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The Construction and Implementation of Heart Beat Monitor Using Fingertip

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***Abstract*— The construction and implementation of a device for measuring heart rate was carried out in this research work. As heart related diseases are increasing day by day, the need for an accurate and affordable heart rate measuring device is essential to ensure quality of health. However, most heart rate measuring tools are expensive. Our proposed heart rate measuring 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 includes pulse detection, signal extraction and pulse amplification. We compared the performance of the constructed heart beat measuring device with standard digital wristwatch heart beat measuring device of ten persons (all adults). The results showed that the error rate in the device is negligible. This device is recommended for use at homes and for individual use. However, because of its less precision and accuracy, individuals should not rely on the measured values. Therefore, more research is needed in order to improve its accuracy and hence making it usable in the clinical world.**

***Index Terms*— heart rate, IR LED, IR photodiode sensor, Low-pass filter and microcontroller.**

I. INTRODUCTION

Heart rate is the number of heart beat per unit time typically expressed in beat human cardiovascular system. The unavailability of a portable personal heart beat monitor to measure the heart rate of an individual has given rise to the prevalence of serious cardiovascular problems. Hence, this research demonstrates a technique to measure the heart rate by sensing the change in blood volume in a finger artery while the heart is pumping blood (Hashem *et al*., 2010). This technique consists of an infrared light emitting diode (IR LED) that transmits an IR signal through the finger tip of the subject, a part of which is reflected by blood cells. The reflected signal is detected by an IR photo diode sensor. The changing blood volume with heart beat results in a train of pulses at the output of the IR photo diode, the magnitude of which is too small to be detected directly by a microcontroller. Therefore, a two-stage high gain active low-pass filter is designated using two operational amplifiers to filter and amplify the signal to appropriate voltage level so that the pulses can be counted by the microcontroller. The heart rate is displayed on a three digit seven segment display. The heart rate is determined in beats per minute (bpm). In adults, a normal heart beats about 60 – 100 times per minute during resting condition.

Generally, heart beats can be felt at location where large arteries are close to the surface of the body. The rate of heart beat is measured in beat per minute (bpm). Normal heart rate may be indicated by the condition of pacemaker, SA node and state of conduction pathway. During resting, an infant rate of heart beat ranges about 130 – 150bpm, toddler's about 100 – 130bpm and older child about 90 – 110bpm. Adult's heart rate is about 60 -100bpm with average heart rate about 70bpm for males and 75bpm for females. However, heart rate varies depending on the age and health condition of the person (Hashem *et al.*, 2010).

Heart rate measurement indicates the soundness of the human cardiovascular system. Heart rate monitoring device is an electronic tool that detect physiological parameter and converts to usable heart rate reading. Heart rate is produced through depolarization at the sinoatrial and antroventricular nodules in the heart

This research work demonstrates a technique to measure the heart rate by sensing the change in blood volume in a finger artery while the heart is pumping the blood.

II. RESEARCH METHODOLOGY

COMPONENTS USED FOR THE CONSTRUCTION
LM358 General Purpose operational Amplifier
8 – pin IC Socket Machine pin
Resistors
Capacitors
9v battery holder tab
Shielded cable
PIC16F628A Microcontroller
4MHZ Crystal
LM7805 5v Voltage Regulator
Vero board
Infrared – light – Emitting – Diode (IR LED)
Infrared Photodiode
Transistor BC547
3- Digit seven segment LED display

STAGES OF THE CONSTRUCTION

a) Sensor Assembly
b) Signal Conditioning Circuit
c) Microcontroller & Display circuit

III. SENSOR ASSEMBLY

The sensor unit consists of an infrared light emitting diode (IR LED) and a photodiode placed side by side and the fingertip is placed over the sensor assembly. The IR LED transmit an infrared light into the fingertip, a part of ehich is reflected back from the blood inside the finger arteries. The

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photodiode senses the portion of the light that is reflected back. The intensity of reflected light depends upon the blood volume inside the fingertip. So, every time the heart beats, the amount of reflected infrared light changes which can be detected by the photodiode. With a high gain amplifier, this little alteration in the amplitude of the reflected light can be converted into a pulse. The diagram for the sensor assembly is shown below in figure 3.1

IV. SIGNAL CONDITIONING CIRCUIT

The reflected IR signal detected by the photodiode is fed to a signal conditioning circuit that filters the unwanted signals and boost the desired pulse signal. The circuit diagram shows the IR LED (D1) and the photodiode (D2) along with the signal conditioning circuit made of two stage operational amplifiers configured as active low pass filters are set to about 2.34HZ and so it can measure the pulse rate up to 2.34 x 60 = 140.4bpm. The gain of each filter is about 101, which gives the total 2-stage amplification of approximately 10,000. This is good enough to convert the weak pulsating signal into a TTL pulse. At the input of each op-amp filter stage, there is a luF capacitor to block any DC component in the signal. At the output is connected a LED that will blink with heart beat. The cathode of LED gets the ground path through the collector of transistor BC547. In order to save the battery life, the transistor is turned on for 15seconds by PIC16F628A microcontroller while the measurement is going on. The number of pulses counted within this interval is multiplied by 4 to get actual beats per minute (bpm). The circuit diagram for the signal conditioning circuit is shown in Fig 2

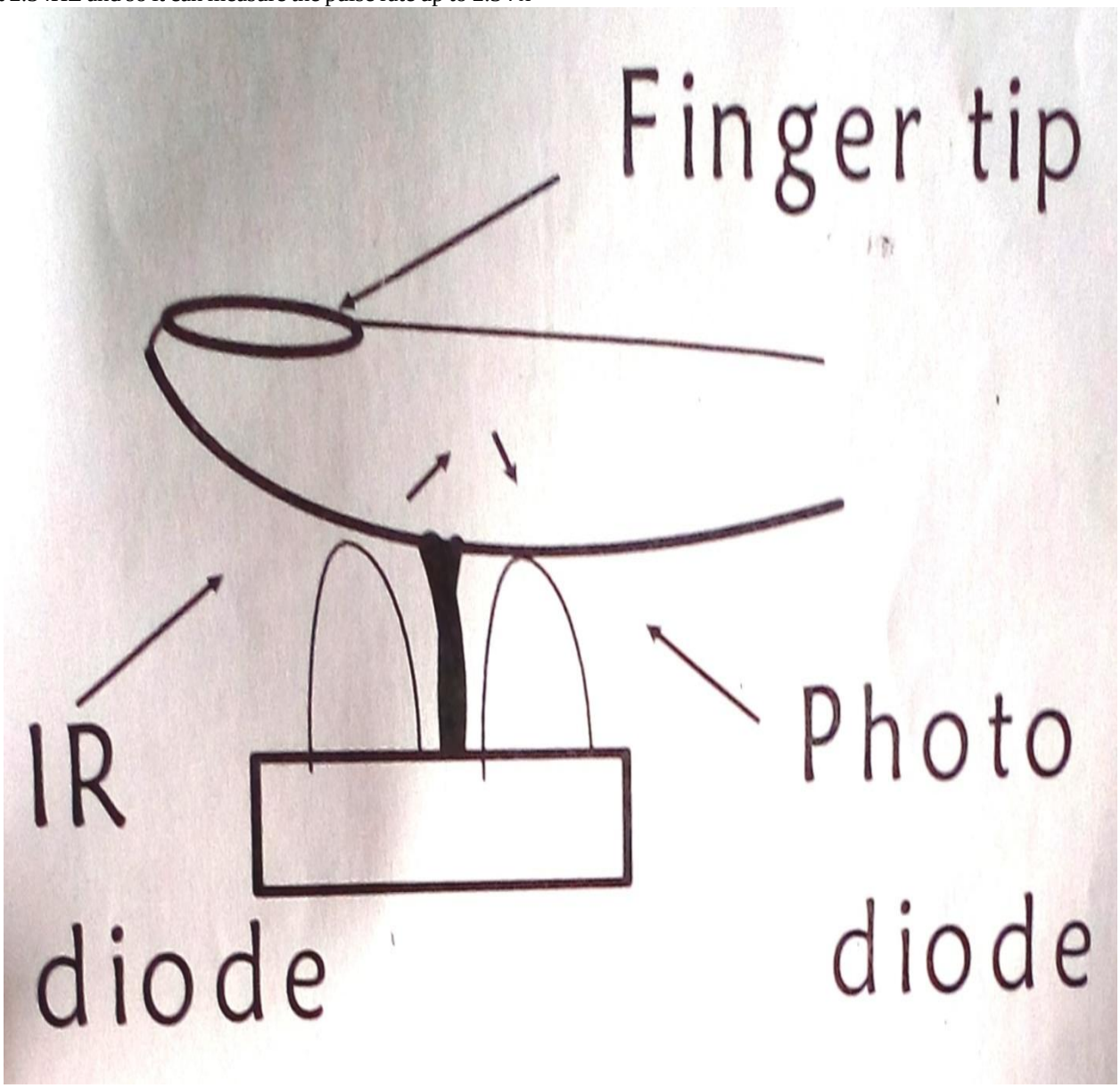

FIG. 1: **SENSOR ASSEMBLY**

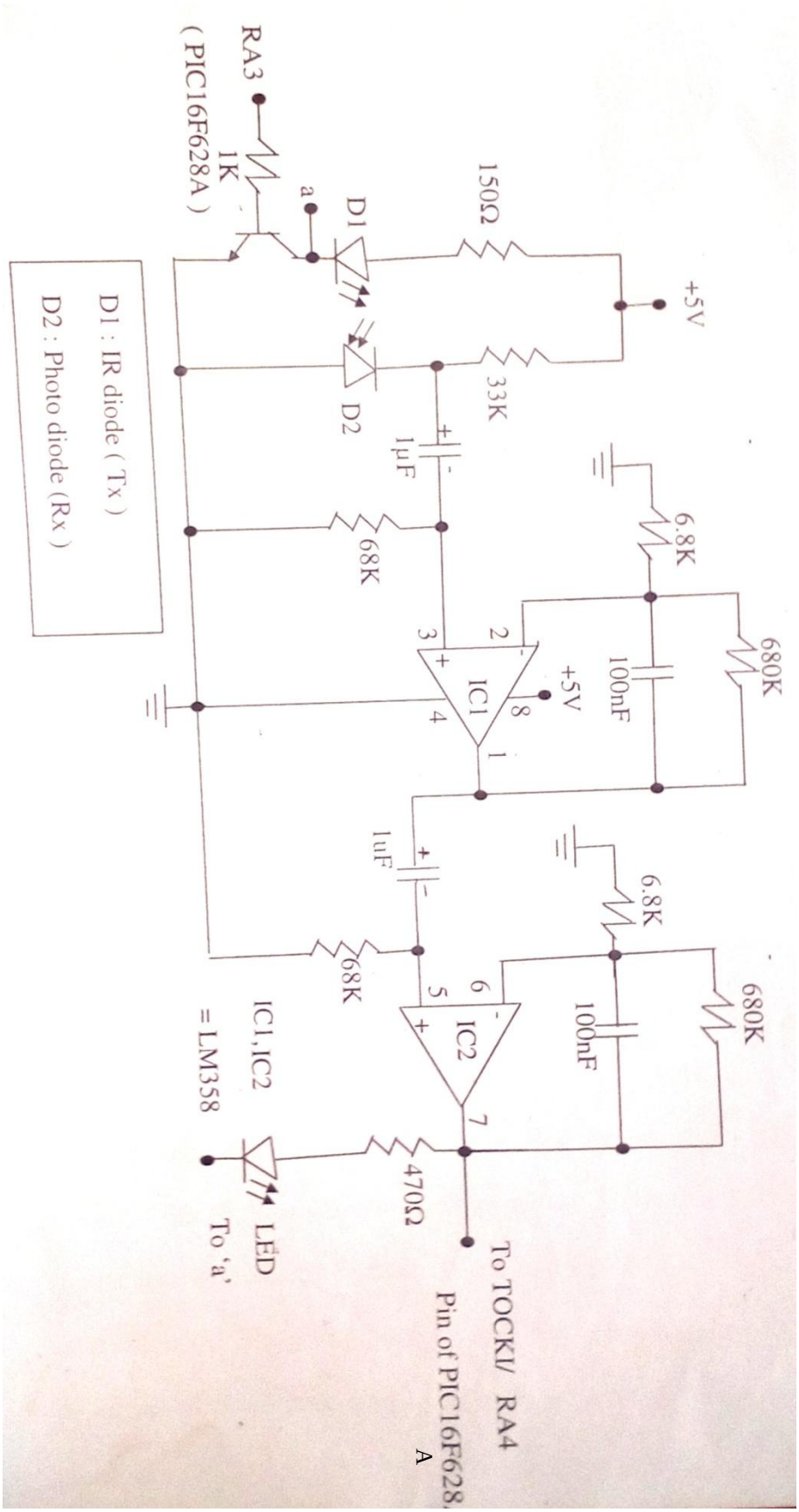

fig.2: signal conditioning circuit

Gain of each stage = 1 + Rf / Ri
= 1 + 680k / 6.8k
= 101
Cut-off frequency = 1 / 2 ΠRfCf
= 2.34Hz

V. MICROCONTROLLER AND DISPLAY CIRCUIT

The output from the signal conditioner goes to the TOCKI input of PIC16F628A. The display unit comprises of a 3-digit common anode seven-segment motor that is driven using multiplexing technique. The segment a-g is driven through

PORT B pins RBO-RB6 respectively. The unit tens and hundreds digit are multiplexed with RA2, RA1 and RA0 PORT pins. A tact switch input is connected to RB7 pin. This is to start the heart rate measurement. Once the start button is pressed, the microcontroller activates the IR transmission in the sensor unit for 15 seconds. During this interval, the number of pulses arising at the TOCK 1 input is counted. The actual heart rate will be four times the count of the actual value and the resolution of measurement will be four and the result is displayed on a 3-digit seven segment LED display. The microcontroller runs at 4.0MHZ using external crystals. The regulated +5V power supply is derived from an external 9V battery using an LM7805 voltage regulator IC.

The microcontroller and display circuit is shown on Fig 3. below:

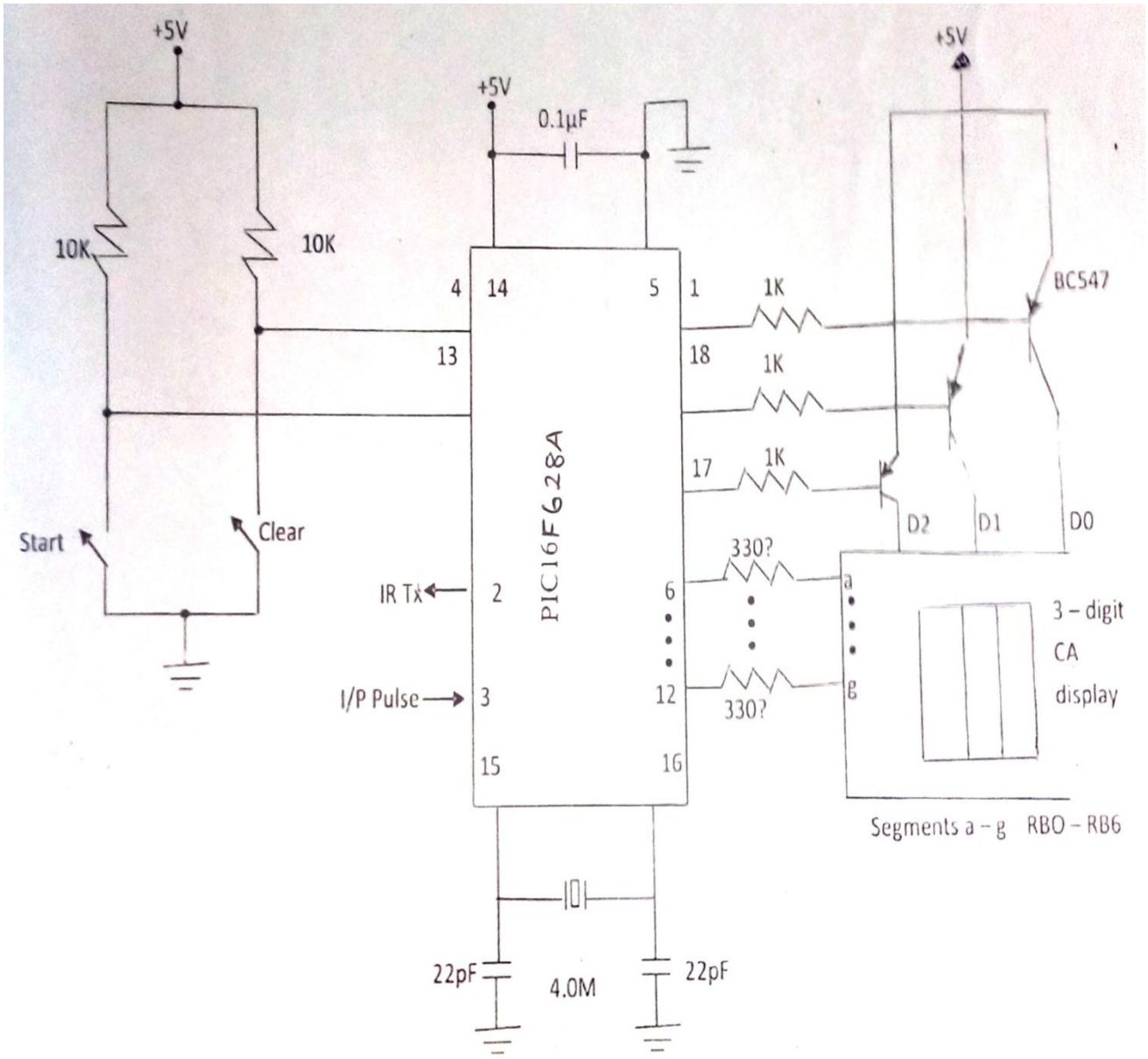

***FIG 3*:** microcontroller and display circuit

VI. PROCEDURE FOR OPERATING THE DEVICE

1. Turn the power on, then press the clear button and you will see the zero displayed on the screen for a few seconds.
2. Wait till the display goes off
3. Place your fore-finger tip on the sensor assembly
4. Press the start button, relax and don't move your finger. You will see the LED blinking which indicates the heartbeat.
5. After 15 seconds, the result will be displayed on the screen.

VII. DATA COLLECTION / ANALYSIS

The heartbeat of ten person (adults) was measured using the constructed fingertip heart beat monitor and this was compared with the results obtained using a standard wrist watch heart beat monitor. The result obtained and the error rate (%) was calculated using the formula:

$$E = 100 \times A - M / A$$

Where E = Error (%)

A = Measured heart beat using the constructed device (bpm)

M = Measured heart beat using manufacture device (bpm)

The values obtained are shown on the table 4.1 below:

TABLE 1: Accuracy comparisons with a Manufacture Device

Manufactured (bpm)	Constructio n (bpm)	Error (%)
78	80	2.50
82	86	4.65
86	86	4.65
74	80	0.00
64	68	7.50
80	88	5.88
77	86	9.09
80	89	10.47
69	74	6.76

VIII. DISCUSSION OF RESULT

In adults, a normal heart beat is about 60 -100 times per minutes during resting condition. The data collected was varied using six males and four females. From the table 1 above, it can be observed that the constructed fingertip heart beat monitor can be used to measure the heart beat rate of an individual although with less precision and accuracy.

IX. CONCLUSION

In this research work, the construction and implementation of a heart rate measuring device measures the heart rate efficiently in a short time and with less expense without using time consuming and expensive clinical pulse detection system. Both analogue and digital signal processing techniques are combined to keep the device simple and to efficiently suppress the disturbance in signals. Simulations showed that heart rate can be detected from changes of blood flow through an index finger. This device is able to detect, filter, digitize and display the heart beat of a user.

X. RECOMMENDATION

This device is recommended for use at homes and for individual use. However, because of its less precision and accuracy, individuals should not rely solely on the measured values. Therefore, more research is needed in order to improve its accuracy and hence making it usable in the clinical world

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