being. This project utilizes a heartbeat sensor, integrating a microphone, amplifier, and low-pass filter to detect and process heartbeat vibrations. Enhancing practicality, a 7-segment display visually represents the heart rate in BPM. Prior to the display, a sequence of components, including a comparator, counter, binary to BCD converter, and BCD to 7-segment decoder, ensures precise signal processing. The combination of accurate heartbeat detection and a clear visual output aims to facilitate effective and holistic health monitoring.

2 Description of the Project

This cost-effective and user-friendly heart rate monitoring system is designed to provide real-time measurements of an individual's heart rate. The simplicity of its construction makes it an accessible tool for various applications, including medical monitoring, fitness tracking, and research. The portable nature of the device allows for versatile usage in different environments. This project holds significant value as a practical and affordable solution, contributing to the advancement of health-related technologies.In addition to its affordability and ease of construction, the project incorporates a beats per minute (BPM) measurement feature. This functionality enhances its utility, allowing users to obtain a comprehensive understanding of their cardiovascular health. Whether used in medical settings, fitness routines, or research endeavors, the combination of real-time heart rate monitoring and BPM display makes this project a versatile and valuable tool for a range of applications.

3 Design

Our heart rate monitoring system integrates a concise design, utilizing a heartbeat sensor with a microphone, amplifier, and low-pass filter for precise signal capture. The 74LS161 binary counter facilitates accurate pulse counting, and the CD4511 BCD-to-7-segment decoder ensures a clear 7-segment display representation of heart rate. With additional components streamlining data flow, this portable and cost-effective design serves medical monitoring, fitness tracking, and research applications, providing a user-friendly solution for real-time heart rate monitoring and BPM display.

3.1 Components used for design

- IC LM741 Op-amp
- Capacitors
- Resistors
- LED
- Stethoscope
- Microphone Condenser
- Veroboard
- Push Switch
- 555 Timer IC
- 74ls32
- 74ls08
- 74HC04
- 74HC11
- 74ls161
- CD4511
- 7 Segment Display Common Cathode

3.1.1 IC LM741 Operational amplifier(op-Amp))

The operational amplifier (op amp) is one of the main components of the electronic heartbeat reader circuit. In our project plays an important role in amplifying the signal from the microphone and filtering out any unwanted noise. As well as used in comparator.[1]

Fig.01:Op-Amp

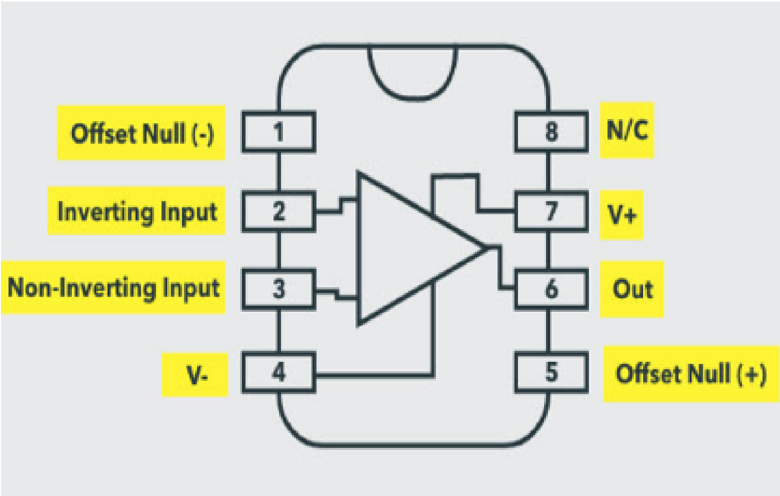


Fig.02:Pinout of LM741

General Specification of LM741

Minimum power consumption	$\pm 10V$
Normal Power Consumption	$\pm 15V$
Minimum power consumption	$\pm 22V$
Supply Current	1.7 to 2.8mA
Input Impedence Range About	2megaohms
Input Impedence Range About	75megaohms
Operating temperature range	-50° to 70°C
Soldering Pin temperature range	PDIP Package- 260°C
Soldering Pin temperature range	To -99 and CDIP- 300°C

3.1.2 Capacitors and Resistors

This are the basic components of the circuit. Here this are mainly used to control amplification, to control frequency filter, 555 IC 10s control and role as a safety factor by reducing the current flow.

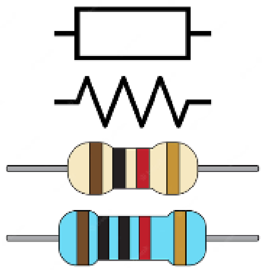


Fig.03:Resistors

Fig.04:Capacitors

3.1.3 Microphone condenser

A condenser microphone is used here to receive the sound frequency from the heart when connected to a stethoscope. Condenser microphones are sensitive to sound and have a wide frequency response, which makes them ideal for capturing the subtle sounds of the heart.[2]

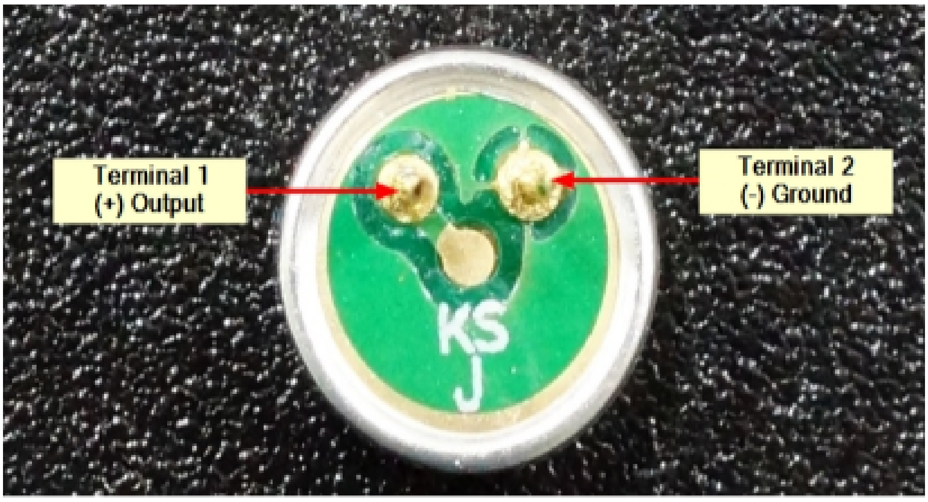


Fig.05:Microphone condenser

General Specifications

Frequency	100Hz - 20KHz
Directivity	Omnidirectional
Sensitivity	-42dB
Operational Voltage	2V typical,10V max
Output Impedence	2.2k Ohm

3.1.4 Stethoscope

This is one of the main components in our device. It takes the heartbeat vibrations as input and converts it into an electrical signal. Then other components do rest of the work.

Fig.06:stethoscope

3.1.5 7 Segment Display (Common Cathode)

7 segment display with cathode is used here to show the BPM output.

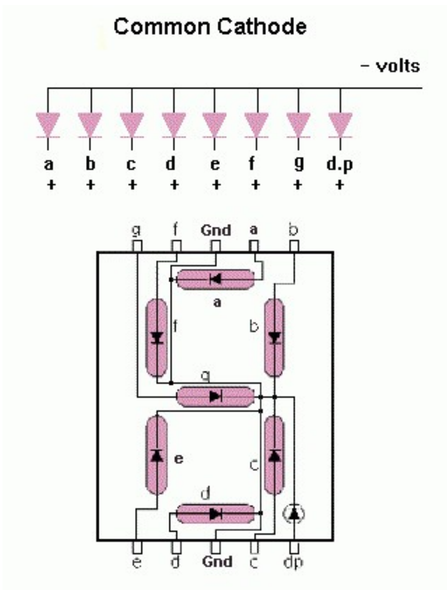


Fig.07: 7 segment display(Cathode)

3.1.6 74ls32

The 74LS32 Quad 2-input OR gate (OR gate IC) is used to implement the logical OR operations in these expressions. Which is mainly a part in our Binary to BCD circuit. The OR gate takes two inputs and produces a high output (1) if at least one of the inputs is high.[3]

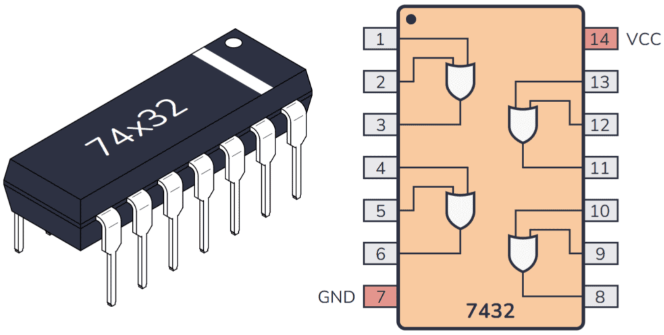


Fig.08:OR and its Pinout

General Specifications

Technology Family	LS
VCC (Min)	4.75V
VCC (Max)	5.25V
No. of Channels	4
Inputs per channel	2
IOL (Max)	0.8mA
IOH (Max)	-16mA
Input type	TTL-Compatible CMOS
Output type	Push-Pull
High Speed	(TPD 10-50ns)
Data rate (Max)	28Mbps
Rating	Catalog
Operating temperature range	0°C to 70°C

3.1.7 74ls08

The 74LS08 is a Quad 2-input AND gate. The AND gate produces a high output (1) only when both of its inputs are high. Here it is used for logical AND operations in Binary to BCD circuit.[4]

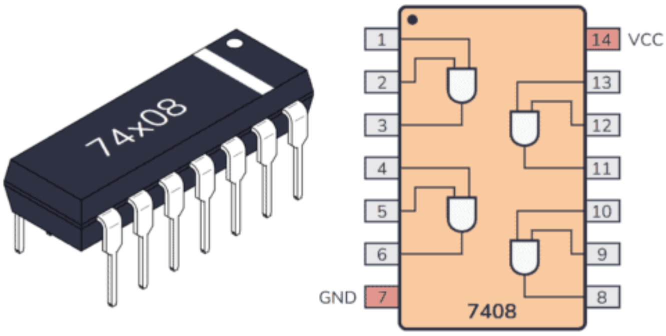


Fig.09: AND and its Pinout

General Specifications

Technology Family	LS
VCC (Min)	4.75V
VCC (Max)	5.25V
I (Max)	8mA
Operating temperature range	0°C to 70°C

3.1.8 74HC11

The 74HC11 is a tri 3-input AND gate. The AND gate produces a high output (1) only when all of its inputs are high. Here it is used for logical AND operations with3 inputs in Binary to BCD circuit.[5]

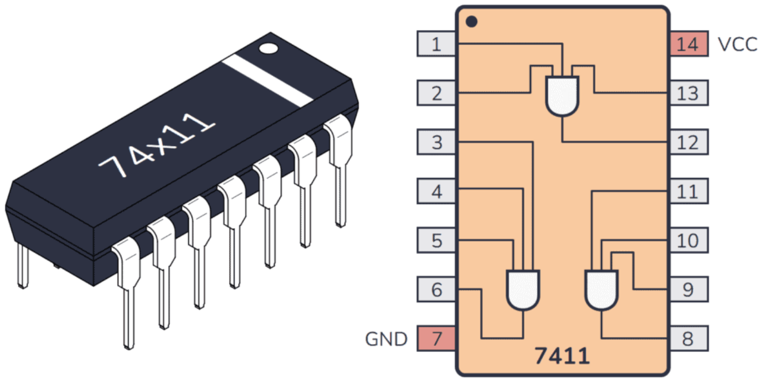


Fig.10: 3-input AND gate and its Pinout

General Specifications

Technology Family	HC
VCC (Min)	2V
VCC (Max)	6V
No. of AND gate	3
Current	5.2 mA
Operating temperature range	-40°C to 125°C

3.1.9 74HC04

The 74HC04 hexa 1-input NOT gate (NOT gate IC) is used to implement the logical NOT operations in these expressions. Which is mainly a part in our Binary to BCD circuit. The NOT gate takes one inputs and produces a high output (1) if input low(0) and produces low(0) if input high(1).[6]

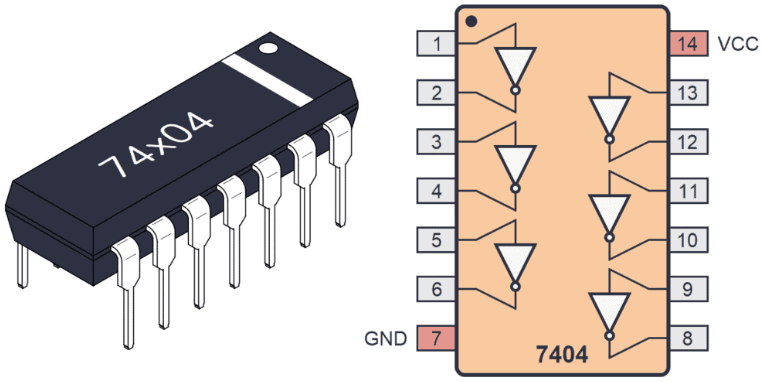


Fig.11: Hex Inverter and its Pinout

General Specifications

Technology Family	HC
VCC (Min)	-0.5V
VCC (Max)	7V
No. of AND gate	6
Current	$\pm 20mA$
Operating temperature range	-40°C to 150°C

3.1.10 74ls161

The 74LS161 is a 4-bit binary counter IC (integrated circuit). It's designed to count in binary from 0000 to 1111 and has several applications in digital circuitry. Here, it is used for count BPM in binary.[7]

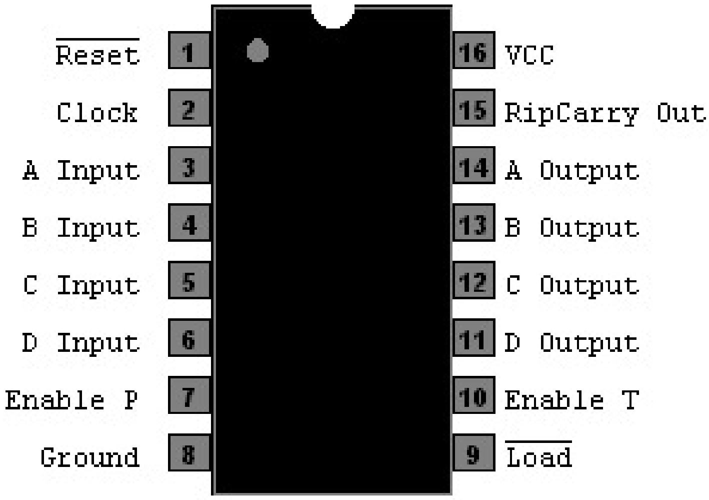


Fig.12:74ls161;4bit binary counter and its Pinout

General Specifications

Technology Family	LS
VCC (Min)	4.75V
VCC (Max)	5.25V
Input HIGH Voltage	2.0V
Input LOW Voltage	0.8V
Input Clamp Diode Voltage	-1.5V
HIGH Level Output Current	-0.4mA
LOW Level Output Current	8mA
Operating temperature range	0°C to 70°C

3.1.11 CD4511

The CD4511 is a BCD-to-7-segment latch/decoder/driver IC. This integrated circuit is commonly used in electronic projects to convert binary-coded decimal (BCD) data into a format suitable for driving a 7-segment display. [8]

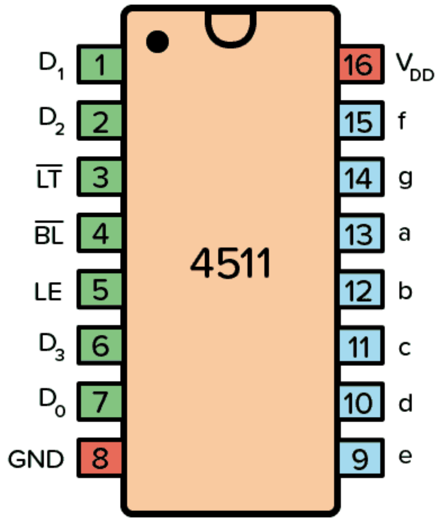


Fig.13:CD4511 and its Pinout

General Specifications

VCC (Min)	3V
VCC (Max)	18V
Set-up-time 150, 70, and 40ns	5v, 10v, and 15v
Strobe pulse width 400, 160, and 100ns	5v, 10v, and 15v
Hold time	0
Quiescent current at	20V
High Input Current	18mA
Maximum output current	25mA
Operating temperature range	-40 °C to 85 °C
Storage temperature ranges	-65 °C to 150 °C

4 Circuit Diagram and Explanation

4.1 Block Diagram

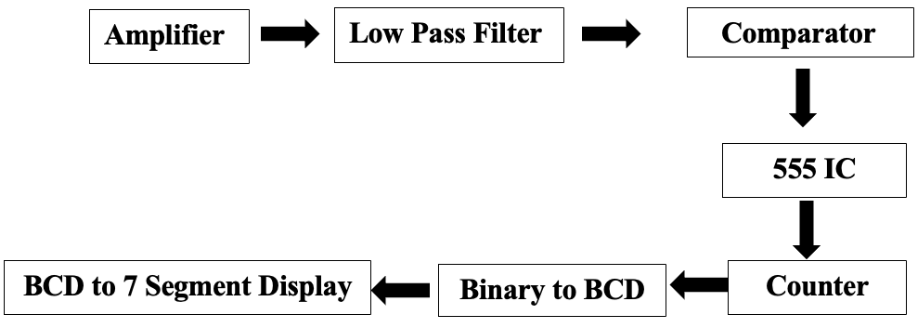


Fig.14: circuit Diagram

4.2 Explanation

The circuit diagram consists of eight parts: the amplifier, the low pass filter, 555IC, the comparator, the counter, binary to BCD converter and BCD to 7 segment display.

Step1 First of all, we need to take input from our heart bit by using stethoscope and microphone to take sound frequency then it pass through the low pass filter is used to remove the high-frequency noise from the signal and give us a purified signal. [9]

Step2 As the amplitutde of our heart is so low, so that the amplifier is used to amplify the sound signal. From Amplifier oscilloscope is connected to watch the real time heart rate monitoring. The display will show the waveform of the heartbeat signal.[10]

Step3 Following the amplifier, the signal encounters in comparator, which identifies and marks the peaks of the heartbeat waveform. Converts heart signal to a digital square wave signal.[11]

Step4 The circuit 555 IC implemented for 10s delay. If it pass the voltage for 10 seconds after 10 seconds it's autometically turned off.

Step5 The passing voltage level of square wave was given as a clock signal input and 555 ic output used as VCC in 74ls161 the 4 bit binary counter IC. Which will counts the positive edges of that square wave clock signal for 10 seconds and gives a 4 bit binary output.[12]

Step6 The binary output from the counter undergoes conversion through a binary-to-BCD converter. Beacuse of the scarcity of binary to BCD converter in the market, we have used 2 input AND, 3 input AND, Hexa Inverter and an OR gate to implement the circuit of binary to BCD.

Step7 The BCD output from the previous section need to be ready to show in 7 segment common cathode display. Finally, the BCD signal is processed by a CD4511 BCD-to-7-segment translating the binary count into a format suitable for the 7-segment display.

This design ensures that the circuit not only captures and refines the heart signal for clear representation but also quantifies the heart rate, displaying it digitally on the 7-segment display. The interconnected components collectively form a comprehensive heart rate monitoring system.

5 Simulation Result

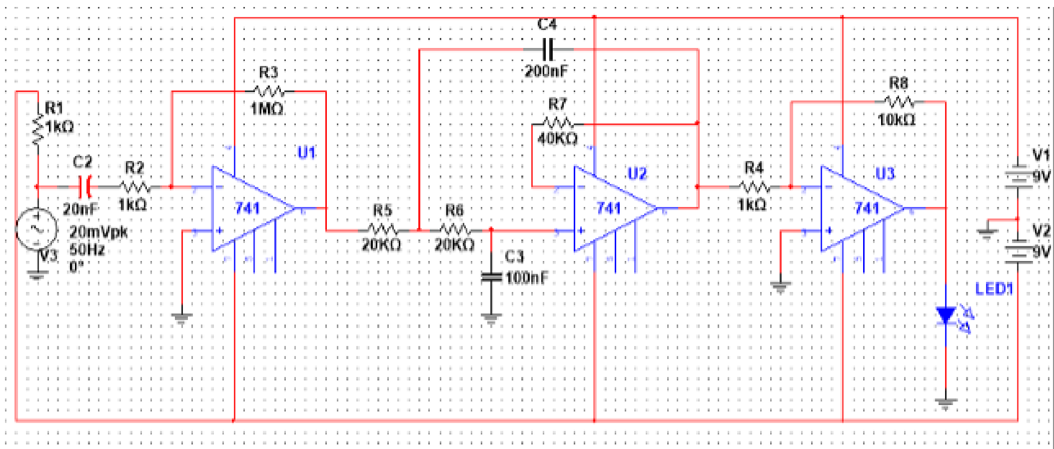
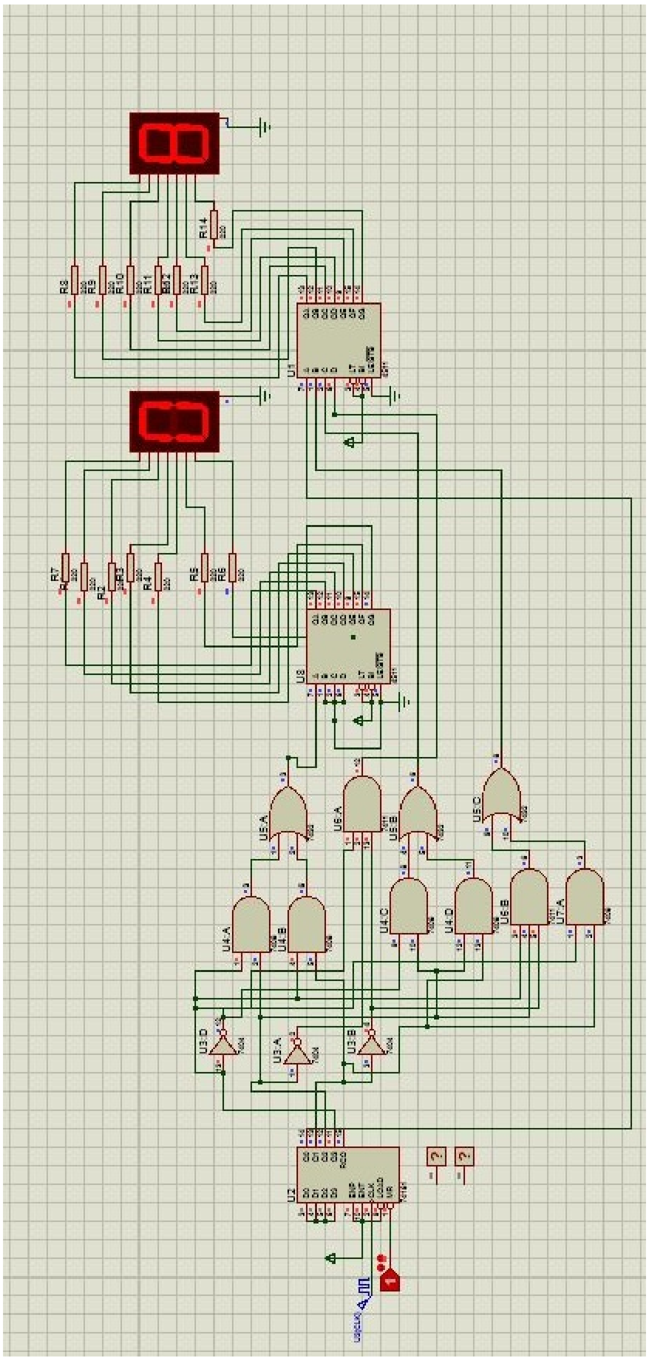


Fig15.Previous part Simulation

From this part output amplified signal converting it as a square wave digital signal. This square wave single will be the 10 second input on our counter.

As we don't have any heart signal in software, we will provide directly a square wave to our next stage of circuit so that our output would be 0-15 in 7 segment display and then reset it to 00, also time is factor here. Our implemented circuit in simulation worked properly and perfectly showing the output.Below: **Fig16. Simulation**



6 Picture of Hardware Implementation

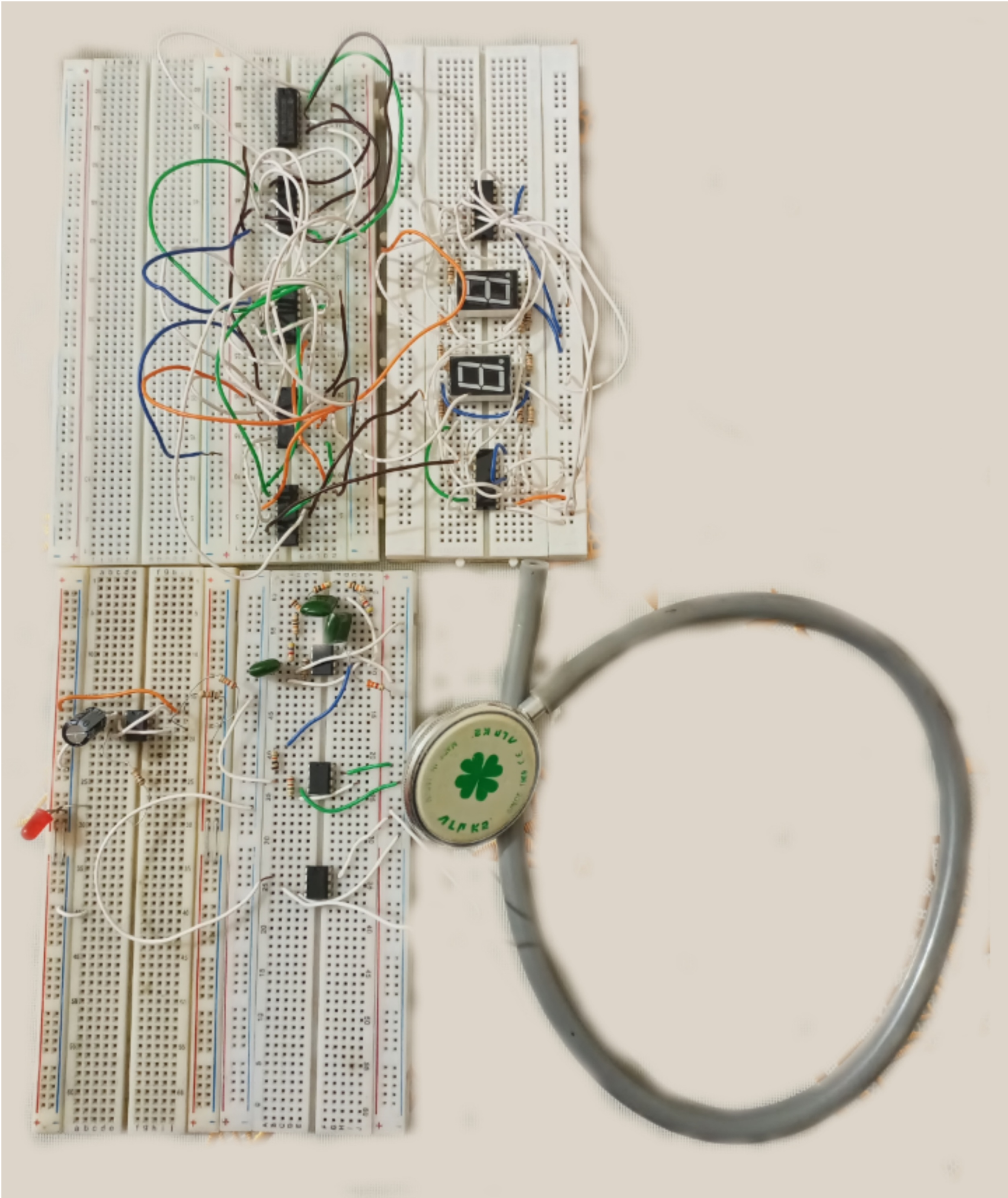


Fig16. Hardware Implementation

7 Application Areas and Limitations

7.1 Real-life Application areas

- Measuring the BPM
- Clinical Diagnosis
- Exercise Physiology and Fitness Training
- Cardiac Research
- Telemedicine and Remote Patient Monitoring
- Emergency Response
- Study on Signal analysis

7.2 Limitations

- Signal Interference: External interference from electronic devices or environmental factors may affect the quality of the signal captured by the microphone.
- Monitoring:The project's simplicity may limit its ability to capture comprehensive cardio data.
- Limited Diagnostic Capability: Because of its limited capability and low budget it might not be a substitute for specialized medical equipment in clinical diagnoses.

8 Cost Estimation

The total cost of the project is estimated to be around 900 BDT. This includes the cost of the components, labor, transportation, and other expenses. The project is considered to be low-cost and can be easily replicated by others. The project uses readily available components, making it easy to obtain the necessary parts. The project is relatively simple to assemble, making it accessible to people with limited technical skills.The project can be used to educate people about heart health and the importance of regular monitoring.

Individual Cost table

Component	**Cost(Tk)**
Stethoscope	400/-
Microphone condenser	20/-
Resistors	15/-
Capacitors	20/-
Wires	10/-
Veroboard	30/-
Op-Amps 3x	45/-
Push switch	3/-
555 IC	15/-
74ls32	30/-
74ls08	25/-
74HC04	30/-
74HC11	50/-
74ls161	50/-
CD4511	40/-
7 Segment Display 2x	60/-
Total	**843**

9 Conclusion

In summary, this digital electronics heartbeat reader and BPM counter project has effectively conceptualized and executed a simple circuit design, with available components. This current implementation provides a functional heart rate monitoring system and BPM counter, future enhancements could include the integration of a higher-quality microphone and a more responsive amplifier for improved signal processing and count BPM more accurately. Further potential improvements involve expanding the project's capabilities to encompass features like data storage and a more advanced display system. The conclusion not only highlights the acknowledgment of challenges and limitations within the project but also showing our path for future refinements and innovations.

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[3] 74ls32 : https://www.build-electronic-circuits.com/7400-series-integrated-circuits/74hc32-74ls32/

[4] 74ls08 : https://www.build-electronic-circuits.com/7400-series-integrated-circuits/74hc08-74ls08/

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[9] Sedra, A.S., Smith, K.C.: Sedra/Smith Microelectronic Circuits

[10] Driscoll, R.C.: Operational Amplifiers, p. 46

[11] M. Morris Mano, M.D.C.: Digital Design-5th Editon ISBN-13: 978-0-13-277420-8, p. 148. Comparator

[12] M. Morris Mano, M.D.C.: Digital Design-5th Editon ISBN-13: 978-0-13-277420-8, p. 271. Synchronus Counter: